Psychology of Aesthetics, Creativity, and the Arts

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Online First Publication, June 9, 2016. http://dx.doi.org/10.1037/a0040368

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1931-3896/16/$12.00 http://dx.doi.org/10.1037/a0040368

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Justin Ostrofsky
Stockton University

Aaron Kozbelt
Brooklyn College and the Graduate Center of the City University of New York

Michael Tumminia and Matthew Cipriano
Stockton University

Nonartists are biased to position the eyes too far up the head when drawing a face from observation. This study aims to determine how schematic knowledge, perceptual processing of the scalp-line, and altitudinal pseudoneglect are related to this bias. Participants were randomly assigned to receive or not receive the schematic knowledge that the eyes are positioned approximately half-way down the head. Participants then drew 2 faces, a bald male and a nonbald male, and completed a vertical line bisection task to measure pseudoneglect. Results suggest that schematic knowledge reduces, but does not eliminate, this bias and alters attentional processes guiding face drawing—because participants lacking schematic knowledge made larger errors when drawing a bald model, while those with schematic knowledge did not. Further, upward biases in the line bisection task were positively correlated with upward eye-drawing errors only for participants given schematic knowledge. This suggests that there are different reasons why individuals draw the eyes too far up the head: inattention to the forehead region for those lacking schematic knowledge versus attentional pseudoneglect of visual information in the lower visual field for those with schematic knowledge.

Keywords: face drawing, knowledge, attentional biases, pseudoneglect, line bisection

Anecdotal reports from art educators (Edwards, 2012; Okabayashi, 2009) and empirical studies have revealed that one of the most prevalent errors nonartists make when drawing faces is positioning the eyes too far up the length of the head—an error made by over 95% of participants in some studies (Clare, 1983; Ostrofsky, Cohen, & Kozbelt, 2014). More specifically, whereas the eyes are positioned approximately half-way down the length of an average adult head (Farkas & Munro, 1987; Hamm, 1963; Ostrofsky, 2015b), nonartists tend to draw the vertical position of the eyes, on average, 44% to 45% down the length of the head (Ostrofsky, 2013).

The ability to recognize faces is strongly dependent on the processing of the precise spatial positioning of facial features (Rotshtein, Geng, Driver, & Dolan, 2007; Tanaka & Sengco, 1997), and individuals are very sensitive to changes in the spatial configurations of these features, including the vertical positioning of the eyes (e.g., Goffaux & Rossion, 2007). Because the goal of observational face drawing is to create a highly recognizable depiction of the model being reproduced, the observed bias in the vertical position of the eyes may be one of the reasons nonartists produce depictions of faces that are typically judged to be low in accuracy (Cohen, 2005; Cohen & Jones, 2008). Indeed, Ostrofsky et al. (2014) provided evidence consistent with this claim, reporting that the degree of error in drawing the vertical position of the eyes (among other spatial relationships between facial features) is negatively correlated with subjective ratings of the perceived overall accuracy of face drawings.

This set of findings raises the interesting psychological question of why there exists a bias for drawing eyes too high on the head (rather than too low or having no bias at all) in the first place and the extent to which art instructional strategies might reduce it. Despite its prevalence, the basis of this bias is currently not well understood. The aim of the current study was to investigate the potential relationships that knowledge-, perception- and attention-based processes have with the observational drawing of the vertical position of the eyes on the length of the head.

Justin Ostrofsky, Department of Psychology, School of Social and Behavioral Sciences, Stockton University; Aaron Kozbelt, Department of Psychology, Brooklyn College and Department of Psychology, the Graduate Center of the City University of New York; Michael Tumminia and Matthew Cipriano, Department of Psychology, Stockton University.

Correspondence concerning this article should be addressed to Justin Ostrofsky, Department of Psychology, School of Social and Behavioral Sciences, Stockton University, 101 Vera King Farris Drive, Galloway, NJ 08205. E-mail: justin.ostrofsky@stockton.edu

Schematic Knowledge and Drawing

Research on the drawings produced by children and unskilled adults has long indicated that observational drawings are not exclusively guided by bottom-up, perceptual processing of the model being depicted. Rather, much theoretical and empirical work has suggested that the production of observational drawings is at least partially guided by canonical knowledge that is represented in long-term memory (e.g., Freeman, 1980; Freeman & Janikoun, 1972; Luquet, 1927/2001; Matthews & Adams, 2008; Ostrofsky, 2015b; Willats, 1997, 2005). This work has taken the perspective that such long-term memories contain representations of objects that reflect their canonical or prototypical appearances. The impact of such representations on drawings produced by children is evident by observations of drawings that include prototypical features not found in the model being copied. As one example, Freeman and Janikoun (1972) demonstrated that some children include a depiction of a handle in their observational drawings of a model mug that was positioned in such a way to occlude visibility of the handle. It has been argued that such drawing errors produced by children are due to "canonical biases," where children are incapable of inhibiting their knowledge of an object's canonical or prototypical features when drawing a model perceived from a specific viewpoint (Freeman, 1980; Willats, 1997, 2005). Later empirical research has suggested that canonical representations stored in long-term memory affect adults as well when producing observational drawings. This has been evident in the observations that the appearance of drawings produced exclusively from long-term memory predicts the appearance and/or errors of drawings produced from an observation of a specific model (Matthews & Adams, 2008; Ostrofsky, 2015b).

Much of this work has taken the perspective that developing the skill to draw accurate, viewpoint-specific depictions of a model requires one to overcome the interfering effects that knowledge exerts on the production of drawings (Edwards, 2012; Freeman, 1980; Fry, 1919/1960; Glazek, 2012; Ruskin, 1857/1971). However, others have argued that the development of drawing skill and expertise is not associated with the inhibition of knowledge, but rather, is associated with the acquisition of schemas that are characterized as sophisticated and accurate sets of knowledge that pertain to the graphical structure of common objects (Gombrich, 1960; Kozbelt & Seeley, 2007). Such schematic knowledge may represent general visual cues that are important to include in drawings of a wide-variety of different objects, such as T-junctions and shading gradients that help define the 3D structure of objects (Biederman & Kim, 2008; Clare, 1983; Ostrofsky, Kozbelt, & Seidel, 2012). Additionally, such schematic knowledge may represent visual properties or canonical proportions that are relevant to specific objects, such as knowing that a typical human body is about 7.5 heads tall, that the horizontal distance between the eyes is approximately the width of one eye, and, relevant to this study, that the eyes are vertically positioned approximately half-way down the head.

In this view, nonartists produce low quality observational drawings because they do not possess sophisticated knowledge that accurately represents the structure and visual appearance of the model objects being drawn. Historically, this perspective has guided art-instruction practices, as evident by the widespread use of "how-to" drawing manuals (e.g., Hamm, 1963; Hogarth, 2002; Kraavanger, 2005; Okabayashi, 2009). Such manuals provide explicit instruction with respect to the schematic visual structure of common objects on the assumption that once such knowledge has been acquired by an individual, drawing ability will improve. However, beyond anecdotal reports of art educators and art historical arguments (e.g., Gombrich, 1960), the beneficial effects of gaining such knowledge on adult drawing performance has not been empirically evaluated.

Vis-à-vis the present study, this view of drawing skill would posit that one reason most nonartists err in drawing the vertical position of the eyes is because they lack the explicit knowledge that the eyes are located approximately half-way down the length of the head and that explicitly providing nonartists with this knowledge would result in the elimination or reduction of this error. This is one hypothesis tested in the present study.

Perception of Contextual Cues and Drawing: Effects of the Presence Versus Absence of Hair in the Model Being Drawn

Even if providing nonartists explicit instruction that the eyes are positioned about half-way down the head reduces or eliminates the tendency to draw the eyes too far up the head, the question of why this bias exists in the absence of such knowledge would still remain. In the attempt to understand the specific directional bias of eye-drawing errors, Clare (1983) speculated that the bias to draw the eyes too far up the head was caused by a context-based perceptual illusion driven by the presence of the scalp-line. Specifically, it was posited that the presence of hair creates an illusion that the eyes are closer to the top of the head than they actually are because the scalp-line is mistakenly perceived as the top of the head. On the basis of this theory, Clare (1983) predicted that drawings of a bald model would reduce the bias to draw the eyes too far up the length of the head relative to drawings of a model with hair.

To test this, Clare (1983) provided 10- to 14-year-old children an image of a model head to draw that was either bald or not. Participants were provided a preprinted contour of the model head that was featureless and without hair, and were asked to draw two ovals to represent the accurate spatial positioning of the two eyes. Participants who drew the bald model reproduced the vertical position of the eyes closer to the vertical midpoint of the head than the participants who drew the model with hair. However, both groups (98% of all participants) still were biased to draw the vertical position of the eyes above the midpoint of the head. Thus, although not the only cause of the bias to draw the eyes too far up the head, the perception of the hair line was demonstrated to influence the magnitude of this error.

The results of this study raise two important questions. First, because participants were provided a preprinted head contour to create their drawings on and were only asked to draw two ovals representing the spatial positioning of the eyes, the participants selectively attended to the task of drawing the spatial positioning of the eyes. However, it remains open to question as to whether the presence versus absence of hair on the model being reproduced would affect eye-drawing performance in a more naturalistic drawing task where participants are asked to draw the entire model with no preprinted guide and no selective goal. Thus, one aim of the present study was to evaluate whether the effect reported by Clare

(1983) generalizes to performance in a free-hand drawing task where adult participants are asked to draw the entire model without selectively attending to the task of only drawing the eyes.

Second, if we find that the perceptual processing of the hair line affects eye-drawing performance, it remains open to question as to whether this perceptual-based drawing bias to draw the eyes too far up the head is mediated by the knowledge or lack thereof that the eyes are positioned half-way down the head. Previous research has demonstrated that explicit knowledge about the veridical properties of a stimulus can have the effect of reducing the magnitude of individuals' experience of perceptual illusions (e.g., Khorasani, Fadardi, Fadardi, Cox, & Sharif, 2007). Thus, another goal of the present study was to investigate whether the potential effect that the presence versus absence of hair has on vertical eye-drawing accuracy differs between individuals with and without accurate schematic knowledge pertaining to the spatial positioning of the eyes.

Attention and Drawing: Pseudoneglect

Another possible psychological factor related to the bias to draw the eyes too far up the head may be attentional in nature. Specifically, one bias found in neurologically intact individuals is to selectively attend to information in the upper visual field more than the lower visual field, an effect sometimes termed *altitudinal pseudoneglect*. This attentional bias is most clearly demonstrated by upward biases commonly observed in vertical-line bisection task performance; most individuals are biased to perceive the midpoint of a vertical line higher than it actually is (Chieffi, 1996; Drain & Reuter-Lorenz, 1996; McCourt & Olafson, 1997; Post, O'Malley, Yeh, & Bethel, 2006; van Vugt, Fransen, Creten, & Paquier, 2000). These results suggest that, when attempting to bisect vertical lines, participants attend to the upper portion of the visual field more than the bottom portion, resulting in the upward bias of the perceived midpoint.

This general upward attentional bias might be associated with the bias to draw the vertical position of the eyes too far up the length of the head. When attempting to draw the vertical position of the eyes, there might be pseudoneglect of the lower portion of the face, causing an upward bias in the perceived vertical position of the eyes. If the bias to draw the eyes too far up the length of the head is related to general pseudoneglect attentional biases, then one would predict that the magnitude of upward biases in a vertical line bisection task would be positively correlated with the magnitude of upward biases when drawing the vertical position of the eyes. Another aim of the current study was to test this prediction.

The Present Study

In the present study, nonartist participants participated in two drawing tasks and a vertical line bisection task. With respect to the drawing tasks, participants were exposed to two model images of faces that were identical in every respect except that one had hair and one was bald (see Figure 1). In one of the drawing tasks (the eye-drawing task), we replicated the method used by Clare (1983), in that participants were provided a preprinted, featureless contour of the model heads and were asked only to draw the eyes as they appeared in the model. In the other drawing task (the free-hand drawing task), participants were asked to draw the entire model face as accurately as possible. Before the drawing tasks were administered, participants were randomly assigned to one of two conditions. In one condition, they were explicitly instructed that the eyes were positioned approximately half-way down the head, whereas in the other condition, the participants received no such instruction. The goals of the study were to

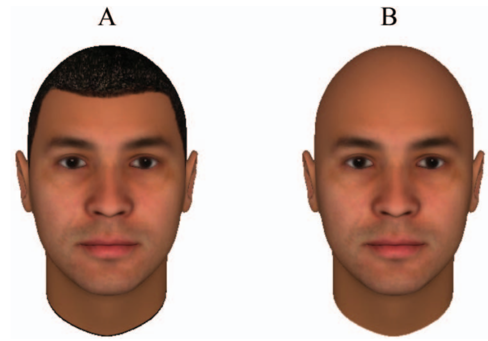


Figure 1. The face models participants attempted to reproduce in the drawing tasks. Note that the two models are visually identical in every respect with the exception of the presence versus absence of hair. Panel A: Model with hair. Panel B: Bald model. See the online article for the color version of this figure.

(a) determine whether the effect of the presence versus absence of hair on the drawn vertical positioning of the eyes reported by Clare (1983) replicated in the eye-drawing task performance and generalizes to performance in the free-hand drawing task and

(b) determine whether schematic knowledge about the vertical position of the eyes reduces the bias to draw the eyes too far up the length of the head and/or mediates any potential effect the presence versus absence of hair has on drawing the vertical position of the eyes.

Further, participants participated in a vertical line bisection task where they were presented with a number of plain vertical lines and were asked to divide the lines in half. Here, we aimed to

(c) determine whether participants display an upward bias reflecting altitudinal pseudoneglect and

(d) determine whether the magnitude of the upward bias in the vertical line bisection task was positively correlated with the magnitude of the bias to draw the eyes too far up the length of the head.

Method

Participants

Seventy-five undergraduate psychology students at Stockton University participated, (*M* age = 21.4 years, *SD* = 5.4 years; 56 females, 19 males). Compensation was provided in the form of course credit. All participants reported no formal training in drawing at the college level. Fourteen participants indicated that they had taken one drawing class during high school, and 9 participants indicated that they had taken one drawing class before high school. When asked to rate their drawing ability on a scale of 1 (*poor*) to 10 (*excellent*; *M* rating = 4.07, *SD* = 1.80). Further, when asked to indicate time spent drawing (*M* response = 0.44, *SD* = 0.85 hours per week).

Materials

Participating in the experiment entailed completing two drawing tasks, a vertical line bisection task, and one questionnaire.

Free-hand drawing task. Participants were asked to create one drawing each of two computer-generated images of an adult male face shown in fronto-parallel view (see Figure 1). The face models were created using the FaceGen Modeler software program (Version 3.1). Both faces were generated by setting the shape and texture of the face to the (a) "male" gender setting, (b) "30-year-old" age setting, (c) "average" caricature setting, (d) "symmetric" asymmetry setting, and (e) "all races" race-morph setting. A face texture was applied to make the face appear more natural (detail texture setting = "middle male 04" set at a modulation value of 1.0 and a gamma correction value of 1.8).

The two face models were identical in appearance, with the exception that one image depicted a bald male (bald stimulus) and the other image depicted a male with short black hair (hair stimulus). For the latter, the hair was generated by using the "short black hair" setting under the texture overlay option. From the top of the head, the lowest portion of the scalp line was positioned 21.2% down the length of the head. The face models were presented against a white background and displayed to participants one at a time on a 19-in. Dell computer monitor. While displayed on the screen, the height of the head was 5.69 in. and the width of the head was 3.63 in. Participants were asked to draw each face model one at a time. For each drawing (and for the following two tasks as well), participants were provided with an 8.5-in. × 11-in. sheet of plain white paper, a Number 2 pencil with an eraser, and a manual pencil sharpener.

Eye-drawing task. Similar to Clare (1983), participants were presented with the two model faces one at a time and were asked to draw only the accurate positioning of the eyes on an 8.5-in. × 11-in. sheet of white paper within a preprinted featureless and hairless contour that precisely matched the size and contour of the model heads (excluding the neck) as displayed on the monitor.

Vertical line bisection task. Participants were presented with 12 black vertical lines presented against a white background and were asked to draw a small horizontal line with the goal of perfectly dividing the line in half. The vertical lines were printed on six 8.5-in. × 11-in. sheets of white paper. Each printed sheet of paper depicted two vertical lines, one printed in the upper left quadrant of the paper and one printed in the lower right quadrant. All 12 lines were 5.69-in. long, identical to the height of the model heads when displayed on the computer monitor during the drawing tasks.

Questionnaire. Participants were asked to complete a one-page questionnaire indicating (a) their sex and age; (b) how many hours a week, on average, they spend drawing; (c) how many drawing classes they took before high school, during high school; and during college, (d) their self-perceived drawing ability (rated on a scale from 1 to 10); and (e) their knowledge of the canonical proportions of a human face. With respect to the latter, they were asked to indicate approximately how far down the length of the head that the eyes, nose, and mouth are positioned and how far apart the two eyes are from one another on the average adult head.

With respect to the latter questions, we intentionally did not ask participants to use a specific scale of measurement in their responses. The participants' freedom to respond using any scale of measurement was intended to gain insight into how individuals naturally think about the spatial positioning of features in a face—for example, whether they think in absolute terms (e.g., using inches as a scale of measurement), relative terms (e.g., using percentages as a scale of measurement), or in nonmetric, qualitative terms (e.g., verbal descriptions such as "the eyes are positioned above the nose").

Procedure

The order of the tasks was the same for every participant: first the free-hand drawing task, then the eye-drawing task, the questionnaire, and finally the vertical line bisection task.

Knowledge manipulation. After providing informed consent and before beginning any of the tasks, each participant was randomly assigned to one of the two knowledge conditions. Participants assigned to the knowledge condition were instructed by the experimenter that one of the most common mistakes people make when drawing a face is that they misplace the vertical position of the eyes along the length of the head. They were further told that, in order to create high-quality face drawings, it is important to know that the eyes are vertically positioned approximately halfway down the length of the head on an average adult face. In contrast, the participants assigned to the nonknowledge condition were not provided any instruction before beginning the drawing tasks.

Free-hand drawing task. Participants were asked to create complete drawings of the two model faces (the bald and hair model stimuli) one at a time. For the first drawing, the experimenter displayed the first model face on the computer monitor, provided the paper and drawing tools, and gave the task instructions. Consistent with free-hand drawing tasks in previous studies (e.g., Cohen & Jones, 2008; Ostrofsky et al., 2012), participants were instructed to attempt to copy the face as accurately as possible. They were told that the goal of the task was to create a drawing that reproduced the exact appearance of the face and not necessarily to generate a highly creative or aesthetically pleasing drawing. They were instructed to include all the major features present in the model, and not to include any details that were not present in the model. Finally, participants were instructed that they could erase and modify their depiction during the course of drawing, and that they could use any drawing technique they wished to use with the exception of tracing. Participants were given a 15-min time limit to complete the drawing.

After the first drawing was complete, the experimenter collected the drawing, displayed the second model image on the monitor, gave the participant with a new sheet of paper, and instructed the participant to draw the new model according to the same set of instructions as with the first drawing, with the same time limit. The order of drawing the bald versus hair model stimulus was counterbalanced across participants.

Eye-drawing task. Participants were informed that they would next be drawing only the eyes of the same two faces from in the previous task. The experimenter displayed one of the two model faces on the monitor and provided the paper with the preprinted head contour. As in Clare (1983), the experimenter instructed participants to draw two ovals within the contour of the head with three goals: (1) to accurately reproduce the vertical position of the eyes along the length of the head, (2) to accurately reproduce the width of each eye, and (3) to accurately reproduce the horizontal distance between the two eyes. Participants were informed that they were allowed to erase and modify their drawing until they felt it was complete; no time limit was imposed.

Once the first eye-drawing was complete, the researcher collected it, provided a second preprinted head contour, displayed the second model face on the monitor, and instructed the participant to draw the new model according to the same set of instructions as with the first drawing, again with no time limit. The order of making the eye-drawings of the bald versus hair model stimuli was counterbalanced across participants. Further, the bald- or hair-order conditions of the two drawing tasks were counterbalanced relative to one another across participants.

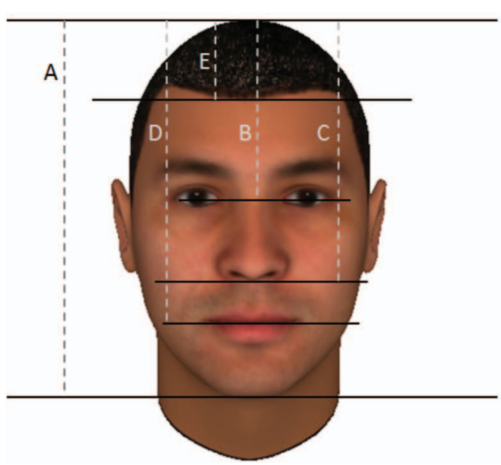
Questionnaire. After the two drawing tasks, participants completed the questionnaire. Beyond collecting demographic information, the main purpose of the questionnaire was to screen participants relative to the knowledge condition manipulation. We checked to make sure that participants assigned to the nonknowledge condition had not previously acquired the knowledge that the eyes are positioned approximately half-way down the head. If participants indicated that they had this knowledge, their data were discarded before analysis; this was the case with 5 (13.9%) participants assigned to this condition. Of the remaining 31 participants in the nonknowledge condition, 5 (16.1%) indicated they did not know how far down the head the eyes were positioned, 2 (6.5%) provided a qualitative description of where the eyes were vertically positioned ("close to the ears" and "the top of the head"), 14 (45.2%) provided responses in terms of how many inches down the head the eyes are positioned (M = 3.25 in., SD = 1.11), and 10 (32.3%) provided responses in terms of how far down the head the eyes are positioned as a proportion of the entire length of the head (M = 32.3% down the length of the head, SD = 6.3%). Thus, responses of these participants in the nonknowledge condition reflect that they had not acquired the schematic knowledge that the eyes are positioned approximately half-way down the head. Indeed, the 10 participants who provided proportional responses mistakenly believed that the eyes were positioned farther up the head than they actually are on average.

We also checked to make sure that participants assigned to the knowledge condition had acquired and retained the schematic knowledge provided at the start of the session. If participants failed to indicate that the eyes were positioned approximately half-way down the head, their data were discarded before analysis; this was the case with 9 (23.8%) participants assigned to this condition. In total, this screening process yielded 30 participants in the knowledge condition (23 females, 7 males) and 31 participants in the nonknowledge condition (21 females, 10 males). Participants assigned to these two conditions did not significantly differ with respect to age, $t(59) = 1.40$, $p = .16$, self-perceived drawing ability, $t(59) = 0.13$, $p = .90$, or self-reported hours per week spent drawing, $t(59) = 0.43$, $p = .67$.

Vertical line bisection task. After completing the questionnaire, participants were told that they would perform a task to determine how accurately they were able to divide vertical lines in half. Participants were provided the first sheet of paper containing two vertical lines and were told to make a small horizontal line at the precise midpoint of each vertical line. For each line, participants were allowed to erase and modify their marking as often as they wished but could not go back and modify previous markings. The experimenter provided the six sheets of paper one at a time. No time limit was imposed.

Data Analysis

Model faces. Five measurements (A through E) were made of the model faces in cm, as illustrated in Figure 2. A was a measurement of the length of the head, measured as the vertical distance between the peak of the top of the head and the bottom of the lowest portion of the chin. B was a measurement of the vertical distance between the top of the head and the midpoint of the horizontal eye-line that intersected the pupils. C was a measurement of the vertical distance between the top of the head and the



Spatial Relation Ratios

Ratio	Interpretation	Model Value
B/A	Vertical Position of Eyes Down the Length of the Head	0.47
C/A	Vertical Position of Nose Down the Length of the Head	0.69
D/A	Vertical Position of Mouth Down the Length of the Head	0.80
E/A	Vertical Position of the Hair Line Down the Length of the Head	0.21

Figure 2. Depiction of the method used to measure and compute the spatial relation ratio values of the model and drawings. See the online article for the color version of this figure.

lowest portion of the nose. *D* was a measurement of the vertical distance between the top of the head and the space between the upper and lower lips of the mouth. *E*, only measured for the model with hair, was a measurement of the vertical distance between the top of the head and the lowest point of the hairline.

From these measurements, four spatial relation ratios were computed. *B/A* was a measure of the vertical position of the eyes relative to the height of the head (model value = 0.47). *C/A* was a measure of the vertical position of the nose relative to the height of the head (model value = 0.69). *D/A* was a measure of the vertical position of the mouth relative to the height of the head (model value = 0.80). *E/A* was a measure of the vertical position of the lowest point of the scalp-line relative to the height of the head (model value = 0.21).

Free-hand drawing task. The same four measurements (A through D) and three spatial relation ratios (B/A, C/A, and D/A) were measured and computed for each of the free-hand drawings. For drawings of the model with hair, measurement of *E* was made and the spatial relation ratio *E/A* was calculated. On the basis of these spatial relation ratios, eye, nose, mouth, and scalp-line *drawing* errors were calculated as

$$\text{Drawing Error} = \text{Drawing Ratio Value} - \text{Model Ratio Value}$$

Calculated in this way, positive error values indicate that a feature was drawn too far down the head, and negative error values indicate that a feature was drawn too far up the head, relative to their position in the model.

Eye-drawing task. The B measurement was made for each eye-drawing, which allowed for calculation of the B/A ratio. Errors in drawing the vertical position of the eyes were calculated in the same way as in the free-hand drawings.

Vertical line bisection task. For each line bisection, a measurement of the vertical distance between the top of the line and the horizontal marking made by the participants was made in cm. A bisection ratio was computed by dividing this measurement by the full height of the vertical line (14.45 cm) to compute the vertical positioning of the bisection relative to the height of the vertical line. Bisection errors (the degree to which participants erred in dividing the line in half) were calculated as

$$\text{Bisection Error} = \text{Bisection Ratio} - 0.5$$

Calculated this way, positive error values indicate that the line was bisected below the midpoint; negative error values indicate that the line was bisected above the midpoint. Because bisection errors did not significantly vary across the 12 bisection trials (or no practice effects were observed), $F(11, 671) = 1.08$, $p = .38$, the 12 bisection error values were averaged for each participant, resulting in one mean bisection error value per participant, which was used in the data analysis.

Results

Table 1 shows descriptive statistics pertaining to the spatial relation ratio values and errors of the drawings. Results are organized as follows. First, we report analyses that aim to determine whether the errors made in the drawing and vertical line bisection tasks were systematically biased in a single direction or whether they are randomly distributed around zero error. These analyses seek to replicate previously reported effects indicating that (a) some errors nonartists make when drawing the spatial relationships between facial features are systematically biased in a single direction for drawings made from both observation and memory (McManus et al., 2012; Ostrofsky, 2015a, 2015b; Ostrofsky et al., 2014), and (b) individuals experience a systematic upward bias in bisecting vertical lines (Chieffi, 1996; Drain & Reuter-Lorenz, 1996; McCourt & Olafson, 1997; Post, O'Malley, Yeh, & Bethel, 2006; van Vugt et al., 2000). Second, we report analyses seeking to determine whether the vertical positioning of facial features is affected by (a) knowledge of the canonical vertical positioning of the eyes and (b) the presence versus absence of hair in the face model being drawn in both drawing tasks. Finally, we report analyses that aim to determine whether eye-drawing errors in the two drawing tasks are reliably related to vertical line bisection errors.

Table 1
Means and Standard Deviations of Spatial Relation Ratio Values and Drawing Errors of the Vertical Positioning of Facial Features

Condition	Knowledge		Nonknowledge	
Model Stimulus	Hair	Bald	Hair	Bald
	Free-hand drawing task			
Ratio value				
Hair Line	.216 (.039)		.209 (.033)	
Eyes	.453 (.036)	.441 (.033)	.441 (.036)	.409 (.040)
Nose	.678 (.045)	.667 (.036)	.676 (.032)	.653 (.036)
Mouth	.802 (.034)	.804 (.033)	.810 (.028)	.796 (.033)
Error				
Hair Line	.004 (.039)		−.003 (.033)	
Eyes	−.017 (.036)	−.029 (.033)	−.029 (.036)	−.061 (.040)
Nose	−.012 (.045)	−.023 (.036)	−.014 (.032)	−.037 (.036)
Mouth	.002 (.034)	.004 (.033)	.010 (.028)	−.004 (.033)
	Eye-drawing task			
Ratio value				
Eyes	.422 (.035)	.427 (.036)	.376 (.030)	.385 (.029)
Error				
Eyes	−.048 (.035)	−.043 (.036)	−.094 (.030)	−.085 (.029)

Note. Errors = Drawing Ratio Value − Model Ratio Value. Negative errors indicate that the vertical position of the feature was drawn farther up the head than it was in the model.

Systematic Versus Random Error Biases in the Drawings and Vertical Line Bisection Tasks

Free-hand drawing task. To determine whether errors in drawing the vertical positioning of the eyes, nose, mouth, and hairline are systematically biased in a single direction or whether they are random, we conducted single-sample *t* tests comparing the drawing errors against a test value of zero error. If drawing errors are systematically biased in a single direction, then the mean drawing error values should be reliably greater than 0 (if the features are positioned too low) or less than 0 (if the features are positioned too high). However, if the direction of error is random across participants, then the mean drawing error values should not be reliably different than 0. Seven *t* tests were conducted for each group, and therefore, we adopted a Bonferroni-corrected $\alpha = .007$ for each test.

The results of these analyses, including effect sizes, are shown in Table 2. With respect to the vertical positioning of the eyes, participants in both the knowledge and nonknowledge groups showed a bias to draw the eyes too far up the head when drawing the model both with and without hair. These biases were significant at the .007 α level, except for the knowledge group's drawing of the model with hair (however, $p < .05$).

With respect to the vertical positioning of the nose, participants in the knowledge and nonknowledge groups showed a bias to draw the nose too high up the head when drawing the bald model. However, when drawing the hair model, participants in both groups did not exhibit such a bias at the .007 α level (although the nonknowledge group exhibited an upward bias at the .05 α level; $p > .05$ in the drawings of the knowledge group).

With respect to the vertical positioning of the mouth and the lowest point of the hairline, neither the knowledge nor nonknowledge group was systematically biased to draw either feature too far up or too far down the head in their drawings. Further, the knowledge and nonknowledge group did not significantly differ from each other with respect to their average vertical placement of the hairline, $t(59) = 0.75$, $p > .05$, Cohen's $d = 0.19$.

Next, we wished to determine if there was a predictive relationship between how far up or down the eyes were drawn and how far up and down the other facial features (hairline, nose and mouth) were drawn. In order to assess this, we computed Pearson r correlation coefficients to assess the relationship between the values of these spatial relation ratios. Five correlation coefficients were conducted for each group, and we therefore adopted a Bonferroni-corrected $\alpha = .01$ for each test.

Table 3 shows the results of these analyses. In the knowledge group, the vertical positioning of the eyes was reliably positively correlated with the vertical position of the hairline, nose, and mouth in drawings of both the models with and without hair. For participants in the nonknowledge group, the vertical positioning of the eyes was similarly correlated with the vertical position of the hairline and nose in drawings of both the models with and without hair. However, these participants did not evince a reliable relationship between their vertical positioning of the eyes and mouth in their drawings of the models with and without hair at the .01 α level (though drawings of the bald model showed a positive correlation reliable at the .05 α level).

Table 2
Free-Hand Drawing Task: Results of Single-Sample t Tests That Compared the Distributions of Vertical Drawing Errors to a Test Value of 0 (No Error)

Model stimulus	Knowledge ($df = 29$) Hair	Knowledge ($df = 29$) Bald	Nonknowledge ($df = 30$) Hair	Nonknowledge ($df = 30$) Bald
Hairline	.57 (.10)		−.48 (.09)	
Eyes	−2.62* (.48)	−4.93[a] (.90)	−4.51[a] (.81)	−8.46[a] (1.52)
Nose	−1.44 (.26)	−3.46* (.63)	−2.38* (.43)	−5.66[a] (1.01)
Mouth	.34 (.06)	.58 (.10)	1.98 (.35)	−.70 (.13)

Note. *T*-test ratio values are presented along with Cohen's d effect size measure in parentheses. Significantly negative t-test ratio values indicate an average bias to draw the feature higher than it appeared in the model. Significantly positive t-test ratio values indicate an average bias to draw the feature lower than it appeared in the model.
[a] $p < .007$ (Bonferonni corrected α-level).
* $p < .05$.

Table 3
Free-Hand Drawing Task: Pearson Correlation Coefficients Assessing the Relationships of the Vertical Positioning of the Eyes With the Vertical Positioning of the Hairline, Nose, and Mouth

Model stimulus	Knowledge ($df = 28$) Hair	Knowledge ($df = 28$) Bald	Nonknowledge ($df = 29$) Hair	Nonknowledge ($df = 29$) Bald
Eyes/Hairline	.67[a]		.60[a]	
Eyes/Nose	.66[a]	.63[a]	.60[a]	.74[a]
Eyes/Mouth	.49[a]	.46[a]	.31	.45*

Note. Pearson correlation coefficients were calculated on the basis of the values of the eyes, hairline, nose, and mouth spatial relation ratios that quantified the relative vertical positioning of these features.
[a] $p < .01$ (Bonferonni corrected α-level).
* $p < .05$.

Eye-drawing task. To test for a bias in drawing the vertical position of the eyes in the eye-drawing task, we conducted single-sample t tests comparing the distribution of eye-drawing errors against a test value of zero error. Two t tests were conducted for each group, and we therefore adopted a Bonferroni-corrected $\alpha = .025$ for each test. Results are presented in Table 4 and demonstrate that participants in both the knowledge and nonknowledge groups drew the eyes higher up the head than it appeared in the model for both the models with and without hair.

Vertical line bisection task. To test for a bias in the vertical line bisection task, we conducted a single-sample t test comparing the distribution of bisection errors against a test value of zero error. We observed a systematic upward bias in the attempts to divide the vertical line in half by participants in the knowledge condition, $t(29) = -6.69$, $p < .001$, Cohen's $d = 1.22$, and in the nonknowledge condition, $t(30) = -4.52$, $p < .001$, Cohen's $d = 0.81$. Further, bisection errors did not reliably differ between participants in the two conditions, $t(59) = 0.11$, $p = .94$, Cohen's $d = 0.11$. This latter observation is important to note in light of the fact that the knowledge manipulation was always conducted before the vertical line bisection task. The lack of an intergroup difference in bisection errors indicates that the knowledge manipulation had no effect on vertical line bisection performance.

Table 4
Eye-Drawing Task: Results of Single-Sample T-Tests That Compared the Distributions of Vertical Eye Drawing Errors to a Test Value of 0 (No Error)

Model stimulus	Knowledge ($df = 29$) Hair	Knowledge ($df = 29$) Bald	Nonknowledge ($df = 30$) Hair	Nonknowledge ($df = 30$) Bald
Eyes	−7.50[a] (1.37)	−6.52[a] (1.19)	−17.38[a] (3.12)	−16.50[a] (2.96)

Note. *T*-test ratio values are presented along with Cohen's d effect size measure in parentheses. Significantly negative t-test ratio values indicate an average bias to draw the eyes higher up the head than it appeared in the model.
[a] $p < .025$ (Bonferonni corrected α-level).

Effects of Knowledge and Presence Versus Absence of Hair on Spatial Drawing Errors

Free-hand drawing task. To determine whether schematic knowledge of the vertical position of the eyes on a head and the presence versus absence of hair affects errors in the drawing of the vertical position of the eyes, a 2 (knowledge: knowledge vs. nonknowledge Conditions) × 2 (model stimulus: with hair vs. bald) analysis of variance (ANOVA) was conducted. We found a main effect of model stimulus, $F(1, 59) = 23.02$, $p < .001$, partial $\eta^2 = .28$, indicating that, overall, participants' errors in drawing the vertical position of the eyes was larger when drawing the bald model than when drawing the model with hair. Further, there was a main effect of knowledge, $F(1, 59) = 7.31$, $p < .01$, partial $\eta^2 = .11$, indicating that, overall, participants in the knowledge condition erred less in drawing the vertical position of the eyes than participants in the nonknowledge condition. However, there was a significant Knowledge × Model Stimulus interaction, $F(1, 59) = 4.75$, $p < .05$, partial $\eta^2 = .08$. Simple effects analyses indicated that, while participants in both the knowledge and nonknowledge conditions tended to produce smaller errors when drawing the model with hair compared to the bald model, this effect was only reliable for participants in the nonknowledge condition, $F(1, 59) = 16.00$, $p < .001$, partial $\eta^2 = 0.29$, but not for participants in the knowledge condition, $F(1, 59) = 2.00$, $p = .16$, partial $\eta^2 = .05$.

Although the manipulation of knowledge between the two groups of participants exclusively pertained to the vertical positioning of the eyes, it would also be interesting to determine if such knowledge affects the vertical spatial positioning of other facial features, like the nose and mouth. Further, previous research (Clare, 1983) has investigated how the presence versus absence of hair affects the drawing of the vertical positioning of the eyes, but it is currently unknown if that also affects the drawing of the vertical position of the nose and mouth. Therefore, to explore this issue, two 2 (knowledge) × 2 (model stimulus) ANOVAs were conducted, one testing for effects on nose drawing errors and one testing for effects on mouth drawing errors.

For nose drawing errors, we observed a main effect of Model Stimulus, $F(1, 59) = 13.38$, $p < .01$, partial $\eta^2 = .19$, indicating that, as with eyes, participants made larger errors when drawing the bald model versus the model with hair. We did not observe a main effect of Knowledge, $F(1, 59) = 0.91$, $p = .34$, partial $\eta^2 = .02$, nor a Knowledge × Model Stimulus interaction, $F(1, 59) = 1.81$, $p = .18$, partial $\eta^2 = .03$.

For mouth drawing errors, we did not observe a main effect of model stimulus, $F(1, 59) = 2.74$, $p = .10$, partial $\eta^2 = .04$, nor a main effect of knowledge, $F(1, 59) = 0.00$, $p = .99$, partial $\eta^2 = .00$. However, we did observe a reliable Knowledge × Model Stimulus interaction, $F(1, 59) = 4.09$, $p < .05$, partial $\eta^2 = .07$. Simple effects analyses indicated that, for participants in the nonknowledge condition, there was a reliable difference in the errors made when drawing the models with and without hair, $F(1, 59) = 7.50$, $p < .01$, partial $\eta^2 = .10$. Specifically, when drawing the model with hair, participants drew the mouth too far up the head, versus too far down the head when drawing the bald model. In contrast, errors in drawing the vertical position of the mouth produced by participants in the knowledge condition did not reliably differ between the two models, $F(1, 59) = 0.08$, $p = .78$, partial $\eta^2 = .00$.

Eye-drawing task. We conducted a 2 (knowledge condition) × 2 (model stimulus) ANOVA testing for effects on errors in drawing the vertical position of the eyes in the eye-drawing task. We observed a main effect of model stimulus, $F(1, 59) = 4.37$, $p < .05$, partial $\eta^2 = .07$. Interestingly, unlike the pattern of eye-drawing errors in the free-hand drawing task, this main effect indicated that errors in drawing the vertical position of the eyes were smaller in drawings of the bald model compared to drawings of the model with hair, replicating the pattern reported by Clare (1983) who administered the same type of drawing task. We additionally observed a main effect of knowledge, $F(1, 59) = 32.66$, $p < .001$, partial $\eta^2 = .36$, indicating that participants in the knowledge condition produced smaller errors than those in the nonknowledge condition when drawing the vertical position of the eyes. Unlike what was observed in the free-hand drawing task, we did not observe a Knowledge × Model Stimulus interaction, $F(1, 59) = 0.40$, $p = .53$, partial $\eta^2 = .01$.

Relation Between Errors in Drawing the Vertical Position of the Eyes and Vertical Line Bisection Errors

To determine whether there was a covarying relationship between participants' errors in drawing the vertical position of the eyes and in their attempts to divide vertical lines in half, we calculated Pearson r correlation coefficients between these two types of errors.

Free-hand drawing task. For participants in the knowledge condition, there was a significant positive correlation between their mean bisection errors and errors in drawing the vertical position of the eyes for both drawings of the model with hair, $r(28) = .58$, $p < .01$, and drawings of the bald model, $r(28) = .52$, $p < .01$. In contrast, for participants in the nonknowledge condition, mean bisection errors and errors in drawing the vertical position of the eyes were not significantly correlated for both drawings of the model with hair, $r(29) = .14$, $p = .44$, and drawings of the bald model, $r(29) = -.12$, $p = .52$.

Tests were conducted using Fisher's z transformation method to compare the correlation coefficients between participants in the knowledge and nonknowledge conditions. The correlation between bisection errors and eye-drawing errors was significantly different between participants in the knowledge and nonknowledge conditions for both the drawings of the model with hair, $z = 1.93$, $p = .05$, and for the drawings of the bald model, $z = 2.43$, $p < .05$.

Eye-drawing task. For participants in the knowledge condition, there was a significant positive correlation between their mean bisection errors and errors in drawing the vertical position of the eyes with respect to the drawings of the model with hair, $r(28) = .42$, $p < .05$, but not with respect to the drawings of the bald model, $r(28) = .24$, $p = .20$. For participants in the nonknowledge condition, mean bisection errors and errors in drawing the vertical position of the eyes were not significantly correlated for both drawings of the model with hair, $r(29) = .00$, $p = .99$, and drawings of the bald model, $r(29) = .13$, $p = .48$.

These correlations did not significantly differ between participants in the knowledge and nonknowledge conditions for both the drawings of the model with hair, $z = 1.65$, $p = .10$, and the drawings of the bald model, $z = 0.42$, $p = .67$.

Discussion

The present study provided evidence that multiple psychological factors are interactively associated with the production of errors in drawing the vertical position of the eyes along the length of the head.

Effects of Knowledge on Vertical Drawing Errors of the Eyes, Nose, and Mouth

Participants who were provided instruction that the eyes were positioned approximately half-way down the head drew the vertical position of the eyes with smaller errors than did participants who were not provided with such instruction in both drawing tasks. This suggests that one reason why individuals produce errors in an observational drawing task is that they do not have accurate knowledge of the structure of the objects they are drawing. Further, such findings are inconsistent with psychological theories that assume canonical knowledge is exclusively a source of interference to be overcome in the development of drawing skill (Edwards, 2012; Fry, 1919/1960; Glazek, 2012; Ruskin, 1857/1971). The demonstration of facilitating effects of knowledge on drawing performance suggests that drawing skill is developed in association with the acquisition of schematic knowledge that (a) accurately represents the visual appearance and structure of common objects and (b) is more sophisticated than "object-centered" knowledge useful for the purposes of "everyday" object recognition purposes but not useful for the purpose of producing high-quality observational drawings.

With respect to the free-hand drawing task, we also found that knowledge of the canonical vertical positioning of the eyes had selective effects on particular face-drawing errors. Specifically, although knowledge about the vertical spatial positioning of the eyes had an effect on vertical eye-drawing errors, this knowledge did not have an effect on vertical nose and mouth drawing errors. Thus, the effects of knowledge observed in this experiment indicate that the effects of at least some forms of drawing-relevant knowledge on drawing performance are object specific, feature specific, or both. One aspect of drawing skill development may involve acquiring a large, complex set of schematic knowledge that contains representations of the canonical structure of individual objects or individual features within a given object (Gombrich, 1960; Kozbelt & Seeley, 2007). This idea is consistent with instructional strategies adopted by "how-to" drawing manuals (e.g., Edwards, 2012; Hamm, 1963; Hogarth, 2002; Kraavanger, 2005; Okabayashi, 2009). Such manuals provide explicit information about how to accurately draw specific types of objects and the various features found within those objects, including descriptions of the canonical spatial relationships between features found within an object.

Causes of the Directional Bias to Draw the Eyes Too Far Up the Head

Although knowledge of the canonical vertical position of the eyes had the effect of reducing vertical eye-drawing errors, this knowledge did not completely eliminate the bias. Indeed, the majority of participants in both the knowledge and nonknowledge conditions in both drawing tasks still drew the eyes too far up the head. Thus, with respect to explaining eye-drawing errors, explicit schematic knowledge appears mainly to affect the magnitude, rather than the presence and direction, of the errors.

Our results provide clues pertaining to the cause of this directional error bias. Interestingly, they suggest that the mechanism producing upward eye-drawing errors differs between individuals with versus without knowledge about the canonical vertical positioning of the eyes. In the free-hand drawing task, the presence versus absence of hair on the face models had an effect on eye-drawing errors for participants in the nonknowledge condition. Specifically, smaller eye-drawing errors were made when drawing the model with hair than when drawing the bald model (the effect was found to reverse in the eye-drawing task, an issue discussed subsequently). However, the presence versus absence of hair did not reliably affect eye-drawing errors for participants in the knowledge condition. Another difference between participants in the knowledge and nonknowledge conditions concerned the relationship between the magnitude of errors in vertically positioning the eyes and bisecting vertical lines. Even though 96% of all participants experienced an upward line bisection bias that did not reliably differ in magnitude between the knowledge and nonknowledge groups, the eye-drawing and line bisection errors were positively correlated for participants in the knowledge, but not in the nonknowledge, condition (especially with respect to performance in the free-hand drawing task, less so with respect to the eye-drawing task). Thus, at least with respect to performance in the free-hand drawing task, one may speculate that the bias to draw the eyes too far up the head is related to perceptual attenuations of the forehead for individuals in the nonknowledge condition. Alternatively, the mechanism producing upward eye-drawing biases may be related to the attentional processes responsible for altitudinal pseudoneglect for individuals in the knowledge condition. These two hypotheses are discussed in more detail in the following text.

Perceptual attenuation of the forehead. Eye-tracking research has demonstrated that, when perceiving a face, individuals spontaneously dedicate less attention to the forehead region than regions containing salient features such as the eyes (Heisz & Shore, 2008; Nguyen, Isaacowitz, & Rubin, 2009). This relative inattention to the forehead region may be adaptive for face recognition purposes, as greater visual attention to the forehead region has been found to be associated with a weaker ability to recognize faces (Corrow, Donlon, Mathison, Adamson, & Yonas, 2013). However, for observational drawing, accurate perceptual encoding of the spatial extent of the forehead region is important in order to accurately reproduce the spatial configuration of the features within a face. As hypothesized by Edwards (2012), one potential drawing-related consequence of inattention to the forehead region may be an attenuation of the reproduced length of the forehead. If this is the case, we can understand why, in the free-hand drawing task, the vertical position of the eyes was drawn farther up the face when drawing the bald model than when drawing the model with hair. After reproducing the hairline when drawing the model with hair (which was not systematically drawn too far up or down the head), there is less forehead leftover to attenuate than when drawing the bald model. This would result in the vertical position of the eye line to be reproduced with less error when drawing the model with hair compared to when drawing the bald model. When drawing the bald model, the absence of the hair line creates a larger forehead region to ignore and attenuate, resulting in the eyes being drawn even farther up the head in the bald model than in the model with hair.

Participants in the knowledge condition did not significantly differ with respect to the drawn vertical position of the eyes between when drawing the bald and nonbald models. This interaction between knowledge and the presence versus absence of hair cannot be accounted for by potential differences in how the hairline was drawn between the two groups, as the drawn vertical position of the hairline did not differ between participants in the knowledge and nonknowledge conditions. This suggests that the reason individuals in the knowledge condition drew the eyes too far up the head was not related to inattention and perceptual attenuation of the forehead region.

Altitudinal pseudoneglect. The finding that vertical line bisection errors were positively correlated with vertical eye-drawing errors for participants in the knowledge condition demonstrates that there is a relationship between the mechanisms responsible for altitudinal pseudoneglect and the bias to draw the eyes too far up the head when one has acquired the schematic knowledge of the spatial positioning of the eyes. Upward biases in vertical line bisection tasks have been theorized to be caused by asymmetries in how attention is deployed between the upper and lower visual fields, with greater attention deployed to the upper than lower visual field (e.g., McCourt & Olafson, 1997). Although one cannot confidently make causal interpretations of correlational results, one may speculate that when participants acquire and attempt to use the knowledge for drawing purposes that the eyes are positioned approximately half-way down the head, their errors in drawing the eyes too far up the head may be caused by pseudoneglect of the lower visual field that contains the lower portion of the face. This would result in the consequence of drawing the eyes too far up the head just as pseudoneglect of the lower visual field causes upward biases in vertical line bisections.

The magnitude of bisection and vertical eye-drawing errors were not significantly correlated for participants assigned to the nonknowledge condition. Therefore, it appears that altitudinal pseudoneglect is only related to eye-drawing errors when individuals have the knowledge that the eyes are positioned approximately half-way down the face. Before acquiring the knowledge that the eyes are positioned approximately half-way down the head, drawing the eyes too far up the head is an error that does not appear to be related to attentional processes responsible for altitudinal pseudoneglect.

Thus, even though both participants in the knowledge and nonknowledge conditions both experienced the systematic bias to draw the eyes too far up the head, the underlying basis of the bias appears to differ between individuals who do versus do not possess schematic knowledge that the eyes are positioned approximately half way down the face. Beyond such knowledge reducing the magnitude of vertical eye-drawing errors, it has the additional effect of altering the attentional processes that guide the perceptual encoding of faces for the purposes of drawing the vertical position of the eyes.

Differences Between the Free-Hand Drawing and Eye-Drawing Tasks

Clare (1983) was the first, and to our knowledge the only, other study that assessed the effects that the presence versus absence of hair have on errors in drawing the vertical position of the eyes. Using what has been termed the eye-drawing task here, Clare (1983) observed that errors were larger when children drew the model with hair compared to when they drew the model without hair. In the eye-drawing task, we replicated this effect, with the novel findings that this effect is also observed (a) in adults and (b) when using a repeated-measures design (Clare used a between-subjects design). Clare (1983) explained this effect as occurring due to a perceptual illusion where, when hair is present on a face model, individuals experience an illusion that the scalp-line is the top of the head, and thus, perceive the eyes as being closer to the top of the head than they actually are.

However, the effect of the presence versus absence of hair was reversed in direction when analyzing the drawings produced in the free-hand drawing task as described above. Presently, it is unclear as to why the effect of the presence versus absence of hair on vertical eye-drawing errors reverses in direction between the two drawing tasks. There are clear differences in the task demands of the two drawing tasks that could potentially be related to this discrepancy. For instance, in the eye-drawing task, participants are instructed to solely attend to the task of drawing the accurate positioning of the eyes, whereas in the free-hand drawing task, participants are instructed to attend to the task of drawing all features found in the model. Attending to drawing all of the features in the free-hand drawing task might affect how the vertical position of the eyes is drawn. This idea is supported by our findings that, in the free-hand drawings, the drawn vertical position of the eyes was positively correlated with the drawn vertical position of the nose, mouth, and scalp-line.

Some have argued that the production of drawings is guided by graphic motor schemas (e.g., Phillips, Hobbs, & Pratt, 1978). Such graphic motor schemas are conceptualized as a motor program stored in long-term memory that represents the sequence of marks to be produced when creating a depiction of a common object. In support of this theory, research has demonstrated that the drawing of different object-categories is associated with different stereotyped mark-making sequences during production (Van Sommers, 1984; Vinter, 1999). It is possible that the different task demands of the free-hand and eye-drawing tasks caused different graphic motor schemas to be activated when the participants produced their drawing. For instance, the free-hand drawing task may have caused participants to activate a global motor program that represents the sequence of marks to be made when drawing a full face that was not activated during the eye-drawing task.

Vinter and Marot (2007) observed that older children and adults sequentially approach the act of drawing by first drawing an outline of the global structure of a multi-featured model object and then later proceed to depict the appearance of individual, local elements. This so-called part-whole integration strategy may have guided the approach participants used when producing the free-hand drawings. For instance, participants may have first approached these drawings by initially framing the structure of the face (drawing the shape of the head and producing simple marks that represented the spatial positioning of the eyes, nose, and mouth) and then later attended to the task of depicting the detailed appearance of the individual, local facial features. Because the relative spatial positioning of all the facial features would have been constrained by the limited amount of space available in the enclosed shape of the head, this global approach may have caused the positioning of some internal features to be directly affected by the positioning of other drawn internal features. For instance, in the free-hand drawing task, the demand of having to draw the scalp-line in the nonbald model may have been the cause as to why participants positioned the eyes, nose and (to a lesser extent) the mouth farther down the head than when this demand was absent in the bald model.

Because the eye-drawing task did not require participants to draw the entire face, a motor program representing the sequence of marks to be made to produce a drawing of a full face was not likely to have been activated and used by participants in this drawing task. Because graphic motor schemas have been theorized to affect how individuals visually process and attend to a model that is being drawn (Kozbelt & Seely, 2007), the absence of such a full-face motor program may have altered how participants attended to and processed the vertical eye position of the model face in the eye-drawing task relative to the free-hand drawing task. For instance, the spatial position of the eyes may have been processed relative to its perceived vertical distance from the top of the head. This may explain why, overall, the eyes were positioned higher up the head in the eye-drawing task than in the free-hand drawing task (with respect to the drawings of both models produced by both groups of participants). If this were the case, Clare's (1983) hypothesis that individuals mistakenly perceive the scalp-line as the top of the head could have caused the eyes to be positioned farther up the head when the model had hair compared to when the model was bald.

Unfortunately, we did not observe and record the participants' sequential approach to creating the drawings that were analyzed in this study. Thus, we are not in a position to evaluate the speculative hypotheses described in the previous three paragraphs. Nevertheless, the discrepancy between the effects found between the eye-drawing and free-hand drawing tasks raises questions about the utility of using such an eye-drawing task to understand natural face drawing performance. Natural face-drawing does not seem to be a behavior that is supported by processing the spatial positioning of individual features in isolation of each other. Rather, drawing the spatial positioning of individual features appears to be supported by processing the configuration of features relative to one another, consistent with the idea that faces are perceptually processed in a holistic fashion (e.g., Farah, Wilson, Drain, & Tanaka, 1998).

Conclusion

The present study demonstrated that knowledge is an important factor in explaining individual variability in observational drawing performance. Here, we provided evidence that not only does knowledge have an impact on the accuracy of a drawing, but it also influences how perceptual and attentional processes guide the reproduction of a model. Such findings add to the growing body of empirical evidence that highlights the role of various top-down processes guiding the task of copying a directly perceivable model in an observational drawing task. Besides schematic knowledge, drawing performance seems to be guided by top-down processes such as (a) decision-making processes that guide the visual selection of what visual information to include versus exclude from a drawing (Biederman & Kim, 2008; Kozbelt, Seidel, ElBassiouny, Mark, & Owen, 2010; Ostrofsky et al., 2012), (b) canonical long-term memories representing the graphical structure of familiar objects (Matthews & Adams, 2008; Ostrofsky, 2015b), and (c) strategies pertaining to the gaze shift between the model and emerging drawing (Cohen, 2005; Tchalenko, 2009). Thus, in addition to the direct perceptual encoding of visual information inherent in the specific model being reproduced, the production of observational drawings is a complex behavior supported by the processing of cognitive representations established before a particular drawing task has been initiated, drawing-relevant knowledge being just one example.

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Received August 6, 2014
Revision received January 28, 2016
Accepted April 5, 2016 ■