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Temporal- and Orientation-Based Properties of the Relationship Between Imagination- and Observation-Based Face Drawings

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Individual variability in how some spatial relationships are depicted in imagination-based drawings reliably predicts how they are reproduced in observation-based drawings. This suggests that when producing observation-based drawings, a long-term memory representing how to draw an object influences drawing in addition to the perception of the visual information apparent in the model. This article reports studies that aim to determine the temporal- and orientation-based properties of this predictive relationship. In 3 studies, participants created an imagination-based face drawing followed by creating observation-based face drawings. Drawings were measured based on how spatial relationships between features were depicted. In Study 1, observation-based drawings were produced approximately 1.5 months after producing imagination-based drawings. We observed significant and positive correlations between the two types of drawings with respect to how spatial relationships between features were depicted, indicating that long-term memory (as opposed to short-term memory) underlies the predictive relationship between the two types of drawings. In Studies 2 and 3, after producing an upright-oriented imagination-based drawing, participants produced observation-based drawings of an upright model and a rotated model (Study 2: upside down; Study 3: sideways). We observed that depictions of some of the spatial relationships between features in the imagination-based drawings were significantly and positively correlated with how they were reproduced in both the upright and rotated observation-based drawings. This indicates that the relationship between imagination- and observation-based drawings is not dependent on the drawings being produced in the same orientation (with respect to some spatial relationships).

Keywords: face drawing, long-term memory, memory drawing, observational drawing, realistic drawing

Observational drawing (referred to as "drawing" for the remainder of this article unless stated otherwise) is the behavior where an individual reproduces the appearance of a model object or scene that they perceive while drawing. Individual variability in quality is an established characteristic of such drawings (Chamberlain & Wagemans, 2016). Some individuals (e.g., trained artists) are skilled in creating a recognizable reproduction of a model while others (e.g., individuals without extensive practice in drawing) struggle to do so. Another aspect of individual variability characterizing this behavior relates to situations where multiple individuals create a drawing based a single, standardized model (e.g., a sample of individuals create a drawing based on a photograph of a single face). In such situations, the appearance of the drawings varies across individuals even though all the drawings were based on a standard model. This extends beyond the observation that some drawings are of higher quality than others; even in situations where individuals of comparable skill produce drawings of a standard model, variability in the drawings' final appearance have been observed (e.g., Ostrofsky et al., 2012).

The novel studies reported here are part of a larger research effort that aims to determine the factors that predict individual variability in the final appearance of drawings. A common theme of such research is the idea that individual variability in drawing performance is largely predicted by individual differences in how visual information apparent in the model is processed during drawing production (e.g., Chamberlain et al., 2019; Chamberlain & Wagemans, 2015; Cohen, 2005; Mitchell et al., 2005; Ostrofsky et al., 2015; Ostrofsky, Kozbelt, Cohen, et al., 2016; Ostrofsky et al., 2012; Perdreau & Cavanagh, 2014; Tchalenko, 2009). Although this is a noncontroversial idea that is supported by empirical evidence, other research indicates that this general perspective is incomplete. Research has established that variability in memory-based information acquired before an individual begins the act of drawing also predicts individual differences in the final appearance of drawings (Ostrofsky et al., 2015; Ostrofsky, Kozbelt, Tumminia, et al., 2016; Ostrofsky et al., 2017).

One line of empirical evidence supporting this idea comes from demonstrations that manipulating what an individual knows about the canonical appearance of common objects directly affects the appearance of drawings they later create (Ostrofsky, Kozbelt,

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Tumminia, et al., 2016). For instance, providing an individual the knowledge that the eyes on a human face are positioned approximately half-way down the head causes them later to draw the vertical position of the eyes more accurately compared to an individual not provided this knowledge. Another line of evidence supporting this idea comes from research assessing drawings of ambiguous figures (Allen & Chambers, 2011; Carmichael et al., 1932; Eberhardt et al., 2003; Ostrofsky et al., 2017; Sommers, 1984; Vinter, 1999). This research has demonstrated that manipulations of how an ambiguous figure's identity is interpreted causes individuals to later draw the figure to look more like the object they interpreted the figure's identity to be.

The final line of evidence to be discussed here that supports this memory-based account of drawing performance, and the one most relevant to the novel studies reported here, comes from studies that have investigated the predictive relationship between imagination- and observation-based drawings (Harrison et al., 2017; Matthews & Adams, 2008; Ostrofsky et al., 2015). Here, imagination-based drawings refer to drawings of an object that are produced from memory and are created in the absence of a model to be perceived and reproduced. An assumption of this research is that the production of imagination-based drawings is based, at least partially, on individuals' long-term graphic memories that represent how to draw common objects. The major question these studies addressed was whether individual differences in the appearance of imagination-based drawings predicted individual variability in observation-based drawings under the Condition that both types of drawings represented the same object category (object categories that have been used in these studies include faces of humans and cats, houses and cylinders). The method of these studies was generally the same: first, individuals were instructed to create an imagination-based drawing of a specific type of object, and afterward, were exposed to and asked to reproduce in an observation-based drawing a standard model representing the same type of object the imagination-based drawings depicted. Both types of drawings were then measured according to how multiple spatial relationships between features were depicted. The analyses in these studies determined whether there was a predictive relationship between the appearance of the imagination- and observation-based drawings with respect to the depictions of these spatial relationships.

In these studies, many of the spatial relationships measured were found to be positively correlated between the two types of drawings. These results have been interpreted to suggest that the production of observation-based drawings is partially guided by graphic-based information stored in long-term memory in addition to the visual information directly perceived in the reproduced model. When an individual is tasked with creating an observation-based drawing of a model representing a commonly drawn object, a long-term memory of how to draw that type of object is thought to be activated and partially biases the production of the drawing. Further, because individual variability in the appearance of the imagination-based drawings was observed across all studies, this suggests that graphic long-term memories are idiosyncratic, and thus, partially explains individual variability in the appearance of observation-based drawings, even under conditions when all participants draw a single, standard model.

However, methodological limitations of these three studies raise questions pertaining to the properties of the relationship between imagination- and observation-based drawings. Evaluating two previously hypothesized properties of this relationship are the focus of the novel studies reported here.

The first is that the relationship between these two types of drawings is reflective of long-term, as opposed to short-term, memories partially biasing the production of observational drawings. The three studies cited above (which, to our knowledge, are the only studies to date that have used this method) share the common method that the observation-based drawings were produced, at most, 10 minutes after the production of the imagination-based drawings. Thus, there are at least two ways of interpreting the positive correlations between the two types of drawing. On the one hand, these correlations could indicate that the observation-based drawings were partially guided by stable long-term memory representations reflected by the imagination-based drawings. On the other hand, the similarity in appearance between the two types of drawings could be due to a lingering short-term memory (STM) of the imagination-based drawings the subjects created that then biased the production of the observation-based drawing produced minutes later. To resolve this ambiguity, Study 1 reported here evaluated whether the predictive relationship between these two types of drawings is found when there was a 1.5-month delay between the production of the two types of drawings. If the relationship between these drawings is based on stable long-term memories, then one would predict correlations between the two types of drawings that are similar in magnitude regardless of whether there is a long- or short-delay between the production of the two types of drawings. In contrast, if this relationship is based on a STM process, then one would predict that an approximately 1.5-month delay between the production of the two types of drawings would result in weaker-to-absent correlations between the drawings than what would be found if the two drawings were produced with a minutes-long delay between them. It is important to acknowledge that these predictions assume that 1.5 months is enough Time to forget the appearance of the imagination-based drawings that the participants initially produced.

The second property of this relationship between these two types of drawings relevant to the current studies concerns the orientation-specificity of the relationship. In Matthews and Adams (2008); all participants created observational drawings based on a standard, upright-oriented cylinder model. However, the instructions for the imagination-based drawing Task did not require the participants to produce a drawing of an upright cylinder. What resulted was that 68% (or, 49) of the participants produced an upright-oriented imagination-based cylinder drawing, whereas 32% (or, 23) of the participants produced a sideways-oriented imagination-based cylinder drawing. For the group of participants that produced both drawings in the same, upright orientation, the correlations pertaining to four of the six spatial relationships that were assessed were significant with correlation coefficients ranging from .30 to .46, and the correlations for the other two relationships were marginally significant with associated p-values of .08 and .07 with correlation coefficients ranging from .26 to .28. In contrast, for the group of participants that produced the two drawings in different orientations, none of the six correlations assessed were significant (p-values ranging from .20 to .79). The correlation coefficients ranged in value from .06 to .28, and the correlations for all of the six spatial relationships assessed were weaker for the different-orientation group than the same-orientation group. Although Matthews and Adams (2008) did not dismiss the possibility of low-statistical power for the different-orientation group explaining this finding (and one should not dismiss the problem that the lack of random assignment to same- vs. different-orientation groups poses), they speculated that it is possible that the long-term graphic memories reflected by the imagination-based drawings are orientation-specific. This orientation-specific hypothesis suggests that when producing an observation-based drawing, a long-term graphic memory is activated whose representation of the object is matched in orientation to that of the model being drawn. This would mean that individual variability in the appearance of imagination-based drawings would only be predictive of individual differences in the appearance of observation-based drawings when the two drawings are produced in the same orientation.

Studies 2 and 3 were designed to evaluate this orientation-specific hypothesis. In Study 2, participants began by producing an imagination-based drawing of a face in the upright orientation. Then, they were asked to produce an observation-based drawing of a model face twice, once while viewing and drawing the model upright and once when the model was rotated upside down. Study 3 was similar, with the exception that, rather than draw an upside-down model face, subjects drew a face that was rotated sideways instead (90 degrees relative to upright). If the relationship between imagination- and observation-based drawings is orientation-specific, then one would predict that the imagination-based drawings would be more strongly correlated with the upright-oriented observation-based drawings than the rotated drawings. In contrast, if the relationship between imagination- and observation-based drawings is not orientation-specific, then one would predict that the imagination-based drawings would be similarly correlated to both the upright and rotated observation-based drawings.

Finally, although not the main focus of the current study, the data collected for these studies allow us to report the results of ancillary analyses that further informs and attempts to replicate prior research. Specifically, across all three studies, we assessed whether the distribution of observation-based drawing errors were biased systematically versus randomly in direction, as past research has demonstrated systematic directional biases in the spatial errors found in face drawings (e.g., drawing the head too round, the eyes too far up the head and the nose too narrow; Ostrofsky et al., 2014; Ostrofsky et al., 2015). Additionally, in Studies 2 and 3, we assessed whether observation-based drawing errors differ or not between reproductions of upright- versus rotated-oriented models. Despite art instructors' claims that drawing upside-down models improves drawing quality (e.g., Edwards, 2012); past research has demonstrated that upside-down model rotation either impairs or has no effect on the drawing of spatial relationships between facial features (Cohen & Earls, 2010; Day & Davidenko, 2018; Ostrofsky, Kozbelt, Cohen, et al., 2016; Viviani & Bruno, 2017).

Study 1

Method

Participants

Fifty undergraduates participated in this study. One participant was excluded from the analysis due to producing an incomplete drawing of a face. Thus, the analysis for this study assessed the drawings of 49 participants (41 females, 8 males; *M* [*SD*] age = 21.34 [3.22] years). In Studies 1–3, recruitment materials indicated that participants were not required to be skilled in drawing to participate, participants provided informed consent, and were provided course credit as compensation.

Materials

Participants were randomly assigned to produce an observation-based drawing of one of four male face models (see Figure 1). The four face models were computer-generated images created using FaceGen Modeller (Version 3.1). The faces were varied by race through manipulating the race-morph tool; the faces differed from each other by being set to either 100% "European," 100% "African," 100% "Southeast Asian," or 100% "East Indian." All faces were set to have an emotionally neutral expression. Models were displayed in color against a white background on a computer monitor. As displayed on the computer monitor, each face was approximately 8.75 in. in height.

Participants created both of their drawings on separate 8.5" × 11" white sheets of paper using a No. 2 pencil with an eraser.

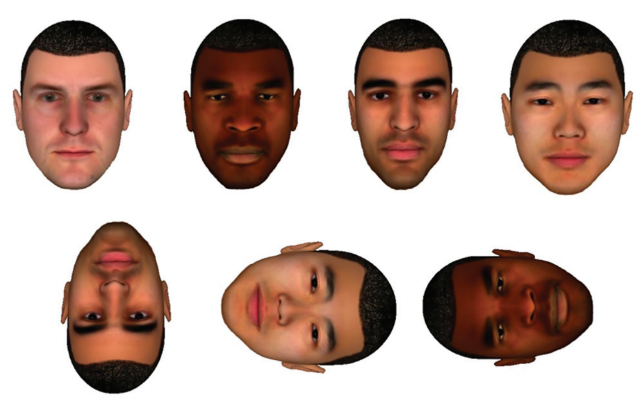
Procedure

The study was conducted in two phases separated in Time by approximately 1.5 months. In Phase 1, participants produced an imagination-based drawing of a face, and, in Phase 2, participants produced an observational drawing based on one of the four model face images described above. Participants were deliberately made to produce the imagination-based drawing first and the observation-based drawing second (as opposed to counterbalancing the order of the two drawing tasks) in order to prevent the production of the imagination drawings from being influenced by a memory of the model face displayed in the observation-based drawing task. This procedure was maintained in Studies 2 and 3 for the same reason.

In Phase 1, participants were asked to use their imagination to create a drawing of an average male face depicted in a full-frontal orientation with a neutral emotional expression and without any

Figure 1

The Four Face Models That Were the Basis of the Observation-Based Drawings (Models 1–4 Depicted From Left to Right), in Addition to Examples of the Appearance of the Upside-Down Models Used in Study 2 and the Sideways Models Used in Study 3



Note. Each participant was randomly assigned to draw one of these four faces. Note that all models were displayed in color to the participants. See the online article for the color version of this figure.

facial hair (drawing hair on the head was explicitly permitted). Further, participants were instructed to only draw a head and face without drawing any other part of the body. Participants were informed that they would have a 15-minute time limit to produce their drawings. Finally, participants were instructed that they could use an eraser to modify any aspect of their drawing during the 15-Minute period. After any questions about the instructions were addressed, participants produced their drawings. After the drawings were complete, the Phase 1 Session concluded.

Participants returned approximately 1.5 months later to participate in Phase 2. Each participant was randomly assigned to draw only one of the four model faces described in the Materials section. The Task began with the presentation of the model face on a computer monitor, and then participants were instructed to draw as accurate a copy of the model as possible. They were instructed not to exclude any of the features found in the face and not to add any features absent from the model. Further, they were instructed that they could use whatever drawing technique they desired to produce the drawing except for tracing. As with the Phase 1 drawing task, subjects had a 15-minute time limit to complete their drawing. Once any questions about the instructions were addressed, participants produced their drawings. After the drawings were completed, participants were debriefed and their participation concluded.

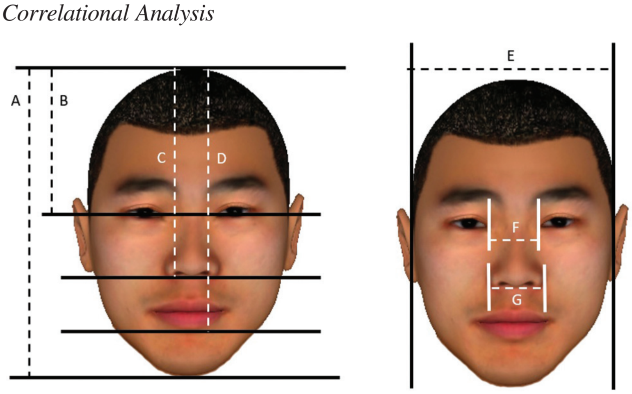
Measures of Drawing Performance

Performance in both drawing tasks were assessed using measures that quantified how participants depicted multiple spatial relationships between facial features. The measurement procedure is illustrated in Figure 2 For each drawing, seven measurements, A—G, were recorded in centimeters:

- **A** = height of the head: measured as the vertical distance from the top of the head to the bottom of the chin.
- **B** = height of the eyes: measured as the vertical distance between the top of the head and the midpoint of the horizontal line that passed through both pupils of the two eyes.
- **C** = height of the nose: measured as the vertical distance between the top of the head and the bottom of the nose.

Figure 2

Illustration of the Seven Measurements, A—G, Made (in CM) for Each Drawing and That Served as the Basis for the Computation of the Nine Spatial Relationship Ratios (SRRs) That Were Subjected to Correlational Analysis



Note. See the online article for the color version of this figure.

- **D** = height of the mouth: measured as the vertical distance between the top of the head and the bottom of the lower lip of the mouth.
- **E** = width of the head: measured as the horizontal distance between the two points where the top corners of the ears intersect with the face.
- **F** = interocular distance: measured as the horizontal distance between the inner corners of the two eyes.
- **G** = width of the nose: measured as the horizontal distance between the two nostrils of the nose.

To control for between- and within-participant differences in the absolute size of the face drawings, nine *Spatial Relation Ratios (SRRs)* were computed based on measurements A-G. For all the following SRRs that divide a measure by measure A, the SRR was computed relative to the height of the head; for all the following SRRs that divide a measure by measure E, the SRR was computed relative to the width of the head:

- **B/A** = eye height
- **C/A** = nose height
- **D/A** = mouth height
- **F/E** = interocular distance
- **G/E** = nose width
- **(D - B)/A** = vertical distance between the eyes and mouth
- **(C—B)/A** = vertical distance between the eyes and nose
- **(D—C)/A** = vertical distance between the nose and mouth
- **A/E** = head shape (or, the height-to-width ratio of the head)

Results

Table 2 provides means, standard deviations and 95% confidence intervals pertaining to the distributions of SSR values for the imagination- and observation-based drawings.

Primary Analyses

The following analyses assessed whether there was a predictive relationship between individual differences in the way the imagination- and observation-based drawings depicted the nine SSRs. We computed Pearson *r* correlation coefficients in order to accomplish this for each of the nine SSRs ($df = 47$).

Table 1 provides the results of these analyses. Seven out of the 9 SRRs were significantly and positively correlated between the two types of drawing tasks at a .05 significance level. These SRRs include (a) eye height, (b) nose height, (c) interocular distance, (d) nose width, (e) eye-mouth distance, (f) eye-nose distance, and (g) nose-mouth distance, whose correlation coefficients varied in value from .380 to .468, indicative of moderately strong relationships. The SRRs that were not significantly correlated between the two types of drawings at the .05 significance level included (a) mouth height and (b) head shape.

Since there were nine correlations computed for this single sample, using a .05 significance level for each correlation analysis inflates the family-wise type-I error rate. In order to control for this, we utilized the Hochberg Step-Up Method to adjust the α-levels in order to maintain a family-wise .05 α-level. Utilizing this α-correction method did not change the outcomes of the significance tests reported above.

Table 1

Pearson r Correlation Coefficients [95% Confidence Interval of r] Between Imagination-Based Drawings and the Five Types of Observation-Based Drawings Produced in Studies 1–3

	Study 1 (df = 47)	Study 2 (df = 54)		Study 3 (df = 52)	
Spatial relationships	Upright	Upright	Upside-down	Upright	Sideways
Eye height	**.443***** [.171, .652]	**.412**** [.156, .616]	.254 [−.014, .488]	**.479***** [.228, .670]	.289* [.017, .521]
Nose height	**.403**** [.126, .622]	.291* [.025, .519]	−.135 [−.385, .134]	**.418**** [.158, .624]	.084 [−.188, .344]
Mouth height	.053 [−.232, .329]	.301* [.035, .527]	−.004 [−.267, .259]	**.362**** [.096, .580]	.148 [−.126, .401]
Interocular distance	**.413**** [.137, .629]	.308* [.043, .533]	**.422***** [.168, .624]	.279* [.007, .513]	.358** [.091, .577]
Nose width	**.454***** [.184, .660]	**.441***** [.189, .638]	**.409**** [.153, .614]	.290* [.018, .522]	.356** [.089, .575]
Eye-mouth distance	**.452***** [.182, .659]	**.513***** [.273, .693]	**.423***** [.169, .625]	**.491***** [.242, .679]	**.422***** [.162, .627]
Eye-nose distance	**.380**** [.100, .604]	.336** [.073, .555]	.282* [.015, .511]	**.486***** [.236, .676]	.305* [.034, .534]
Nose-mouth distance	**.468***** [.200, .671]	**.438***** [.186, .636]	.217 [−.052, .457]	**.441***** [.184, .642]	.270 [−.003, .505]
Head shape	.185 [−.104, .445]	.163 [−.106, .410]	.084 [−.183, .340]	.016 [−.253, .283]	−.246 [−.485, .027]

Note. Bold values indicate the correlation is statistically significant at the corrected α level that was determined using the Hochberg Step-Up Method to maintain a familywise α level of .05 (corrected for 9 correlations for Study 1 and for 18 correlations each for Studies 2 and 3).
$^{*} p \leq .05$. $^{**} p \leq .01$. $^{***} p \leq .001$.

Ancillary Analyses

To assess whether the distribution of observation-based drawing errors was systematically or randomly biased in direction, we utilized an approach described in detail in prior reports (Ostrofsky et al., 2014; Ostrofsky et al., 2015). First, for each SSR, we computed directional errors by dividing the SSR value computed from the drawing by the SSR value computed from the model. Here, an error value of 1.00 would indicate no error at all. After collapsing across the drawings of all 4 models, we performed single-sample *t*-tests comparing the mean directional drawing error to a Test value of 1.00. Using this method, random directional error biases are indicated by the mean SRR value of the drawings not being significantly different from 1.00. In contrast, systematic directional error biases are indicated by mean SSR values being significantly greater or less than 1.00.

Results relevant to these analyses are reported in Table 2 To highlight the key findings, the distribution of directional errors were systematically biased, on average, to reproduce (a) the eyes too high and too close together (B/A & F/E), (b) the head too round (A/E), (c) the nose too high and too narrow (C/A & G/E), and (d) the vertical distances between the eyes-and-mouth and the nose-and-mouth too long ([D-B]/A & [D-C]/A). In contrast, random directional error biases were observed for the drawing of the height of the mouth (D/A) and the vertical distance between the eyes and nose ([C-B]/A).

Discussion

Individual differences in the depictions of the eye height, nose height, interocular distance, nose width, eye-mouth distance, eye-nose distance and nose-mouth distance in the imagination-based drawings reliably predicted how they were reproduced in the observation-based drawings approximately 1.5 months later. Comparing these results to those observed in prior studies of human face drawing (Harrison et al., 2017; Ostrofsky et al., 2015); wherein the production of these two types of drawings were separated by minutes, reveals a strong degree of consistency in the results. Ostrofsky et al. (2015) reported significant, positive correlations between the two types of drawings with respect to the depictions of the eye-height (r = .33), interocular distance (r = .32) and nose-width (r = .54). Further, although not reported in Ostrofsky et al. (2015); reanalysis of the data from that study revealed, similar to what was observed in the current study, a significant, positive correlation between the two types of drawings with respect to drawings of the eye-mouth distance, $r(36)$ = .420, p = .009. Since the assessment of the drawings in the Ostrofsky et al. (2015) study did not measure the nose-height, we could not assess the consistency of results between current and past research with respect to any of the nose-related spatial relationships assessed here. Moreover, the results of the current study are consistent with the results reported by Harrison and colleagues (2017), who reported a significant, positive correlation between the two types of drawings with respect to the depiction of the eye height (the only spatial relationship assessed in that study) in drawings of a human face (r = .43) and a cat face (r = .62).

However, the results of the current study were inconsistent with some of the results reported by Ostrofsky et al. (2015). Namely, although not found to be significantly correlated here, Ostrofsky et al. (2015) reported significant, positive correlations between the two types of drawings with respect to the depictions of the mouth height (r = .65) and head-shape (r = .44).

Assuming the production of imagination-based drawings are based on long-term graphic memories and that 1.5 months is enough Time to forget the appearance of the imagination-based drawings before the observation-based drawings were produced, the results of the current study provide evidence supporting the idea that the relationship between these two types of drawings is based on long-term, as opposed to short-term, memory processes.

More detailed discussion of these results and the results of the ancillary analyses is found in the General Discussion section.

Studies 2 and 3

The next two studies were designed to assess whether this relationship is orientation-specific or -nonspecific. In these studies, we assessed whether the depictions of spatial relationships in upright imagination-based drawings were predictive of the reproductions of these relationships in upright- and/or upside-down-oriented

Table 2

Study 1: Spatial Relation Ratio (SSR) Values of the Four Drawing Models; M, Standard Deviation & 95% Confidence Intervals of the M of the SRR Values for the Observation-Based and Imagination-Based Drawings; M, Standard Deviation and 95% Confidence Intervals of the Means for the Observation-Based Drawing Errors; Results of Inferential Tests Assessing for Systematic Biases in Observation-Based Drawing Errors

	Spatial relation ratios (SSRs)								
Models	B/a	C/a	D/a	A/E	F/E	G/E	(D-B)/a	(C-B)/a	(D-C)/a
Model 1 (*n* = 12)									
Model Value	.46	.68	.81	1.63	.25	.27	.36	.22	.13
O.D. *M* (*SD*)	0.45 (.06)	0.67 (.04)	0.83 (.02)	1.50 (.17)	0.24 (.05)	0.23 (.03)	0.38 (.05)	0.22 (.03)	0.16 (.04)
95% CI of O.D. Mean	[.41, .48]	[.64, .69]	[.81, .84]	[1.40, 1.61]	[.21, .27]	[.21, .25]	[.35, .41]	[.20, .24]	[.14, .19]
I.D. *M* (*SD*)	.41 (.07)	.64 (.06)	.81 (.04)	1.34 (.12)	.22 (.08)	.17 (.06)	.40 (.07)	.23 (.04)	.17 (.05)
95% CI of I.D. Mean	[.36, .46]	[.60, .68]	[.79, .83]	[1.27, 1.42]	[.17, .27]	[.13, .21]	[.36, .44]	[.21, .25]	[.14, .20]
Model 2 (*n* = 11)									
Model Value	.47	.66	.85	1.66	.30	.38	.39	.19	.19
O.D. *M* (*SD*)	.42 (.04)	.64 (.03)	.84 (.03)	1.49 (.13)	.23 (.08)	.27 (.07)	.42 (.03)	.21 (.04)	.20 (.02)
95% CI of O.D. Mean	[.40, .45]	[.62, .66]	[.82, .86]	[1.40, 1.58]	[.18, .29]	[.23, .32]	[.39, .44]	[.19, .24]	[.19, .22]
I.D. *M* (*SD*)	.40 (.03)	.62 (.05)	.81 (.04)	1.35 (.20)	.19 (.04)	.16 (.05)	.40 (.04)	.22 (.04)	.19 (.04)
95% CI of I.D. Mean	[.38, .43]	[.58, .66]	[.78, .83]	[1.22, 1.48]	[.16, .22]	[.13, .19]	[.38, .43]	[.19, .24]	[.16, .22]
Model 3 (*n* = 13)									
Model Value	.46	.66	.83	1.78	.28	.31	.37	.20	.17
O.D. *M* (*SD*)	.43 (.04)	.65 (.04)	.83 (.02)	1.58 (.16)	.27 (.05)	.26 (.06)	.40 (.04)	.22 (.04)	.18 (.03)
95% CI of O.D. Mean	[.41, .45]	[.62, .67]	[.81, .84]	[1.48, 1.67]	[.24, .30]	[.22, .29]	[.38, .43]	[.20, .24]	[.16, .20]
I.D. *M* (*SD*)	.45 (.07)	.66 (.04)	.83 (.05)	1.32 (.11)	.22 (.09)	.18 (.06)	.38 (.03)	.21 (.04)	.17 (.03)
95% CI of I.D. Mean	[.41, .49]	[.63, .69]	[.80, .85]	[1.25, 1.39]	[.16, .27]	[.15, .21]	[.36, .40]	[.19, .24]	[.15, .18]
Model 4 (*n* = 13)									
Model Value	.47	.68	.85	1.54	.27	.28	.38	.21	.17
O.D. *M* (*SD*)	.44 (.04)	.65 (.03)	.85 (.04)	1.40 (.13)	.25 (.08)	.24 (.04)	.41 (.06)	.20 (.04)	.20 (.03)
95% CI of O.D. Mean	[.42, .47]	[.63, .66]	[.83, .87]	[1.32, 1.48]	[.20, .29]	[.22, .26]	[.37, .44]	[.18, .23]	[.18, .22]
I.D. *M* (*SD*)	.41 (.08)	.63 (.06)	.82 (.04)	1.36 (.14)	.23 (.07)	.18 (.06)	.41 (.05)	.22 (.05)	.19 (.04)
95% CI of I.D. Mean	[.37, .46]	[.60, .67]	[.79, .84]	[1.27, 1.44]	[.19, .28]	[.14, .22]	[.38, .44]	[.19, .25]	[.16, .21]
Total (*N* = 49)									
O.D. Error *M* (*SD*)	.94 (.10)	.97 (.05)	1.00 (.04)	.90 (.09)	.92 (.24)	.82 (.16)	1.07 (.12)	1.03 (.19)	1.13 (.21)
95% CI of O.D. Error Mean	[.92, .97]	[.96, .99]	[.99, 1.01]	[.88, .93]	[.85, .99]	[.77, .86]	[1.04, 1.11]	[.98, 1.09]	[1.07, 1.19]
t, *p* (two-tailed)	4.06, <.001	3.84, <.001	0.40, .69	7.69, <.001	2.35, .02	8.16, <.001	4.12, <.001	1.18, .24	4.45, <.001
Cohen's *d*	.58	.05	.06	1.10	.34	1.16	.59	.17	.64

Note. [a] O.D. = Observation-based Drawing; I.D. = Imagination-based Drawing; [b] O.D. Error = (O.D. SSR/Model SSR), error values farther away from 1.00 represent larger errors; [c] *M* (*SD*) values of O.D. errors were calculated after collapsing across the drawings of all 4 models; [d] Values of *t*, *p* and Cohen's *d* are based on a single-sample t-tests ($df = 48$) designed to assess whether the mean O.D. errors significantly differed from a test value of 1.00 (indicative of no error).

observation-based drawings (Study 2) and in upright- and/or sideways- oriented drawings (Study 3).

Study 2

Method

Participants

Sixty-four undergraduates participated in this study. Eight participants were excluded from analysis due to either producing an incomplete drawing of a face in at least one of their drawings and/or completing at least one of their drawings in less than five minutes. Thus, the analysis for this Study assessed the drawings of 56 participants (40 females, 16 males; *M (SD)* age = 20.89 (4.76) years).

Materials

The materials for Study 2 were generally the same as those used in Study 1. The only exception to this is that, in addition to reproducing an upright-oriented model in the observation-based drawing task, each participant also reproduced an upside-down-oriented model. For these latter drawings, participants were displayed with an image of the model face rotated 180° from the upright orientation (see Figure 1 for an example). The display size of the upright and upside-down model images was identical.

Procedure

Participants produced three face drawings in this study. All participants first produced an upright-oriented imagination-based face drawing following the same set of instructions used in Study 1.

Afterward, participants produced the two observation-based drawings (one upright and one upside down). Participants were randomly assigned one of the four face models to base both drawings on. We also counterbalanced the order of producing upright and upside-down observational drawings across the sample.

Participants completed the upright-oriented observation-based drawing Task following the same instructions used in Study 1.

The instructions and procedure for the upside-down observation-based drawing Task were identical to those used for the upright drawing Task with one exception. Participants were instructed to produce a drawing of an upside-down face based on the upside-down model. The instructions emphasized that participants should not produce a drawing of an upright-oriented face based on the upside-down-oriented model. The researchers monitored the participants while they drew to ensure this instruction was followed.

After all three drawings were completed, participants were debriefed and their participation concluded.

All three drawings were measured in the same way as the drawings were measured in Study 1 (see the *Measures of Drawing Performance* subsection in the Method section for Study 1).

Results

Table 3 provides means, standard deviations and 95% confidence intervals pertaining to the distributions of SSR values for the imagination- and observation-based drawings.

Primary Analyses

The following analyses determined if individual differences in the depiction of spatial relationships between features in the imagination-based drawings predicted how they were reproduced in the two observation-based drawings. We computed the Pearson *r* correlation coefficients ($df = 54$) pertaining to the nine SRRs twice, once for determining the relationship between the imagination- and upright observation-based drawings and once for determining the relationship between imagination- and upside-down observation-based drawings. Table 1 displays the results of these analyses.

When comparing the imagination- and upright observation-based drawings, 8 of the 9 SRRs were significantly and positively correlated at the .05 α level. These 8 correlations included all 7 of the SRRs that were significantly correlated between the imagination- and upright observation-based drawings produced in Study 1 (namely, eye height, nose height, interocular distance, nose width, eye-mouth distance, eye-nose distance and nose-mouth distance), in addition to the mouth height SRR. The correlation coefficients for these 8 relationships ranged from .291 to .513, reflecting moderately strong relationships. As in Study 1, we did not observe a significant correlation at the .05 α level between the two types of drawings with respect to the head shape SRR.

When comparing the imagination- and upside-down observation-based drawings, four out of the nine SRRs were significantly and positively correlated at the .05 α level. These four correlations included the following SRRs: (a) interocular distance, (b) nose-width, (c) eye-mouth distance, and (d) eye-nose distance. The correlation coefficients for these four relationships ranged from .282

Table 3

Study 2: Spatial Relation Ratio (SSR) Values of the Four Drawing Models; M, Standard Deviation and 95% Confidence Intervals of the M of the SRR Values for the Upright and Upside-Down Observation-Based Drawings and the Imagination-Based Drawings

	Spatial relation ratios								
Models	B/A	C/A	D/A	A/E	F/E	G/E	(D-B)/A	(C-B)/A	(D-C)/A
Model 1 (*n* = 11)									
Model Value	.46	.68	.81	1.63	.25	.27	.36	.22	.13
U.O.D. *M* (*SD*)	.43 (.05)	.67 (.04)	.82 (.03)	1.51 (.11)	.23 (.05)	.22 (.05)	.39 (.06)	.24 (.04)	.15 (.04)
95% CI of U.O.D. Mean	[.40, .46]	[.65, .69]	[.80, .84]	[1.45, 1.57]	[.20, .26]	[.19, .24]	[.36, .43]	[.22, .26]	[.13, .18]
R.O.D. *M* (*SD*)	.41 (.06)	.66 (.04)	.81 (.04)	1.52 (.11)	.25 (.06)	.23 (.04)	.40 (.07)	.25 (.05)	.15 (.03)
95% CI of R.O.D. Mean	[.37, .44]	[.64, .68]	[.79, .83]	[1.45, 1.58]	[.21, .28]	[.20, .25]	[.36, .44]	[.22, .28]	[.13, .17]
I.D. *M* (*SD*)	.40 (.06)	.65 (.06)	.83 (.04)	1.38 (.09)	.18 (.06)	.18 (.05)	.43 (.06)	.25 (.04)	.18 (.05)
95% CI of I.D. Mean	[.37, .43]	[.62, .68]	[.81, .86]	[1.33, 1.44]	[.15, .22]	[.15, .21]	[.40, .47]	[.23, .27]	[.16, .21]
Model 2 (*n* = 14)									
Model Value	.47	.66	.85	1.66	.30	.38	.39	.19	.19
U.O.D. *M* (*SD*)	.44 (.05)	.66 (.04)	.86 (.03)	1.46 (.11)	.24 (.05)	.32 (.07)	.42 (.04)	.22 (.03)	.20 (.03)
95% CI of U.O.D. Mean	[.41, .46]	[.64, .68]	[.85, .87]	[1.40, 1.52]	[.21, .26]	[.28, .35]	[.40, .45]	[.21, .24]	[.18, .22]
R.O.D. *M* (*SD*)	.43 (.05)	.66 (.05)	.86 (.05)	1.51 (.12)	.26 (.06)	.33 (.08)	.43 (.04)	.23 (.04)	.20 (.03)
95% CI of R.O.D. Mean	[.41, .46]	[.63, .69]	[.83, .88]	[1.45, 1.58]	[.23, .30]	[.29, .37]	[.40, .45]	[.21, .25]	[.18, .21]
I.D. *M* (*SD*)	.41 (.07)	.64 (.06)	.82 (.05)	1.36 (.14)	.20 (.06)	.19 (.06)	.40 (.04)	.23 (.03)	.17 (.03)
95% CI of I.D. Mean	[.38, .45]	[.61, .68]	[.79, .84]	[1.29, 1.43]	[.17, .23]	[.16, .22]	[.38, .43]	[.21, .25]	[.16, .19]
Model 3 (*n* = 16)									
Model Value	.46	.66	.83	1.78	.28	.31	.37	.20	.17
U.O.D. *M* (*SD*)	.44 (.04)	.66 (.04)	.83 (.03)	1.54 (.12)	.22 (.04)	.25 (.03)	.40 (.04)	.22 (.03)	.18 (.03)
95% CI of U.O.D. Mean	[.41, .46]	[.64, .68]	[.82, .85]	[1.48, 1.60]	[.20, .25]	[.23, .26]	[.38, .42]	[.21, .24]	[.16, .19]
R.O.D. *M* (*SD*)	.42 (.06)	.66 (.05)	.84 (.04)	1.61 (.23)	.21 (.06)	.26 (.04)	.42 (.07)	.24 (.04)	.18 (.04)
95% CI of R.O.D. Mean	[.39, .45]	[.63, .68]	[.82, .85]	[1.50, 1.72]	[.18, .24]	[.24, .27]	[.39, .45]	[.22, .26]	[.16, .20]
I.D. *M* (*SD*)	.40 (.04)	.65 (.03)	.83 (.03)	1.34 (.13)	.19 (.05)	.16 (.03)	.43 (.04)	.25 (.03)	.18 (.03)
95% CI of I.D. Mean	[.38, .42]	[.63, .66]	[.82, .85]	[1.28, 1.41]	[.16, .21]	[.14, .17]	[.41, .45]	[.23, .26]	[.17, .20]
Model 4 (*n* = 15)									
Model Value	.47	.68	.85	1.54	.27	.28	.38	.21	.17
U.O.D. *M* (*SD*)	.44 (.05)	.66 (.05)	.85 (.04)	1.41 (.15)	.23 (.05)	.23 (.03)	.41 (.04)	.22 (.02)	.19 (.03)
95% CI of U.O.D. Mean	[.42, .46]	[.63, .68]	[.83, .87]	[1.34, 1.48]	[.21, .25]	[.22, .25]	[.39, .43]	[.21, .23]	[.18, .21]
R.O.D. *M* (*SD*)	.42 (.06)	.66 (.05)	.84 (.03)	1.47 (.11)	.22 (.05)	.24 (.03)	.42 (.05)	.24 (.03)	.17 (.03)
95% CI of R.O.D. Mean	[.39, .45]	[.64, .69]	[.82, .85]	[1.41, 1.52]	[.20, .25]	[.22, .26]	[.39, .44]	[.23, .26]	[.16, .19]
I.D. *M* (*SD*)	.40 (.05)	.64 (.07)	.82 (.05)	1.37 (.15)	.21 (.06)	.19 (.07)	.42 (.04)	.24 (.04)	.18 (.05)
95% CI of I.D. Mean	[.37, .43]	[.60, .68]	[.79, .84]	[1.30, 1.45]	[.18, .23]	[.16, .22]	[.40, .44]	[.22, .26]	[.15, .20]

Note. U.O.D. = Upright Observation-based Drawing; R.O.D. = Rotated (Upside-down) Observation-based Drawing; I.D. = Imagination-based Drawing.

to .423, reflecting moderately strong relationships. Unlike what was observed when comparing the imagination- and upright observation-based drawings in this study, we did not observe significant correlations at the .05 α level for the following four SRRs: (a) eye height, (b) nose height, (c) mouth height, and (d) nose-mouth distance, whose correlation coefficients ranged from -.135 to .254, indicative of weak-to-no associative strength. As was observed when comparing imagination- and upright observation-based drawings in Studies 1 and 2, we did not observe a significant correlation with respect to the head shape SRR between the imagination- and upside-down observation-based drawings.

Since 18 correlation coefficients were assessed in this study, we utilized the Hochberg Step-Up Method to maintain a familywise .05 α level. When utilizing this criterion, 4 of the 8 SRRs that were observed to be significantly correlated between the imagination- and upright observation-based drawings at the .05 α-level remained statistically significant. These 4 SRRs included (a) eye height, (b) nose width, (c) eye-mouth distance, and (d) nose-mouth distance, and their correlation coefficients ranged between .412 and .513. The correlations pertaining to the 4 SRRs whose p-values fell between the Hochberg corrected α level and .05 included (a) nose-height (p = .03), (b) mouth height (p = .02), (c) interocular distance (p = .02), and (d) eye-nose distance (p = .01), and their correlation coefficients ranged between .291 and .336.

Further, when adopting the Hochberg corrected α-levels, 3 of the 4 SRRs that were observed to be significantly correlated between the imagination- and upside-down observation-based drawings at the .05 α-level remained statistically significant. These 3 SRRs included (a) interocular distance, (b) nose width, and (c) eye-mouth distance, and their correlation coefficients ranged between .409 and .423. The only SRR whose correlation coefficient fell between the Hochberg corrected α-level and .05 was the eye-nose distance relationship (r = .282, p = .04).

Ancillary Analyses

The following ancillary analyses use two different measures of drawing errors. For the first set of analyses, directional drawing errors were analyzed (calculated in the same way as in Study 1). For the second set of analyses, absolute drawing errors were analyzed, calculated as the absolute value of [1 – Directional Error Value].

The first set of ancillary analyses assessed systematic versus random *directional error biases* in the upright and upside-down observation-based drawings using the same method described for Study 1. Highlighting results depicted in Table 4, we observed that the distribution of errors for both types of drawings were systematically biased, on average, in the direction of drawing (a) the eyes too high and too close together (B/A & F/E), (b) the nose too narrow (G/E), (c) the head too round (A/E) and (d) the eyes-to-mouth ([D-B]/A), eyes-to-nose ([C-B]/A) and nose-to-mouth ([D-C]/A) vertical distances too long. In contrast, we observed random directional error biases for both types of drawings with respect to the nose and mouth height (C/A & D/A).

The second set of ancillary analyses were a series of paired-samples t-tests that compared the mean *absolute drawing errors* between the upright versus upside-down observation-based drawings. Absolute, as opposed to directional, errors were assessed for this comparison in order to maintain consistency with prior research on this topic (e.g., Ostrofsky, Kozbelt, Cohen, et al., 2016). The results are depicted in Table 4 Upside-down drawings were significantly less accurate than the upright drawings with respect to the vertical distances between the eyes and the mouth and the eyes and the nose ([D-B]/A & [C-B]/A). In contrast, upside-down drawings were significantly more accurate when drawing the head shape (A/E). Nonsignificant differences in absolute errors were observed for the drawings of the height of the eyes, nose and mouth (B/A, C/A & D/A), interocular distance (F/E), nose-width (G/E) and the vertical distance between the nose and mouth ([D-C]/A).

Discussion

When assessing the relationship between upright imagination- and observation-based drawings, we observed that all the spatial relationships assessed here, except for the head-shape spatial relationship, were significantly and positively correlated (at a .05 α-level). In comparing these results to those reported in Study 1, a strong consistency between the results is observed despite differences between the studies with respect to the Time delay in between producing the two types of drawings. The only discrepant finding concerns the drawing of the mouth height, which was found to be significantly correlated between the two types of upright drawings in Study 2 but not in Study 1. Thus, this aspect of the results lends further support to the idea that the relationship pertaining to the drawings of multiple spatial relationships between upright imagination- and observation-based drawings is not temporally specific (at least within a Time range of minutes to 1.5 months).

Of central interest to Study 2 was the assessment of whether the relationship between these two types of drawings was orientation specific. We observed mixed evidence concerning this. We found that individual differences in how the interocular distance, nose-width, eye-mouth distance and eye-nose distance were depicted in the upright imagination-based drawings reliably predicted individual variability in how they were reproduced in the observation-based drawings at both orientations. However, while the imagination-based drawings' depictions of the eye height, nose height, mouth height and nose-mouth distance reliably predicted how they were reproduced in the upright observation-based drawings, they were not correlated with the upside-down drawings with respect to these spatial relationships.

Thus, the results of Study 2 indicate that the issue of orientation-specificity as it concerns the predictive relationship between these two types of drawings is somewhat complex. Inspection of the pattern of correlations in Study 2 does not lend itself to a clear categorization of the predictive relationships between imagination- and observation-based drawings that are orientation-specific versus -nonspecific. One possible categorization method relates to the distinction between the absolute spatial positioning of an individual feature within the space of a face (e.g., height of the eyes, nose and mouth) versus the relative spatial distances between two features (e.g., eye-mouth distance, eye-nose distance, nose-mouth distance, interocular distance). Distinguishing between absolute versus relative spatial positioning can largely, but not completely, account for the distinction between the spatial relationships which were found to be orientation-specific versus -nonspecific with respect to the predictive relationship between imagination- and observation-based drawings. For the most part, individual differences in the imagination-based drawings depictions of the relative spatial distances between two features (interocular distance, eye-mouth distance,

Table 4

Study 2: M, Standard Deviation and 95% Confidence Intervals of the Means for the Upright and Upside-Down Observation-Based Drawing Errors; Results of Inferential Tests Assessing Systematic Biases in the Upright and Upside-Down Observation-Based Drawing Directional Errors; Results of Inferential Tests Assessing Significant Differences in Absolute Errors Between the Upright vs. Upside-Down Observation-Based Drawings

	Spatial relation ratios								
Statistics	B/A	C/A	D/A	A/E	F/E	G/E	(D-B)/A	(C-B)/A	(D-C)/A
U.O.D. Directional Error *M* (*SD*)	.95 (.10)	.99 (.07)	1.01 (.04)	.90 (.08)	.85 (.19)	.81 (.14)	1.08 (.12)	1.08 (.15)	1.08 (.22)
95% CI of U.O.D. Error Mean	[.92, .98]	[.97, 1.01]	[1.00, 1.02]	[.88, .92]	[.80, .90]	[.77, .85]	[1.04, 1.11]	[1.04, 1.12]	[1.02, 1.14]
t, *p* (two-tailed)	3.60, .001	1.00, .321	1.21, .233	9.78, <.001	6.09, <.001	10.11, <.001	4.70, <.001	3.98, <.001	2.76, .008
Cohen's *d*	.48	.13	.16	1.31	.81	1.35	.63	.53	.37
R.O.D. Directional Error *M* (*SD*)	.90 (.11)	.98 (.07)	1.00 (.05)	.92 (.08)	.86 (.22)	.85 (.16)	1.12 (.14)	1.16 (.19)	1.06 (.20)
95% CI of R.O.D. Error Mean	[.87, .93]	[.97, 1.00]	[.99, 1.01]	[.90, .94]	[.81, .92]	[.81, .89]	[1.08, 1.15]	[1.11, 1.21]	[1.01, 1.12]
t, *p* (two-tailed)	6.36, <.001	1.63, .109	0.22, .827	7.44, <.001	4.57, <.001	6.85, <.001	6.10, <.001	6.59, <.001	2.25, .029
Cohen's *d*	.85	.22	.03	.99	.61	.91	.81	.88	.30
M (*SD*) U.O.D.-R.O.D. A.E. Difference	−.03 (.10)	−.00 (.06)	−.00 (.04)	.02 (.05)	−.02 (.15)	.02 (.11)	−.04 (.10)	−.07 (.14)	.00 (.18)
95% CI of A.E. Mean Difference	[−.05, .00]	[−.02, .01]	[−.01, .01]	[.01, .03]	[−.06, .02]	[−.01, .05]	[−.01, −.06]	[−.03, −.11]	[−.05, .05]
t, *p* (two-tailed)	1.93, .058	0.44, .662	0.12, .902	2.76, .008	0.93, .358	1.57, .122	2.70, .009	3.61, .001	0.09, .931
Cohen's *d*	.26	.06	.02	.37	.12	.21	.36	.48	.01

Note. [a] U.O.D. = Upright Observation-based Drawing; R.O.D. = Rotated (Upside-down) Observation-based Drawing; [b] Directional U.O.D. & R.O.D. Error = (O.D. SSR/Model SSR), comparatively, error values closer to 1.00 indicate smaller errors than error values farther away from 1.00; [c] *M* (*SD*) values of O.D. directional errors were calculated after collapsing across the drawings of all 4 models; [d] Values of *t*, *p* and Cohen's *d* in the first two sections of the table are based on single-sample t-tests ($df = 55$) designed to assess whether the mean O.D. directional errors significantly differed from a test value of 1.00 (indicative of no error); [e] U.O.D. & R.O.D. Absolute Error (A.E.) = Absolute Value (1-Directional Error); [d] Values of *t*, *p* & Cohen's *d* in the last section of the table are based on a paired-sample t-tests ($df = 55$) designed to assess whether absolute errors significantly differed between the upright vs. upside-down drawings (all difference scores were calculated as U.O.D. absolute error—R.O.D. absolute error).

eye-nose distance) reliably predicted individual variability in how they were reproduced in both the upright and upside-down observation-based drawings, suggesting a lack of orientation-specificity for relative spatial relationships. In contrast, individual differences in the upright imagination-based drawings' depictions of the absolute spatial positioning of individual features (heights of the eyes, nose and mouth) reliably predicted how they were positioned in the upright, but not upside-down, observation-based drawings, suggesting orientation-specificity for absolute spatial relationships.

However, caveats to these categorizations must be noted. First, the relative spatial relationship of the nose-mouth distance was orientation-specific with respect to the relationship between imagination- and observation-based drawings, where the imagination drawings of this relationship was reliably correlated in the upright, but not upside-down, observational drawings.

Second, it is unclear how to categorize the nose-width spatial relationship within this classification scheme (which did not exhibit orientation-specificity). On the one hand, if one considers the left and right sides of the nose as distinct features, then the distance between them could be considered a relative spatial relationship as defined above. If one accepts this, then the results observed here pertaining to the width of the nose would provide additional support to the claim that relative spatial relationships are not orientation-specific with respect to the relationship between imagination- and observation-based drawings. On the other hand, if one considers the nose to be a single, integrated feature that is not comparable, to say, the distance between the two eyes, then it seems that this is the one spatial relationship assessed here that resists falling within the absolute versus relative spatial relationship classification scheme.

Nevertheless, regardless of how one interprets the specific pattern of results observed here, it is clear that there are at least some spatial relationships depicted in face drawings whose individual differences are associated between imagination- and observation-based drawings in a nonorientation-specific manner. Specific to this study, the results suggest that there are some spatial relationships between facial features represented in long-term memory that are activated and bias the reproduction of a model in an observational drawing Task regardless of whether the model is oriented upright or upside down.

Discussion of the results of the ancillary analyses is found in the General Discussion section of this article.

Moving ahead, Study 3 utilized a similar method to Study 2, with the exception that rather than drawing an upside-down-oriented model, participants were asked to draw the model when it was rotated 90-degrees (oriented sideways). This is an important follow-up to Study 2 because upright and upside-down faces are like each other with respect to how the spatial relationships assessed here are oriented on the vertical and horizontal axes of the face. For instance, although the position of the eyes and mouth are reversed in relation to the top and bottom positions, the distance between them is still vertical in orientation. Additionally, the spatial relationships of nose width and interocular distance assess horizontal distances in both upright and upside-down faces. In Study 3, however, each spatial relationship has been rotated (relative to the upright orientation) in terms of the vertical and horizontal axes (e.g., the eye-mouth distance becomes a horizontal distance and the interocular distance becomes a vertical distance in sideways-orientated models).

Study 3

Method

Participants

Sixty-four undergraduates participated in this study. Ten participants were excluded from analysis due to either producing an incomplete drawing of a face in at least one of their drawings and/or completing at least one drawing in less than five minutes. The final analysis for this study assessed the drawings of 54 participants (42 females, 12 males; *M (SD)* age = 21.06 (3.61) years).

Materials and Procedure

The materials, procedures and measurement methods of Study 3 were almost identical to that of Study 2. The only exceptions to this are that participants produced observation-based drawings of sideways- rather than upside-down-oriented models. For each of the four model faces, two versions of a sideways-oriented model image were created: one that was rotated 90 °F from upright in the clockwise direction and another in the counterclockwise direction (see Figure 1). Participants were randomly assigned to draw either the clockwise or counterclockwise rotated model. Similar to instructions provided in Study 2, participants were instructed to produce a sideways-oriented drawing from the sideways-oriented model that was displayed. Across the sample, the order of creating the upright- and sideways-oriented observation-based drawings was counterbalanced.

Results

Table 5 provides means, standard deviations and 95% confidence intervals pertaining to the distributions of SSR values for the imagination- and observation-based drawings.

Primary Analyses

These analyses investigated whether individual variability in how the spatial relationships between features were depicted in the imagination-based drawings predicted how they were reproduced in the upright and sideways observation-based drawings. We computed Pearson r correlation coefficients ($df = 52$) pertaining to the nine SRRs twice, once for determining the relationship between the imagination- and upright observation-based drawings and once for determining the relationship between imagination- and sideways observation-based drawings. Table 1 displays the results of these analyses.

When comparing the imagination- and upright observation-based drawings, eight of the nine SRRs assessed in this study were significantly and positively correlated at a .05 α level. These were the same 8 SRRs that were significantly correlated at the .05 α level in Study 2 when the imagination- and upright observation-based drawings were compared (eye height, nose height, interocular distance, nose width, eye-mouth distance, eye-nose distance and nose-mouth distance). The correlation coefficients for these 8 relationships varied from .279 to .491, reflecting weak-to-moderately strong relationships. As was the case in Studies 1 and 2, the head shape SRR was not significantly correlated at the .05 α level between these two types of drawings.

When comparing the imagination- and sideways observation-based drawings, 5 out of the 9 SRRs were significantly and

Table 5

Study 3: Spatial Relation Ratio (SSR) Values of the Four Drawing Models; M, Standard Deviation and 95% Confidence Intervals of the M of the SRR Values for the Upright and Sideways Observation-Based Drawings and the Imagination-Based Drawings

	Spatial relation ratios								
Models	B/A	C/A	D/A	A/E	F/E	G/E	(D-B)/A	(C-B)/A	(D-C)/A
Model 1 (*n* = 15)									
Model Value	.46	.68	.81	1.63	.25	.27	.36	.22	.13
U.O.D. *M* (*SD*)	.43 (.04)	.66 (.05)	.81 (.05)	1.45 (.12)	.24 (.05)	.23 (.04)	.37 (.03)	.22 (.03)	.15 (.02)
95% CI of U.O.D. Mean	[.41, .46]	[.63, .69]	[.78, .84]	[1.38, 1.52]	[.21, .27]	[.21, .25]	[.36, .39]	[.21, .24]	[.14, .16]
R.O.D. *M* (*SD*)	.43 (.04)	.66 (.04)	.82 (.04)	1.55 (.15)	.23 (.05)	.24 (.04)	.39 (.04)	.23 (.03)	.16 (.04)
95% CI of R.O.D. Mean	[.41, .45]	[.64, .68]	[.80, .84]	[1.47, 1.64]	[.21, .26]	[.22, .27]	[.36, .41]	[.21, .25]	[.14, .18]
I.D. *M* (*SD*)	.42 (.06)	.64 (.06)	.82 (.04)	1.37 (.18)	.20 (.04)	.19 (.06)	.40 (.08)	.21 (.05)	.18 (.06)
95% CI of I.D. Mean	[.39, .46]	[.60, .67]	[.80, .84]	[1.26, 1.47]	[.18, .23]	[.16, .23]	[.35, .44]	[.19, .24]	[.15, .22]
Model 2 (*n* = 15)									
Model Value	.47	.66	.85	1.66	.30	.38	.39	.19	.19
U.O.D. *M* (*SD*)	.41 (.04)	.63 (.04)	.84 (.03)	1.48 (.10)	.25 (.05)	.32 (.06)	.43 (.04)	.22 (.04)	.21 (.03)
95% CI of U.O.D. Mean	[.39, .44]	[.61, .66]	[.82, .86]	[1.43, 1.53]	[.22, .28]	[.29, .35]	[.41, .45]	[.20, .24]	[.19, .22]
R.O.D. *M* (*SD*)	.45 (.04)	.66 (.03)	.85 (.03)	1.49 (.13)	.24 (.05)	.29 (.07)	.40 (.05)	.21 (.05)	.19 (.04)
95% CI of R.O.D. Mean	[.43, .48]	[.64, .68]	[.83, .87]	[1.42, 1.56]	[.22, .27]	[.25, .33]	[.37, .43]	[.18, .23]	[.17, .21]
I.D. *M* (*SD*)	.40 (.06)	.62 (.05)	.82 (.04)	1.34 (.13)	.21 (.06)	.17 (.06)	.42 (.06)	.23 (.04)	.20 (.05)
95% CI of I.D. Mean	[.36, .43]	[.59, .65]	[.80, .84]	[1.34, 1.41]	[.17, .24]	[.14, .20]	[.39, .46]	[.21, .25]	[.17, .22]
Model 3 (*n* = 12)									
Model Value	.46	.66	.83	1.78	.28	.31	.37	.20	.17
U.O.D. *M* (*SD*)	.41 (.05)	.64 (.05)	.82 (.04)	1.62 (.07)	.25 (.05)	.27 (.03)	.41 (.05)	.23 (.03)	.18 (.03)
95% CI of U.O.D. Mean	[.38, .44]	[.61, .67]	[.80, .84]	[1.58, 1.67]	[.22, .28]	[.25, .29]	[.38, .44]	[.21, .25]	[.16, .20]
R.O.D. *M* (*SD*)	.42 (.04)	.64 (.04)	.82 (.03)	1.62 (.12)	.22 (.06)	.28 (.05)	.40 (.04)	.22 (.04)	.18 (.03)
95% CI of R.O.D. Mean	[.40, .45]	[.62, .67]	[.80, .84]	[1.54, 1.70]	[.18, .26]	[.24, .31]	[.37, .43]	[.19, .24]	[.16, .20]
I.D. *M* (*SD*)	.40 (.07)	.65 (.04)	.83 (.03)	1.34 (.16)	.20 (.05)	.19 (.04)	.43 (.06)	.25 (.03)	.18 (.04)
95% CI of I.D. Mean	[.36, .45]	[.63, .68]	[.81, .85]	[1.24, 1.44]	[.17, .24]	[.16, .22]	[.39, .47]	[.23, .27]	[.16, .20]
Model 4 (*n* = 12)									
Model Value	.47	.68	.85	1.54	.27	.28	.38	.21	.17
U.O.D. *M* (*SD*)	.43 (.05)	.65 (.04)	.82 (.04)	1.44 (.13)	.23 (.03)	.27 (.03)	.39 (.04)	.23 (.04)	.17 (.03)
95% CI of U.O.D. Mean	[.40, .46]	[.63, .68]	[.79, .85]	[1.36, 1.53]	[.21, .25]	[.25, .28]	[.37, .42]	[.20, .25]	[.15, .18]
R.O.D. *M* (*SD*)	.44 (.06)	.67 (.04)	.85 (.03)	1.48 (.11)	.22 (.04)	.24 (.05)	.41 (.05)	.24 (.05)	.17 (.03)
95% CI of R.O.D. Mean	[.40, .47]	[.64, .70]	[.83, .86]	[1.41, 1.56]	[.19, .24]	[.21, .27]	[.38, .44]	[.21, .27]	[.15, .19]
I.D. *M* (*SD*)	.40 (.07)	.64 (.06)	.80 (.06)	1.36 (.10)	.20 (.03)	.21 (.05)	.40 (.05)	.24 (.04)	.16 (.03)
95% CI of I.D. Mean	[.35, .44]	[.60, .68]	[.76, .83]	[1.30, 1.43]	[.18, .22]	[.18, .23]	[.37, .43]	[.21, .27]	[.14, .18]

Note. U.O.D. = Upright Observation-based Drawing; R.O.D. = Rotated (Side-Ways) Observation-based Drawing; I.D. = Imagination-based Drawing.

positively correlated at the .05 α level. These included the same 4 SRRs that were significantly correlated at the .05 α level when imagination- and upside-down observation-based drawings were compared in Study 2 (interocular distance, nose-width, eye-mouth distance and eye-nose distance), in addition to the eye height SRR. The correlation coefficients for these 5 relationships varied from .289 to .422, reflecting moderately strong relationships. Unlike the significant correlations observed when comparing the imagination- to the upright observation-based drawings in this study, the nose height, mouth height and nose-mouth distance SRRs were not significantly correlated at the .05 α level between the imagination- and sideways observation-based drawings, and the correlation coefficients for these 3 relationships ranged from .084 to .270, indicating weak-to-absent associative strength. Additionally, and like every analysis performed thus far involving this SRR, head shape was not significantly correlated at the .05 α level between these two types of drawings.

As with the prior two studies, we reassessed the significance tests using Hochberg Step-Up corrected α levels. With respect to the comparison of the imagination- and upright observation-based drawings, 6 out of the 8 SRRs that were significantly correlated at the .05 α level remained statistically significant at the Hochberg corrected α level. These included the eye height, nose height, mouth height, eye-mouth distance, eye-nose distance and nose-mouth distance SRRs, and their correlation coefficients ranged from .362 to .486. The two SRRs whose *p*-values fell between the Hochberg corrected α level and .05 included the interocular distance and nose-width SRRs, whose coefficient values were .279 (p = .04) and .290 (p = .03), respectively.

When adopting the corrected α-levels with respect to the significance tests relevant to the comparison of the imagination- and sideways observation-based drawings, only 1 of the 5 SRRs that were significant at the .05 α-level remained statistically significant at the corrected α level. This was the eye-mouth distance SRR, and its correlation coefficient equaled .422. The four SRRs whose *p*-values fell between the Hochberg corrected α level and .05 were the eye height (p = .03), interocular distance (p = .008), nose width (p = .008) and eye-nose distance (p = .02) SRRs, and their correlation coefficients ranged from .289 to .358.

Ancillary Analyses

First, we assessed systematic versus random *directional drawing error biases* in the upright and sideways observation-based drawings following the method of Studies 1 and 2. Based on results depicted in Table 6, we observed that the distribution of errors for both types of drawings were systematically biased, on

Table 6

Study 3: M, Standard Deviation and 95% Confidence Intervals of the Means for the Upright and Sideways Observation-Based Drawing Errors; Results of Inferential Tests Assessing Systematic Biases in the Upright and Sideways Observation-Based Drawing Directional Errors; Results of Inferential Tests Assessing Significant Differences in Absolute Errors Between the Upright vs. Sideways Observation-Based Drawings

	Spatial relation ratios								
Statistics	B/A	C/A	D/A	A/E	F/E	G/E	(D-B)/A	(C-B)/A	(D-C)/A
U.O.D. Directional Error *M* (*SD*)	.91 (.10)	.96 (.07)	.99 (.05)	.90 (.07)	.89 (.18)	.88 (.14)	1.08 (.11)	1.09 (.17)	1.07 (.17)
95% CI of U.O.D. Error Mean	[.88, .94]	[.95, .98]	[.97, 1.00]	[.89, .92]	[.84, .94]	[.84, .92]	[1.05, 1.11]	[1.04, 1.14]	[1.03, 1.12]
t, *p* (two-tailed)	6.56, <.001	3.68, .001	2.11, .039	10.32, <.001	4.54, <.001	6.50, <.001	5.25, <.001	3.87, <.001	3.12, .003
Cohen's *d*	.89	.50	.29	1.40	.62	.88	.71	.53	.42
R.O.D. Directional Error *M* (*SD*)	.95 (.09)	.98 (.06)	1.00 (.04)	.93 (.08)	.85 (.19)	.85 (.18)	1.07 (.13)	1.07 (.20)	1.07 (.22)
95% CI of R.O.D. Error Mean	[.92, .97]	[.97, 1.00]	[.99, 1.01]	[.91, .95]	[.80, .90]	[.80, .90]	[1.03, 1.10]	[1.02, 1.13]	[1.01, 1.13]
t, *p* (two-tailed)	4.31, <.001	1.91, .061	0.04, .965	6.35, <.001	5.89, <.001	6.00, <.001	3.94, <.001	2.72, .009	2.36, .022
Cohen's *d*	.59	.26	.01	.86	.80	.82	.54	.37	.32
M (*SD*) U.O.D.-R.O.D. A.E. Difference	.03 (.08)	.01 (.06)	.01 (.04)	.01 (.07)	−.02 (.15)	−.04 (.12)	−.01 (.08)	−.02 (.13)	−.01 (.17)
95% CI of A.E. Mean Difference	[.01, .05]	[−.01, .03]	[−.00, .02]	[−.00, .03]	[−.07, .02]	[−.01, −.07]	[−.03, .01]	[−.05, .02]	[−.06, .03]
t, *p* (two-tailed)	2.59, .012	1.19, .240	1.69, .096	1.64, .106	1.24, .219	2.32, .024	0.82, .416	0.97, .336	0.62, .536
Cohen's *d*	.35	.16	.23	.22	.17	.32	.11	.13	.08

Note. [a] U.O.D. = Upright Observation-based Drawing; R.O.D. = Rotated (Side-Ways) Observation-based Drawing; [b] Directional U.O.D. & R.O.D. Error = (O.D. SSR/Model SSR), comparatively, error values closer to 1.00 indicate smaller errors than error values farther away from 1.00; [c] *M* (*SD*) values of O.D. directional errors were calculated after collapsing across the drawings of all 4 models; [d] Values of *t*, *p* and Cohen's *d* in the first two sections of the table are based on single-sample t-tests ($df = 53$) designed to assess whether the mean O.D. directional errors significantly differed from a test value of 1.00 (indicative of no error); [e] U.O.D. & R.O.D. Absolute Error (A.E.) = Absolute Value (1-Directional Error); [d] Values of *t*, *p* and Cohen's *d* in the last section of the table are based on a paired-sample t-tests ($df = 53$) designed to assess whether absolute errors significantly differed between the upright vs. sideways drawings (all difference scores were calculated as U.O.D. absolute error—R.O.D. absolute error).

average, in the direction of drawing (a) the eyes too high and too close together (B/A & F/E), (b) the nose too narrow (G/E), (c) the head too round (A/E) and (d) the vertical distances between the eyes-to-mouth ([D-B]/A), eyes-to-nose ([C-B]/A) and nose-to-mouth ([D-C]/A) too long. In the upright but not sideways drawings, the distribution of errors were systematically biased in the direction of drawing the nose and mouth too high (C/A & D/A; error biases were random in direction for the sideways drawings).

Next, we tested for differences in *absolute drawing errors* between the upright versus sideways drawings using the same method of analysis described in Study 2 when comparing errors between the upright versus upside-down drawings. The results found in Table 6 indicate that sideways drawings were significantly more accurate in reproducing the height of the eyes (B/A). In contrast, sideways drawings were significantly less accurate in reproducing the width of the nose (G/E). Absolute drawing errors did not significantly differ between the two types of drawings with respect to height of the nose and mouth (C/A & D/A), the shape of the head (A/E), the interocular distance (F/E), and vertical distances between the eyes and mouth ([D-B]/A), eyes and nose ([C-B]/A) and nose and mouth ([D-C]/A).

Discussion

First, when assessing the correlations between the upright imagination- and observation-based drawings in Study 3, we observed consistency in how these upright drawings were correlated in Studies 1 and 2. Namely, we observed that individual differences in how the imagination-based drawings depicted the eye height, nose height, interocular distance, nose width, eye-mouth distance, eye-nose distance and nose-mouth distance reliably predicted how they were reproduced in the upright observation-based drawings. Additionally, as in Study 2 (but not in Study 1), the mouth height was significantly correlated for upright imagination- and observation-based drawings. Further, across all three studies, we did not observe a significant correlation between the two types of upright drawings with respect to the shape of the head. Overall, the strong consistency observed for these correlations pertaining to these drawings suggests that the predictive relationships between upright imagination- and observation-based drawings are generally stable across different samples and is not temporally-specific to short- or long-delays between the production of the two types of drawings.

Next, when assessing the predictive relationship between upright imagination-based drawings and sideways observation-based drawings, the pattern of correlations observed was very similar to that observed in Study 2 when assessing the relationship between upright imagination-based drawings and upside-down observation-based drawings. Across Studies 2 and 3, individual differences in how the upright imagination-based drawings depicted the interocular distance, nose width, eye-mouth distance and eye-nose distance reliably predicted individual variability in how they were reproduced in the observational drawings of both types of rotated models. Further, in both studies, how the imagination-based drawings depicted the nose height, mouth height and nose-mouth distance did not reliably predict how they were reproduced in the two rotated observation-based drawings. The only discrepancy in the results of the significance tests was the observation in Study 3 that the imagination-based drawings' depictions of eye height was significantly correlated with how eye height was reproduced in the sideways, but not upside-down, observational drawings. However, it is important to note that there was a minimal difference between the correlation coefficients that quantified how imagination-based drawings were related to the sideways observational drawings (r = .289, p = .03) and the upside-down observational drawings (r = .254, p = .06) pertaining to this SSR. Thus, the results pertaining to how the imagination-based drawings of eye height were related to subsequent reproductions in the two rotated observational drawing tasks were generally consistent, at least when evaluated based on correlation coefficients as opposed to the results of the significance tests.

This general consistency between the results of Studies 2 and 3 demonstrates that the nonorientation-specific relationships between the imagination- and upside-down observation-based drawings pertaining to interocular distance, nose width, eye-mouth distance and eye-nose distance were not observed due to the fact that both upright and upside-down faces do not differ from each other in terms of the vertical versus horizontal directions of the spatial relationships assessed in these studies. This provides stronger evidence in favor of the notion that, at least with respect to these four SSRs, the predictive relationship between imagination- and observation-based drawings is not orientation-specific.

As in Study 2, the results indicate that the relationship between imagination- and observation-based drawings is orientation-specific for some spatial relationships but not for others. As in the Discussion of Study 2, we may utilize an absolute versus relative spatial relationship framework to distinguish between the spatial relationships that are orientation-specific versus -nonspecific with respect to their predictive relationships between these two types of drawings. Since the results of Study 3 pertaining to the sideways drawings were so similar to the results of Study 2 pertaining to the upside-down drawings, we will not reiterate that discussion here. However, it is important to note the finding that the depicted eye-height was significantly correlated between imagination- and sideways observation-drawings, which may be inconsistent with the idea that the relationship between imagination- and observation-based drawings is orientation-specific for absolute spatial relationships but not for relative spatial relationships. Despite this apparent inconsistency, support for this idea may still be provided by the finding that the correlations between imagination- and observation-based drawings pertaining to the eye height were stronger when the orientation of the two types of drawings were both upright than when they were mismatched in orientation (r values of .412 vs. .254 in Study 2 and .479 vs. .289 in Study 3). Thus, if one adopts a continuous, rather than dichotomous, perspective of the concept of orientation-specificity, one may conclude that the associative relationship between imagination- and observation-based drawings with respect to eye height is more orientation-specific than the associative relationship between the two types of drawings with respect to the relative spatial relationships assessed in this study.

Discussion of the results of the ancillary analyses is found in the General Discussion section of this article.

General Discussion

Primary Analyses

In Studies 1–3, the finding that the depiction of many spatial relationships within a face are positively correlated between upright imagination- and observation-based drawings regardless of there being a months- versus minutes-long delay in the production of the two types of drawings indicates that long-term memory is the basis of the predictive relationship between these two types of drawings. Further, in Studies 2 and 3, we found that there were a set of spatial relationships (e.g., interocular distance, nose width, eye-mouth distance and eye-nose distance) that were positively correlated between upright imagination-based drawings and observation-based drawings that reproduced both upright and rotated models. This demonstrates that, at least for these four spatial relationships, the predictive relationship between these two types of drawings is not dependent on the two types of drawings being matched in orientation.

In sum, we interpret these findings to suggest that when individuals attempt to reproduce a model in an observational drawing task, a stable long-term memory representing how to depict the spatial relationships between features in a face is activated and partially biases, in addition to the perceptual processing of visual information found in the model, how those spatial relationships are reproduced in the drawings. This may provide a partial explanation of the individual variability that is found in the ultimate appearance of observational drawings. We assume, based on the individual differences in the appearance of the imagination-based drawings, that the long-term memories representing how to draw a face are idiosyncratic. Thus, individual differences in the depictions of spatial relationships in observation-based drawings may be partially based on individual differences in how these spatial relationships are represented in long-term memory. However, despite this evidence that suggests a role of some type of long-term memory process in the production of observational drawings, it is presently unclear what exactly is represented in such long-term memories. Such memory representations could contain perceptual, spatial (either categorical or metric), procedural, motor and/or declarative knowledge information. Presently, the methods of the studies conducted to date on this topic do not provide information that would allow one to characterize the nature of the long-term memories relevant to the relationships that were assessed here.

Moving along, we next discuss multiple limitations of the current studies. First, the predictive relationships between imagination- and observation-based drawings were only assessed in the current and prior studies (Harrison et al., 2017; Matthews & Adams, 2008; Ostrofsky et al., 2015), with respect to spatial aspects of drawing. This narrow focus on the depiction of spatial relationships does not reflect a presumption on our part that spatial relationships are a special aspect of drawing when considering the predictive relationship between these two types of drawings. There are many other aspects of drawing (e.g., how individual features are depicted independent of spatial positioning and shading patterns) that may just as well have representations in long-term memory that are activated and bias the production of observation-based drawings. However, the reason for this narrow focus is because spatial relationships between features, unlike nonspatial aspects of drawing, are capable of being easily measured using quantitative variables (e.g., spatial relation ratios) that can be subjected to correlational analysis. Thus, it is presently unclear as to whether the predictive relationship between these two types of drawings extend to nonspatial aspects of drawing, and consequently, it is presently unclear as to whether there are representations in long-term memory concerning nonspatial aspects of drawing that are activated and ultimately bias the production of observational drawings.

A second limitation, relevant to Study 1, concerns our inability to control the experiences of subjects during the 1.Five-month delay period between the production of the imagination- and observation-based drawings. It cannot be ruled out that some participants produced imagination-based face drawings immediately before they returned to the lab to produce the observation-based drawing. If most participants did this, then that would potentially limit our ability to conclude that the correlations between the two types of drawings were mediated by a long-term memory process. Although there is no way to know for sure, we suspect that most participants did not produce a drawing of a face immediately before returning to the lab to produce their observation-based drawing. However, even assuming that they did, the fact that the observation-based drawings were correlated in appearance with the imagination-based drawings produced in the lab 1.5 months earlier still suggest an influence of stable long-term graphic memories in the production of observation-based drawings. For instance, if the observation-based drawings were more biased by the production of an imagination-based drawing produced immediately before they returned to the lab (as opposed to the one produced in the lab during the first session), the fact that the observation-based drawings were still correlated with the appearance of the imagination-based drawings produced 1.5 months earlier would suggest that the production of imagination-based face drawings are guided by a stable, long-term graphic memory that does not change much over a 1.5 month Time period (as opposed to an unstable memory process that varies within a 1.5 month Time period). Thus, although it would have been ideal if participants were prevented from creating any face drawings during the 1.5 month delay, this was not practical (although, an improvement to the method of Study 1 would have been to use a survey to assess whether they did or not). Further, based on the reasoning described above, we do not believe this to be a limitation that raises major doubt over the main conclusions we have drawn from the results of Study 1.

Another limitation to this study is that the sample was composed of mostly, if not all, untrained novices who were not particularly skilled in face drawing[1]. Thus, we are not able to evaluate how well these findings generalize to expert populations of artists who are skilled in drawing. Future research aiming to determine whether the predictive relationship between imagination- and observation-based drawings generalizes to those skilled in drawing could help to inform expertise-related theories of drawing performance. Matthews and Adams (2008) titled their article that originally reported the predictive relationship between these two types of drawings, "*Another reason why adults find it hard to draw accurately*," and wrote in their article, ". . . *it seems that part of the reason why adults struggle to produce accurate drawings is because they are biased toward using certain proportions which are specific to the individual and independent of both the appearance of the object in front of them and their knowledge of that object,*" (p. 630). This reflects a perspective that the influence of long-term memory representations is primarily a source of error

[1] Identifying participants as mostly untrained novices is speculative, though informal inspection of the drawings suggested a low general level of drawing skill.

when individuals produce an observational drawing. Consequently, this perspective further assumes that skilled observational drawing is achieved by an individual suppressing the activation of long-term memories that represent how to draw an object so that the drawing is guided more strongly, if not exclusively, by the visual information apparent in the model. This theory would predict that, for a sample of expert artists skilled in drawing, there would not be an associative relationship between how spatial relationships are depicted between imagination- and observation-based drawings.

However, schema theories of drawing expertise (Gombrich, 1960; Kozbelt & Seeley, 2007) have provided an alternative perspective. In this view, the development of drawing expertise coincides with the development of increasingly more accurate and sophisticated long-term memories that represent the appearance, form and spatial proportions inherent in commonly drawn objects and features. An application of this perspective is reflected by art educators' common use of "how-to" drawing manuals, many of which provide art-students explicit, declarative knowledge pertaining to canonical proportions among features within objects (e.g., the eyes are positioned approximately half-way down the head; the human body is approximately 7.5 heads tall, etc.), visual cues to use to effectively convey three-dimensional form (e.g., shading, appropriate use of line junctions), and sequential strategies that provide step-by-step procedures for how to draw common objects. This schema theory of drawing expertise generally argues that the difference between novice and expert drawers is not related to the influence versus Noninfluence of activated long-term memories during observational drawing production, but rather, the influence of nonsophisticated, inaccurate long-term memory representations in novices (leading to low-quality observational drawings) versus more sophisticated and accurate long-term memory representations in experts (leading to higher quality observational drawings). If this perspective provides an accurate account of drawing expertise, then one would hypothesize no difference between experts and novices with respect to the existence of predictive relationships between the appearance of imagination- and observation-based drawings.

A third possible account of expertise in drawing relating to this issue may involve what could be considered to be an integration of the two perspectives described above. Gombrich (1960) offered a "making before matching" perspective to drawing expertise. Here, expert artists begin their depictions of an object by first utilizing, at least partially, their long-term memories of how to draw an object to initially depict the model being reproduced ("making"). Once an initial memory-biased depiction of the object is conveyed, experts engage in an error-correction process ("matching") that adjusts the initial, inaccurate depiction to better match the visual appearance of the model being reproduced. Adopting this view, one may argue that the difference between experts and novices in drawing ability is not due to experts totally suppressing the influence of long-term memory on drawing performance but is instead due to a difference between experts and novices in a later error-correction process. It may be that experts are more likely to accurately correct any errors initially made due to the influence of long-term memory biases whereas novices do not engage in (or do so in a less accurate manner) a process of correcting for any long-term memory biases.

Ancillary Analyses

Across all three studies, we assessed whether errors in reproducing the spatial relationships between features were directionally biased in a systematic or random manner. We observed in upright, upside-down and sideways drawings systematic directional biases to draw the eyes too high and too close together, the head too round, the nose too narrow, and the vertical distances between the eyes and mouth, eyes and nose and nose and mouth to be too long. Although not all of these relationships were assessed in prior studies (Ostrofsky et al., 2014; Ostrofsky et al., 2015); these results were consistent with prior findings of systematic directional error biases to reproduce the eyes too high, the head too round and the nose too narrow in upright face drawings. However, one prior finding of the eyes being drawn too far apart (Ostrofsky et al., 2014) was inconsistent with the results of the current study, and one prior finding of the mouth being drawn too high (Ostrofsky et al., 2014) was only replicated in the upright drawings of Study 3 (the remaining drawings in Studies 1–3 observed random directional error biases for the reproduction of the mouth height). The current studies add to the literature on this specific topic by uncovering, for the first time, systematic biases in (a) drawing the vertical distances between the eyes and mouth, eyes and nose and nose and mouth in upright drawings and (b) in the reproduction of these spatial relationships in upside-down and sideways observation-based drawings. Based on prior research that demonstrated a similarity in these types of systematic directional biases between imagination- and observation-based drawings (Ostrofsky et al., 2015), one may speculate that these types of observational drawing biases are present due to these biases being represented within the long-term memories that are relevant to the current studies.

In Studies 2 and 3, we assessed differences in absolute drawing errors between upright and upside-down drawings in the attempt to replicate prior findings (Day & Davidenko, 2018; Ostrofsky, Kozbelt, Cohen, et al., 2016; Viviani & Bruno, 2017); and for the first time, between upright and sideways drawings. With respect to the comparison of upright and upside-down observation-based drawings, we replicated in Study 2 the prior finding that reproductions of the eye-mouth distance were less accurate in upside-down drawings relative to upright drawings, and that there were no significant differences between these two types of drawings with respect to errors in reproducing the nose-mouth distance and the interocular distance (Ostrofsky, Kozbelt, Cohen, et al., 2016). Study 2 adds to our knowledge on the effect of face inversion on drawing errors by demonstrating nonsignificant differences in errors between the two types of drawings with respect to the reproductions of the heights of the eyes, nose and mouth, the nose width and the nose-mouth distance (these spatial relationships were not assessed in prior studies on this topic). Another novel finding is the first demonstration, as far as we are aware, of a spatial relationship (specifically, head-roundness) that is drawn more accurately in upside-down, relative to upright, drawings (once again, this spatial relationship was not assessed in prior studies on this topic).

The comparison of errors between upright and sideways drawings in Study 3 is a comparison with no precedent in the literature. Here, we observed that the effects of rotating a model face sideways does not produce the same pattern of effects that rotating a model face upside down does. Unlike the pattern of effects observed in Study 2, we observed that the only effects of rotating the model sideways (relative to upright) was larger errors in reproducing the nose-width and smaller errors in reproducing the eye height.

Due to the posthoc nature of many of these ancillary analyses, we will not discuss the results of these ancillary analyses any further, saving for the suggestion that some of the interesting discrepancies with prior findings and novel findings reported here should be pursued and discussed in future research.

Conclusion

The results of the current study add to the body of evidence that individual differences in observational drawing performance are not only associated with individual variability in the perceptual, attentional and decision-making processes that occur during the act of drawing. In addition to findings that the production of observational drawings is biased by declarative knowledge acquired before a model is viewed and drawn (Ostrofsky, Kozbelt, Cohen, et al., 2016) and by verbal descriptions of what model object represents (Ostrofsky et al., 2017), the results of the current sideways generally suggest that long-term memories acquired and processed before the act of drawing is initiated partially biases the production of observational drawings. In applying these findings to art-education, it seems important that instruction is not only targeted to developing students' perceptual, attentional and decision-making skills, but is also targeted to developing more sophisticated and accurate long-term memories about the form and proportions of objects which individuals commonly draw.

References

Allen, M. L., & Chambers, A. (2011). Implicit and explicit understanding of ambiguous figures by adolescents with autism spectrum disorder. *Autism: An International Journal of Research and Practise*, *15*(4), 457–472. https://doi.org/10.1177/1362361310393364

Carmichael, L., Hogen, H. P., & Walter, A. A. (1932). An experimental study of the effect of language on the reproduction of visually perceived form. *Journal of Experimental Psychology*, *15*(1), 73–86. https://doi.org/10.1037/h0072671

Chamberlain, R., Drake, J. E., Kozbelt, A., Hickman, R., Siev, J., & Wagemans, J. (2019). Artists as experts in visual cognition: An update. *Psychology of Aesthetics, Creativity, and the Arts*, *13*(1), 58–73. https://doi.org/10.1037/aca0000156

Chamberlain, R., & Wagemans, J. (2015). Visual arts training is linked to flexible attention to local and global levels of visual stimuli. *Acta Psychologica*, *161*, 185–197. https://doi.org/10.1016/j.actpsy.2015.08.012

Chamberlain, R., & Wagemans, J. (2016). The genesis of errors in drawing. *Neuroscience and Biobehavioral Reviews*, *65*, 195–207. https://doi.org/10.1016/j.neubiorev.2016.04.002

Cohen, D. J. (2005). Look little, look often: The influence of gaze frequency on drawing accuracy. *Perception & Psychophysics*, *67*(6), 997–1009. https://doi.org/10.3758/bf03193626

Cohen, D. J., & Earls, H. (2010). Inverting an image does not improve drawing accuracy. *Psychology of Aesthetics, Creativity, and the Arts*, *4*(3), 168–172. https://doi.org/10.1037/a0017054

Day, J. A., & Davidenko, N. (2018). Physical and perceptual accuracy of upright and inverted face drawings. *Visual Cognition*, *26*(2), 89–99. https://doi.org/10.1080/13506285.2017.1388323

Eberhardt, J. L., Dasgupta, N., & Banaszynski, T. L. (2003). Believing is seeing: The effects of racial labels and implicit beliefs on face perception. *Personality and Social Psychology Bulletin*, *29*(3), 360–370. https://doi.org/10.1177/0146167202250215

Edwards, B. (2012). *Drawing on the right side of the brain: The definitive* (4th ed.). Penguin Group USA.

Gombrich, E. H. (1960). *Art and illusion*. Princeton University Press.

Harrison, N. R., Jones, J., & Davies, S. J. (2017). Systematic distortions in vertical placement of features in drawings of faces and houses. *Perception*, *8*(1), 2041669517691055. https://doi.org/10.1177/2041669517691055

Kozbelt, A., & Seeley, W. (2007). Integrating art historical, psychological, and neuroscientific explanations of artists' advantages in drawing and perception. *Psychology of Aesthetics, Creativity, and the Arts*, *1*(2), 80–90. https://doi.org/10.1037/1931-3896.1.2.80

Matthews, W. J., & Adams, A. (2008). Another reason why adults find it hard to draw accurately. *Perception*, *37*(4), 628–630. https://doi.org/10.1068/p5895

Mitchell, P., Ropar, D., Ackroyd, K., & Rajendran, G. (2005). How perception impacts on drawings. *Journal of Experimental Psychology: Human Perception and Performance*, *31*(5), 996–1003. https://doi.org/10.1037/0096-1523.31.5.996

Ostrofsky, J., Cohen, D. J., & Kozbelt, A. (2014). Objective versus Subjective Measures of Face-Drawing Accuracy and their Relations with Perceptual Constancies. *Psychology of Aesthetics, Creativity, and the Arts*, *8*(4), 486–497. https://doi.org/10.1037/a0037558

Ostrofsky, J., Kozbelt, A., Cohen, D. J., Conklin, L., & Thomson, K. (2016). Face inversion impairs the ability to draw long-range, but not short-range, spatial relationships between features. *Empirical Studies of the Arts*, *34*(2), 221–233. https://doi.org/10.1177/0276237416634851

Ostrofsky, J., Kozbelt, A., & Seidel, A. (2012). Perceptual constancies and visual selection as predictors of realistic drawing skill. *Psychology of Aesthetics, Creativity, and the Arts*, *6*(2), 124–136. https://doi.org/10.1037/a0026384

Ostrofsky, J., Kozbelt, A., Tumminia, M., & Cipriano, M. (2016). Why do non-artists draw the eyes too far up the head? How vertical eye-erawing errors relate to schematic knowledge, pseudoneglect and context-based perceptual biases. *Psychology of Aesthetics, Creativity, and the Arts*, *10*(3), 332–343. https://doi.org/10.1037/a0040368

Ostrofsky, J., Nehl, H., & Mannion, K. (2017). The effect of object interpretation on the appearance of drawing of ambiguous figures. *Psychology of Aesthetics, Creativity, and the Arts*, *11*(1), 99–108. https://doi.org/10.1037/aca0000084

Ostrofsky, J., Kozbelt, A., & Cohen, D. J. (2015). Observational drawing biases are rredicted by biases in perception: Empirical support of the misperception hypothesis of drawing accuracy with respect to two angle illusions. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *68*(5), 1007–1025. https://doi.org/10.1080/17470218.2014.973889

Perdreau, F., & Cavanagh, P. (2014). Drawing skill is related to the efficiency of encoding object structure. *Perception*, *5*(2), 101–119. https://doi.org/10.1068/i0635

Sommers, P. V. (1984). *Drawing and cognition: Descriptive and experimental studies of graphic production processes*. Cambridge University Press. https://doi.org/10.1017/CBO9780511897672

Tchalenko, J. (2009). Segmentation and accuracy in copying and drawing: Experts and beginners. *Vision Research*, *49*(8), 791–800. https://doi.org/10.1016/j.visres.2009.02.012

Vinter, A. (1999). How meaning modifies drawing behavior in children. *Child Development*, *70*(1), 33–49. https://doi.org/10.1111/1467-8624.00004

Viviani, E., & Bruno, N. (2017). Learning to draw: Does the inversion technique work? *Psihologija*, *50*(3), 271–283. https://doi.org/10.2298/PSI1703271V

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