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The Effects of Disrupting Holistic Processing on the Ability to Draw a Face

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Abstract

Previous research has demonstrated that those more skilled in drawing tend to exhibit stronger local perceptual processing biases than those less skilled in drawing. However, due to the correlational nature of this research, it is unclear whether drawing performance is facilitated by biasing perception towards local visual information. In order to investigate this, we conducted an experiment where participants drew an aligned face or a horizontally-misaligned face. Previous perceptual research has demonstrated that aligned faces are processed holistically, whereas misaligned faces are processed locally. Thus, drawings of aligned faces are assumed to be guided by holistic processing, whereas drawings of misaligned faces are assumed to be guided by local processing. Drawings were objectively measured according to the relative spatial positioning of facial features. Relative to drawings of aligned faces, the accuracy of misaligned face drawings was either impaired (for drawings of the distance between the eyes and mouth) or was not affected (for drawings of the interocular distance, the distance between the nose and mouth, and the distance between the eyes and eyebrows). This pattern of drawing errors mirrored the effects of face inversion that has previously been reported, another manipulation that is thought to disrupt holistic processing. At least with respect to drawing the relative spatial positioning of facial features, we did not observe any evidence that supports the notion that biasing perceptual processing towards local visual information directly facilitates drawing performance.

Keywords

Face drawing, holistic processing, face misalignment, spatial drawing

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1. The Effects of Disrupting Holistic Processing on the Ability to Draw a Face

Observational drawing is the activity of attempting to draw a recognizable reproduction of a model object that is directly perceived by the individual producing the drawing. Substantial individual variability exists with respect to adults' ability to produce high quality drawings of this type, and much research has been dedicated to understanding the cognitive processes that directly influence and/or are associated with this variability (Chamberlain and Wagemans, 2016). Because observational drawing begins with visually perceiving the model to be drawn, many researchers have generally focused on individual variability in perceptual processing as a source of variability in observational drawing ability (e.g., Cohen, 2005; Cohen and Jones, 2008; Mitchell *et al.*, 2005; Ostrofsky *et al.*, 2012, 2015; Perdreau and Cavanagh, 2011).

A specific line of questioning that has come out of this area of research concerns how observational drawing ability is associated with differences in local vs global visual processing (e.g., Chamberlain *et al.*, 2013; Chamberlain and Wagemans, 2015; Drake, 2013; Drake and Winner 2011; Drake *et al.*, 2010; Zhou *et al.*, 2012). Local vs global visual processing refers to the distinction between individuals' ability to perceive and attend to, respectively, the isolated individual features that are contained in an object vs the singular holistic form of an object.

Collectively, the research referenced in the previous paragraph has suggested that stronger observational drawing ability is associated with a stronger ability to perceive and attend to local visual information and/or a stronger ability to suppress perceptual processing towards global visual information. For instance, three studies published by Drake and her colleagues reported that neurotypical children (Drake, 2013; Drake *et al.*, 2010) and adults (Drake and Winner, 2011) capable of producing higher-quality observational drawings exhibited a stronger local processing bias than those who produced lower-quality observational drawings. The strength of local visual processing was assessed in these studies by performance in two non-drawing perceptual tasks: (a) a modified version of the Wechsler Intelligence Test's Block Design Task and (b) the Group Embedded Figure Test.

Zhou and colleagues (2012) provided converging evidence that drawing ability is associated with local processing biases. Here, art students with extensive experience in drawing faces were compared to non-art students with respect to their performance on a composite-face task that assessed holistic processing. The composite-face task (for a review, see Rossion, 2013) is a perceptual recognition task that requires participants to compare two sequentially presented faces and make a judgment as to whether a target feature is the same or different between the two faces. Further, the face stimuli are combinations of the top and bottom halves of various faces. Participants are asked to only attend to the top-half of the faces (the target feature) and make a judgment as to whether the top-half of the face is the same or different between the first and second face displayed in each pair. The key manipulation in this task concerns only the trials in which the top-halves of the faces are the same: in some trials, the bottom halves of the two faces in a pair are the same (or, the two faces in a pair are completely identical) whereas in other trials the bottom halves of the two paired faces differ. A common result in this task is that participants are less accurate in judging that the top halves of faces in a pair are the same when the bottom halves differ than when the bottom halves are the same. This finding has been termed by some as the *holistic processing effect*, as it demonstrates that faces are normally recognized as a singular global percept more so than a collection of isolated, local features. The holistic processing effect generally disappears when: (a) the top and bottom halves of the faces are horizontally misaligned and (b) when the faces are presented upside-down. These two observations suggest that holistic face processing is disrupted by perceiving faces that are displayed in an unnatural, non-canonical fashion.

Zhou and colleagues (2012) reported two key findings. First, while both art students and non-art students displayed the holistic processing effect when the top and bottom halves of the faces were aligned, art students exhibited this effect to a significantly weaker degree than non-art students. Second, when the top and bottom halves of the faces were horizontally misaligned, the holistic processing effect disappeared, and there was no significant difference in performance between the art students and non-art students. Converging with the findings reported by Drake and her colleagues, these findings suggest that greater drawing skill is associated with a stronger ability to attend to local visual information and/or a stronger ability to suppress attention towards global information.

In assessing the claim that greater drawing skill is associated with local visual processing biases, it is worth highlighting two main limitations of the studies summarized above. First, the non-drawing perceptual tasks (Block Design Task, Group Embedded Figures Test, Composite Face Task) demand for accurate performance that participants selectively attend to the local visual information and ignore the global visual information. Thus, it is unclear from these studies whether those more skilled in drawing experience a local processing bias in general (or, that they generally prioritize attention towards local over global information) or only in cases when the specific task that is being performed requires the suppression of attention towards global visual information (or, that they generally prioritize attention towards task-relevant information over task-irrelevant information). If the latter, then one may re-interpret these findings to suggest that the local processing bias associated with greater drawing skill simply reflects a more general advantage in perception and/or attention for those with greater drawing skill relative to those with weaker drawing skill (Kozbelt, 2001, 2017). In support of this latter possibility, Chamberlain and Wagemans (2015) reported that those with stronger drawing skill were better able to switch attention between global and local visual information according to task demands. This suggests that greater drawing skill is associated with a stronger ability to deploy attention to task-relevant information rather than a general bias to attend to local over global visual information.

Second, the relationships between drawing skill and local processing biases have been mostly observed in correlational studies assessing the relationship between drawing skill and performance in non-drawing perceptual judgment tasks. What has not been researched well is how, or even if, drawing performance itself is affected by reduced global processing and/or stronger local processing. It could be that drawing performance generally benefits from the selective deployment of attention towards local visual information and away from global visual information. In contrast, and more in line with what is suggested by Chamberlain and Wagemans (2015), it could be that drawing performance is facilitated by reduced holistic processing only when an individual is focusing on drawing a local aspect of the model object (e.g., drawing the details of a small part of a larger object face such as a single eye within a face) but is not facilitated by reduced holistic processing when an individual is focusing on drawing a global aspect of the drawing (e.g., drawing the relative spatial positioning of two or more features contained within an object such as the vertical distance between the eyes and mouth in a face).

One way this discrepancy can be resolved is to conduct experimental studies that manipulate the presence vs absence of global, holistic processing towards a model object and determine how that affects individuals' ability to draw the model. Here, face inversion-based perceptual and drawing experiments are informative, as we have mentioned earlier that face inversion disrupts holistic, global processing of faces. With respect to faces, accurate perception of the spatial relationships between features (e.g., the vertical distance between the eyes and mouth) is strongly supported by holistic processing. An illustrative example comes from a study reported by Freire and co-workers (2000). Here, individuals were observed to be able to accurately discriminate two upright faces as being different when they only differed with respect to the vertical distance between the eyes and mouth and the horizontal distance between the two eyes. When the faces were presented upside down, however, individuals lost their ability to successfully make these discriminations. In contrast, individuals were able to accurately discriminate two faces, when presented both upright and upside down, when the two faces only differed with respect to individual features (e.g., when the two faces only differed with respect to the appearance of the eyes, nose and/or mouth). In addition to the same/different discrimination task used in this study, similar results have been observed using different perceptual tasks (e.g., the use distinctiveness ratings by Leder and Bruce, 1998). Collectively, these findings suggest that disrupting global, holistic processing impairs individuals in their ability to accurately perceive the spatial relationships between facial features, but has no effect with respect to the perception of the individual features themselves.

If drawing performance generally benefits from selective attention towards local visual information and away from global visual information, one would predict that individuals would be able to produce more accurate face drawings when the face model is upside down compared to when it is upright since global, holistic processing is disrupted by face inversion. Prior research has demonstrated, however, that this is not the case (Cohen and Earls, 2010; Day and Davidenko, 2018; Ostrofsky *et al.*, 2016). Cohen and Earls (2010) demonstrated that the effects of face inversion on drawing performance mirrored the perceptual effects (or, lack thereof) discussed above. Namely, individuals were perceived by independent judges to be less accurate in reproducing the spatial relationships between features when drawing an upside-down face relative to when drawing an upright face, but perceived accuracy in drawing the individual features themselves were not affected by the face's orientation. They further provided evidence to suggest that drawing experience does not modulate these effects, as art students and non-art students exhibited the same pattern of drawing effects due to face inversion despite the fact that art students, unsurprisingly, produced more accurate drawings than non-art students. With respect to the effects of face inversion on the drawing of spatial relationships between features, Ostrofsky *et al.* (2016a) reported that the objectively measured accuracy in drawing long-range spatial relationships (e.g., the vertical distance of the eyes and mouth) was selectively impaired by face inversion, as drawing short-range spatial relationships (e.g., the horizontal distance between the two eyes; the vertical distance between the eyes and eyebrows; the vertical distance between the nose and mouth) was unaffected by face inversion. These two studies suggest that, at least with respect to faces, disrupting global processing (and, thus, relying more on local processing) has been demonstrated to have either an impairing effect or no effect at all on drawing performance depending on the aspect of the model being drawn. Thus, there seem to be some cases where a local processing bias would be detrimental, rather than beneficial, to drawing performance.

These face-inversion drawing studies are the only source of evidence to date that suggests holistic, global processing aids drawing performance for some aspects of drawing. However, it is currently unclear whether these patterns of drawing effects were due to intact vs disrupted holistic processing or due to another mechanism that affects the drawing of upright vs inverted faces. For instance, the detrimental effects of face-inversion on the drawing of long-range spatial relationships may be related to attentional biases as opposed to disrupted holistic perceptual processing. It has been previously established that individuals exhibit a bias to allocate attention more strongly to the upper than lower visual field in some studies (Feng and Spence, 2014; Quek and Finkbeiner, 2016; Zito, Cazzoli, Müri, Mosimann and Nef, 2016) and a bias to allocate attention more strongly to the lower than upper visual field in other studies (Christman, 1993; Niebauer and Chistman, 1998). Further, in relation to drawing, one prior study established that face-drawing errors (particularly, vertical eye positioning errors) are associated with upper visual field attentional biases (Ostrofsky *et al.*, 2016b). Although it is not within the scope of this paper to discuss the specific reasons why the upper vs lower visual field would experience an attentional bias, and what determines when the upper vs lower visual field experiences this attentional bias, it is sufficient for our purposes to acknowledge that the upper vs lower visual fields are differentially attended to. Since face-inversion switches which facial features are in the upper vs lower visual field, any face-inversion drawing effect may due to such vertical asymmetries in visual attention. Thus, utilizing an alternative method of disrupting holistic processing that equates which features are found in the upper vs lower visual field across experimental conditions would prevent this mechanism as being a viable explanation of an effects observed.

The current study is an effort to establish convergent validity of different methods that are presumed to disrupt holistic processing in relation to an observational face drawing task. If the pattern of face-inversion effects on drawing performance (pertaining to errors in drawing long-range vs short-range spatial relationships) was due to the disruption of holistic processing, we should expect to observe the same pattern of results when utilizing a different experimental paradigm other than face-inversion to manipulate intact vs disrupted holistic processing. In this study, we administered a drawing task that manipulated whether the model face being drawn was horizontally aligned vs misaligned. As discussed above, horizontal misalignment of faces eliminates the holistic processing effect that is observed for horizontally aligned faces in a face-composite task. Thus, the key assumption of our experiment is that individuals are predominately engaging in global, holistic processing when drawing an aligned face model vs predominately engaging in local processing when drawing a misaligned face model. We measured each model and drawing with respect to the spatial relationships with the same method used in the face-inversion drawing experiment reported by Ostrofsky *et al.* (2016a). Specifically, we measured one long-range spatial relationship (the vertical distance between the eyes and mouth) and three short-range spatial elationships (the vertical distance between the eyes and eyebrows; the vertical distance between the nose and mouth; the horizontal distance between the two eyes). Drawing accuracy was assessed by determining the difference in the relative spatial positioning of features between the models and drawings.

If drawing performance generally benefits from biasing attention towards local information and away from global information, we would expect to observe cases of greater accuracy in drawings of the misaligned faces compared to drawings of the aligned faces. In contrast, if (a) holistic processing facilitates drawing performance and (b) misaligning and inverting a face both disrupts holistic processing in the same way, we would expect to observe cases of greater accuracy in drawings of the aligned faces (relative to the misaligned faces) with respect to the long-range spatial relationship, but no difference in accuracy between the aligned and misaligned faces with respect to drawings of the three short-range spatial relationships. The following experiment evaluated these hypotheses.

2. Method

2.1. Participants

Sixty-four Stockton University undergraduate psychology students participated in the experiment. However, the drawings of two participants were excluded from data analysis for either not completing the drawing (e.g., one or more major facial features were excluded from the drawing; n = 1) or for spending less than five minutes creating the drawing (less than 33.33% of the allotted time limit to complete the drawings; $n = 1$). Thus, our analyses were based on a sample of sixty-two of these participants [53 females, 9 males; M (SD) age = 20.89 (3.78) years old].

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

2.2. Materials

Participants created two drawings of one of four male face models (see Fig. 1). The face models were computer-generated images created using FaceGen Modeller (version 3.1, https://facegen.com/modeller.htm). The faces were varied by race through manipulating the race-morph tool in FaceGen Modeller; 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 facial expression.

Three versions of each face were created using Adobe Photoshop: aligned, bottom misaligned-to-the-right and bottom misaligned-to-the-left. For the misaligned versions, the bottom half of the face was horizontally shifted to the left or right so that the nose was vertically aligned with the ear. In order to equate the edges displayed in the aligned and misaligned faces, a small

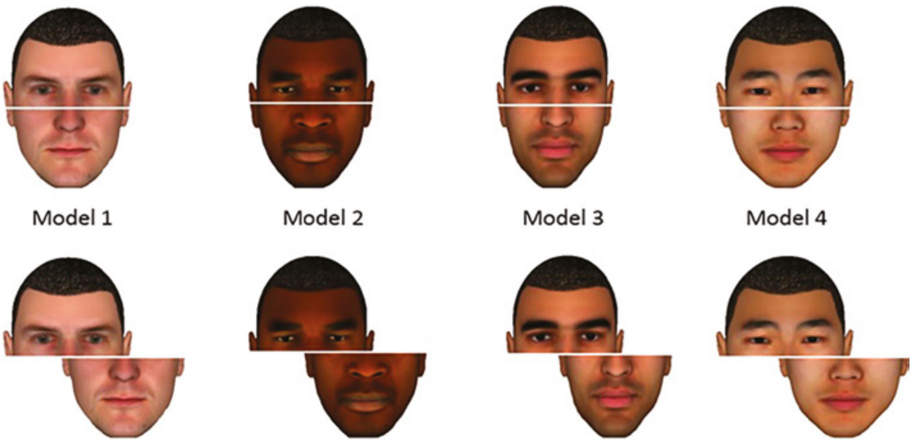


Figure 1. The four face models that participants reproduced in their drawings. Participants were randomly assigned to draw only one of these four models. All four faces in the bottom row depict the appearance of the misaligned-to-the-right models.

horizontal gap (matched in color to the background) was included to separate the top and bottom halves of the faces for both aligned and misaligned face stimuli. In this way, there are two segregated regions of the face presented to participants in both the aligned and misaligned face models.

Face models were displayed against a white background on a computer monitor. As displayed on the computer monitor, each face was approximately 8.75 inches in height, and the horizontal gap in between the top and bottom halves of the face measured 0.13 inches in height.

Participants created each their drawings on a plain 8.5″ × 11″ white sheet of paper using a No. 2 pencil.

2.3. Procedure

After providing informed consent, participants were seated in front of the computer monitor that ultimately would display the models they were asked to draw. Before displaying a face model, the researcher explained that the participants were going to be asked to create multiple drawings of a face model. The researcher further indicated that the participants were not required to be skilled in drawing and that they should try to draw to the best of their ability.

Each participant was randomly assigned to draw one of the four face models twice. All participants were exposed to and asked to draw the aligned face model for their first drawing. For this drawing, the researcher displayed the model image on the computer monitor. Participants were instructed that they were to draw as accurate a copy of the model image as they were capable of. They were instructed not to exclude any of the major features found in the image and not to include any features absent from the image. They were further instructed to include the gap that separated the top and bottom half of the face model in their drawings. Participants were given a 15-minute time limit to complete their drawing and were told that they were allowed to erase and modify any aspect of their drawing during this time period. Once any questions were addressed by the researcher, the participants began drawing.

After the 15-minute time limit expired (or the participants indicated that they had completed their drawing), the drawing was taken by the researcher and participants were provided a new sheet of paper for their second drawing. All participants created a second drawing of the same face model used during the first drawing. Here, participants were randomly assigned to either draw the aligned face model for a second time (this group of participants were labeled the *Aligned-Face Drawing Group*) or to draw the misaligned face model (this group of participants were labeled the *Misaligned-Face Drawing Group*). Within the latter group, participants were further randomly assigned to draw the model whose bottom half was misaligned to the left or right. Participants in the *Aligned-Face Drawing Group* received an explanation that the reason they were being asked to draw the same model again was in order to assess the effect of practice on face drawing performance. Then, they were provided the same instructions as they received for their first drawing. Participants in the *Misaligned-Face Drawing Group* received an explanation that the reason they were drawing the misaligned face was to assess the effects of practice and face misalignment on drawing performance. They then received the same instructions that were provided for the first face drawing, with the added instruction to draw the misaligned face as it appeared on the screen (or to depict a misaligned face as opposed to aligning the face in their drawing).

After the second drawings were complete and collected, the researcher debriefed the participants and ended the session.

The logic of this experimental design is as follows. All participants drew the aligned model first in order to establish a baseline measure of drawing performance. The second drawings produced by the *Aligned-Face Drawing Group* served to control for practice effects and were compared to the second drawings produced by the *Misaligned-Face Drawing Group* in order to assess the effects of face misalignment on drawing performance. For the *Misaligned-Face Drawing Group*, the random assignment to a left vs right misaligned face was included to ensure any potential effect of misalignment was not directionally specific. With this design, the strongest evidence of an effect of face misalignment on drawing performance would be the observation of an interaction between the drawing order (first vs second drawing) and drawing group (aligned vs misaligned) that indicates a non-significant group-difference in performance for the first drawings and a significant group difference in performance for the second drawings.

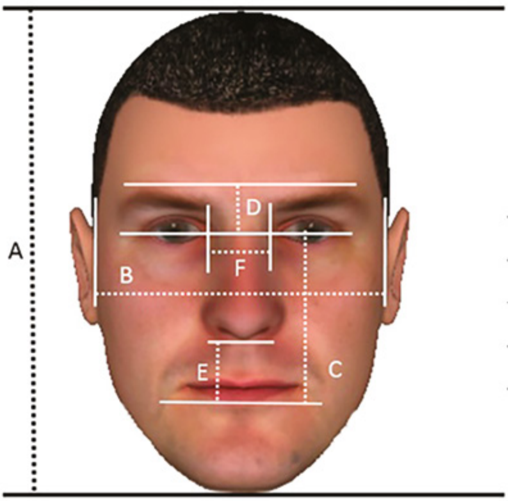
2.4. Measures of Drawing Performance

Drawing performance in this study was assessed using measures that quantified how participants depicted multiple spatial relationships between facial features. The measurement procedure that was employed was adopted from Ostrofsky *et al.* (2016a) and is illustrated in Fig. 2. For each drawing and model, six measurements, A–F, were recorded:

- A = height of the head, measured as the vertical distance from the top of the head to the bottom of the chin
- B = width of the head, measured as the horizontal distance between the two points where the top corners of the ears intersect with the face
- C = the vertical distance between the eyes (midpoint of the horizontal line that intersects the two pupils) and the mouth (bottom of the lower lip)
- D = the vertical distance between the eyes and the top of the eyebrows
- E = the vertical distance between the bottom of the nose and the mouth
- F = interocular distance: measured as the horizontal distance between the inner corners of the two eyes

Four *Spatial Relation Ratios (SRR)* were computed based on these measurements:

- C/A = vertical distance between the eyes and the mouth relative to the height of the head



Spatial Relation Ratios

Ratio	Description
C/A	Vertical Distance Between Eyes & Mouth
D/A	Vertical Distance Between Eyes & Eyebrows
E/A	Vertical Distance Between Nose & Mouth
F/B	Horizontal Distance Between the Two Eyes

Figure 2. Illustration of how each drawing and model was measured (measures A–F), and a definition of each of the four spatial relation ratios (SSRs) calculated from these measures.

- D/A = vertical distance between the eyes and eyebrows relative to the height of the head
- E/A = vertical distance between the nose and mouth relative to the height of the head
- F/B = interocular distance relative to the width of the head

Table 1 displays the SRR values for each model and the mean and standard deviation SRR values of the drawings.

Drawing Errors for each of the four SRRs were calculated using the following formula:

- Deviation of Drawing from Model % = $\left| [(\text{Drawing SRR} - \text{Model SRR}) / \text{Model SRR}] \right| \times 100$

3. Results

The following analyses aimed to assess the effects of face misalignment on drawing errors for each of the four spatial relationships described above. Before the analyses were performed, we collapsed across (a) the drawings of the four different models and (b) the drawings of the leftward- and rightward-misaligned models. Table 2 displays the mean and standard deviation values of the drawing errors for each of the four SRR measures.

We performed four 2 (Drawing Order: First vs Second Drawing) × 2 (Group: Aligned vs Misaligned) ANOVAs that tested for effects on the drawing errors; one ANOVA was performed for each of the spatial relationships assessed in this experiment.

3.1. Errors in Drawing the Vertical Distance between the Eyes and Mouth (C/A)

There were no significant main effects of Drawing Order, $F_{1,60} = 0.49$, $p = 0.49$, $\eta_p^2 = 0.01$, or Group, $F_{1,60} = 1.93$, $p = 0.17$, $\eta_p^2 = 0.03$. However, there was a significant interaction, $F_{1,60} = 4.23$, $p = 0.04$, $\eta_p^2 = 0.07$. Simple main effect analyses indicated that, while there was no significant difference in drawing errors between the two groups with respect to their first drawings, $F_{1,60} = 0.09$, $p = 0.76$, $\eta_p^2 < 0.01$, the Misaligned Drawing Group was significantly less accurate than the Aligned Drawing Group when drawing the eye–mouth distance in their second drawings, $F_{1,60} = 4.75$, $p = 0.03$, $\eta_p^2 = 0.07$.

3.2. Errors in Drawing the Vertical Distance between the Eyes and Eyebrows (D/A)

For this analysis, we discarded one individual's data from the 'Aligned Drawing Group', as their drawing error value for their first drawing was identified

Table 1.
Spatial Relation Ratio (SRR) values of models and mean (SD) SRR values of drawings.

Model/Group	**Eye–mouth distance (C/A)**		**Eye–eyebrow distance (D/A)**		**Nose–mouth distance (E/A)**		**Interocular distance (F/B)**	
	Drawing 1	**Drawing 2**	**Drawing 1**	**Drawing 2**	**Drawing 1**	**Drawing 2**	**Drawing 1**	**Drawing 2**
Model 1	0.35		0.08		0.13		0.25	
Aligned	0.44 (0.07)	0.42 (0.03)	0.09 (0.03)	0.09 (0.02)	0.17 (0.03)	0.16 (0.02)	0.22 (0.05)	0.23 (0.05)
Misaligned	0.45 (0.03)	0.48 (0.06)	0.08 (0.01)	0.08 (0.01)	0.19 (0.03)	0.20 (0.04)	0.24 (0.04)	0.23 (0.05)
Model 2	0.40		0.10		0.19		0.29	
Aligned	0.46 (0.05)	0.46 (0.04)	0.12 (0.02)	0.12 (0.01)	0.19 (0.03)	0.19 (0.04)	0.25 (0.06)	0.25 (0.06)
Misaligned	0.46 (0.04)	0.47 (0.03)	0.10 (0.02)	0.10 (0.02)	0.21 (0.03)	0.19 (0.04)	0.29 (0.05)	0.28 (0.05)
Model 3	0.38		0.10		0.17		0.28	
Aligned	0.46 (0.06)	0.45 (0.05)	0.10 (0.02)	0.11 (0.01)	0.19 (0.02)	0.19 (0.02)	0.24 (0.08)	0.22 (0.04)
Misaligned	0.47 (0.06)	0.49 (0.06)	0.11 (0.02)	0.11 (0.02)	0.19 (0.05)	0.21 (0.03)	0.25 (0.06)	0.22 (0.06)
Model 4	0.38		0.12		0.17		0.26	
Aligned	0.43 (0.03)	0.43 (0.07)	0.11 (0.02)	0.10 (0.02)	0.19 (0.03)	0.18 (0.04)	0.25 (0.05)	0.24 (0.05)
Misaligned	0.43 (0.06)	0.44 (0.05)	0.10 (0.02)	0.10 (0.02)	0.18 (0.02)	0.19 (0.03)	0.21 (0.06)	0.23 (0.05)

Table 2.
Mean (SD) drawing error values (%).

Group	**Eye–mouth distance (C/A)**		**Eye–eyebrow distance (D/A)**		**Nose–mouth distance (E/A)**		**Interocular distance (F/B)**	
	Drawing 1	**Drawing 2**	**Drawing 1**	**Drawing 2**	**Drawing 1**	**Drawing 2**	**Drawing 1**	**Drawing 2**
Aligned	18.89 (14.25)	16.72 (11.63)	21.41 (13.42)	16.36 (10.12)	16.95 (16.47)	17.78 (12.65)	19.44 (15.60)	18.44 (11.51)
Misaligned	19.97 (13.62)	24.38 (15.87)	13.75 (11.48)	16.72 (10.23)	21.35 (20.47)	24.53 (22.75)	17.89 (12.87)	17.31 (13.46)

as an extreme outlier (z-score = +3.26). There were no significant main effects of Drawing Order, $F_{1,59} = 0.35$, $p = 0.56$, $\eta_p^2 = 0.01$, or Group, $F_{1,59} = 2.45$, $p = 0.12$, $\eta_p^2 = 0.04$. However, there was a significant interaction, $F_{1,59} = 5.22$, $p = 0.03$, $\eta_p^2 = 0.08$. Simple main effect analyses indicated that the Aligned Drawing Group was significantly less accurate than the Misaligned Drawing Group when drawing the eye–eyebrow distance in their first drawing, $F_{1,59} = 5.72$, $p = 0.02$, $\eta_p^2 = 0.09$. In contrast, there was no significant difference in drawing errors between the two groups with respect to their second drawings, $F_{1,59} = 0.02$, $p = 0.89$, $\eta_p^2 < 0.01$.

3.3. Errors in Drawing the Vertical Distance between the Nose and Mouth (E/A)

There were no significant main effects of Drawing Order, $F_{1,60} = 0.55$, $p = 0.46$, $\eta_p^2 = 0.01$, or Group, $F_{1,60} = 2.14$, $p = 0.15$, $\eta_p^2 = 0.03$, nor was there a significant interaction between these two factors, $F_{1,60} = 0.19$, $p = 0.66$, $\eta_p^2 < 0.01$.

3.4. Errors in Drawing the Interocular Distance (F/B)

There were no significant main effects of Drawing Order, $F_{1,60} = 0.18$, $p = 0.67$, $\eta_p^2 < 0.01$, or Group, $F_{1,60} = 0.22$, $p = 0.64$, $\eta_p^2 < 0.01$, nor was there a significant interaction between these two factors, $F_{1,60} = 0.01$, $p = 0.91$, $\eta_p^2 < 0.01$.

4. Discussion

To summarize the results described above, the horizontal misalignment of faces (relative to the horizontal alignment of faces) causes individuals to generate more errors in drawing a long-range spatial relationship (the vertical distance between the eyes and mouth) but does not affect the accuracy in drawing three short-range spatial relationships (the vertical distance between the eyes and eyebrows; the vertical distance between the nose and mouth; the horizontal distance between the two eyes).

However, there is one important caveat to this summary. Earlier, we argued that an effect of face misalignment on drawing performance would be most strongly evident by the observation of no group difference in the accuracy of the first drawings participants produced (since both groups started with a drawing of an aligned face) and a group difference in the accuracy of the second drawings produced (since the two groups differed here with respect to being asked to draw an aligned vs misaligned face). For three out of the four spatial relationships assessed in this study, we found no group difference in the accuracy of the first drawings. However, with respect to reproducing the vertical distance between the eyes and eyebrows in the first drawings, the *Aligned-Face Drawing Group* was significantly less accurate than the *Misaligned-Face Drawing Group*. Since the vertical distance between the eyes and eyebrows was a short-range spatial relationship, it was hypothesized that face misalignment would not affect the drawing of this spatial relationship. While the significant group difference in the accuracy of the first drawings is not ideal for the purposes of evaluating this hypothesis, there are two reasons that lead us to believe that this observation does not substantially weaken our claim that face misalignment has no effect on drawing this short-range spatial relationship. First, as mentioned in the Results section and with respect to the second drawings, there was no significant difference in accuracy between the drawings of the aligned and misaligned face. One may argue, however, that this is not a fair comparison as the groups differed in their initial baseline accuracy, potentially masking any drawing effects due to face misalignment as assessed by a group comparison of the second drawings. In order to resolve this, we ran a *post-hoc* within-group analysis testing for differences in accuracy between the first and second drawings produced by those in the *Misaligned-Face Drawing Group*. In this way, if the different baseline points in accuracy between the two groups is masking face misalignment-based group-based effects in the second drawings, we should see a significant difference in accuracy between the aligned and misaligned face drawings produced by the *Misaligned-Face Drawing Group*. In a statistically liberal analysis, this was not observed, $t(29) = 1.23$, $p = 0.11$. Thus, we maintain the claim that face misalignment has no effect on the drawing of the short-range spatial relationship between the eyes and eyebrows.

As a side-note relating to this issue, a reviewer pointed out that, with respect to the *Aligned-Face Drawing Group*, the errors for the first drawing were larger than those observed for the second drawing, indicating a potential practice effect that was not observed for the *Misaligned-Face Drawing Group*. The reviewer suggested that if such a practice effect existed, it may indicate an effect of disrupting holistic processing on eye–eyebrow distance drawing errors. Specifically, since the eye–eyebrow distance drawing errors were not observed to differ between the first and second drawings of the *Misaligned-Face Drawing Group*, a practice effect observed in the *Aligned-Face Drawing Group* could indicate that disrupting holistic processing prevents practice from reducing drawing errors. To clarify whether the potential practice effect observed in the *Aligned-Face Drawing Group* was statistically significant, we conducted a statistically liberal analysis comparing the eye–eyebrow distance drawing errors between the first and second drawings produced by the *Aligned-Face Drawing Group* and observed a non-significant difference in drawing errors, $t(30) = 1.98$, $p = 0.06$. Thus, we did not observe a significant practice effect pertaining to the *Aligned-Face Drawing Group* with respect to their eye–eyebrow distance drawing errors. In considering the total sum of the evidence pertaining to this measure, we conclude that disrupting holistic processing has no effect on the eye–eyebrow distance drawing errors.

Nevertheless, the pattern of drawing effects we observed in this experiment is congruent with the pattern of drawing effects due to face inversion that has been previously observed (Ostrofsky *et al.*, 2016a), suggesting that misalignment and inversion both disrupt holistic processing of faces in a similar, if not identical, way. However, we acknowledge that this is not the strongest method of assessing convergent validity of drawing effects due to disrupted holistic processing, due to the comparison of inverted and misaligned drawing errors between two different samples. Planned future research will more strongly assess the claim that face inversion and misalignment are affecting drawing errors in the same way by having participants draw an upright face, an inverted face and a misaligned face. From this, we will be able to further assess whether face inversion and misalignment are affecting drawing in the same way by, in addition to comparing drawing errors between upright models vs inverted models and upright models vs misaligned models, also assessing the correlation of the drawing errors observed for the inverted and misaligned models to determine if inversion and misalignment are producing similar types of errors in a within-subjects analysis.

Moving on, since face misalignment and inversion have been associated with either an impairing effect or a lack of effect on drawing performance, it seems that, in some cases, holistic processing facilitates drawing performance and, in other cases, holistic processing does not influence drawing performance at all. As discussed in the Introduction, previous research reported that drawing skill predicted a stronger local processing bias that was evident by performance in a variety of non-drawing tasks including the Block Design Task, Group Embedded Figures Test and the Face-Composite Task (Drake, 2013; Drake and Winner 2011; Drake *et al.*, 2010; Zhou *et al.*, 2012). One possible way of interpreting this is that drawing performance generally benefits from biasing attention towards local and away from global visual information. However, the current findings illustrate that drawing performance does not generally benefit from such a local processing bias. Consistent with the arguments and evidence provided by Chamberlain and Wagemans (2015), we are more confident in re-interpreting the association of drawing skill and local processing biases referenced above as indicating that greater drawing skill is associated with a stronger ability of deploying attention towards task-relevant information and away from task-irrelevant information (Ostrofsky and Kozbelt, 2011). Recall that the three tasks mentioned above that assessed local processing biases were designed so that accurate performance necessitates ignoring global visual information and biasing attention towards local visual information. According to this re-interpretation, we would hypothesize that drawing performance would predict a global processing bias in situations when accurate performance demanded attention towards global visual information. Since previous perceptual research shows that accurately perceiving some spatial relationship between facial features requires global, holistic processing (e.g., Freire *et al.*, 2000; Leder and Bruce, 1998; Sekunova and Barton, 2008), the results of the current study and the face-inversion drawing studies referenced earlier demonstrating poorer drawing accuracy when holistic processing is experimentally disrupted supports this claim.

4.1. Limitations

As one reviewer commented, one methodological limitation of this experiment concerns the presence of a confounding variable, namely, the difference in the eye–mouth distance between the aligned vs misaligned face stimuli. In the misaligned faces, the absolute distance between the eyes and mouth is longer than it is in the aligned faces, and thus, could potentially explain the difference in error in drawing this spatial relationship between the aligned and misaligned faces (which is an especially relevant point given that the average direction of error was for subjects to draw this distance longer in the misaligned, relative to aligned, faces). While our method does not allow us to rule this out as a possibility, it is worth emphasizing that both face misalignment in the current study and face inversion in Ostrofsky *et al.* (2016a) (where this absolute distance between the eyes and mouth is equal to upright faces) caused individuals to draw, on average, the eye–mouth distance with a greater degree of error in the same direction (the eye–mouth distance was drawn longer, on average, in both misaligned, relative to aligned, and inverted, relative to upright, faces). Thus, the specific eye–mouth distance drawing errors observed in this experiment was not unique to the face misalignment manipulation. However, whether this same pattern of error was due to the same mechanism is open to question. An alternative method to disrupt holistic processing that could be employed in future research to clarify this issue would be to present and have subjects draw aligned top and bottom-halves of faces either simultaneously (intact holistic processing) vs sequentially (disrupted holistic processing). If the effect of face misalignment on the eye–mouth distance drawing errors was solely due to the increased absolute distance between these two features, one would predict no difference in drawing error between simultaneous vs sequential conditions. However, if the effect of face misalignment on eye–mouth distance drawing errors was caused by the disruption of holistic processing, we would predict increased drawing errors of this spatial relationship (specifically by drawing the distance longer) in the sequential (relative to simultaneous) condition just as what is observed in face misalignment and inversion conditions. However, this method of comparing simultaneously vs sequentially presented top and bottom halves of faces would result in another confounding variable. Namely, the total amount of visual information in the model perceived at any given moment during the drawing process would differ between the simultaneous and sequential drawing conditions. Thus, this may not be a fully satisfactory solution to addressing the limitation described here concerning aligned vs misaligned faces.

Moving along, one should be cautious in the generalization of these results, as the methods employed in this experiment were quite narrow in focus. We assessed the effects of disrupting holistic processing on the drawing of the relative spatial positioning of facial features. Needless to say, reproducing the spatial relationships between features is only one of many important aspects to accurately drawing a face. Other important aspects of face drawing include reproducing the detailed appearance of individual facial features, accurately shading different areas of the face and reproducing the subtle cues that contribute to representing the emotional expression displayed in the face. Because our methods neglected these aspects of face drawing, we are not able to make a strong judgment with respect to the influence holistic processing has on drawing them. It is worth re-emphasizing here that Cohen and Earls (2010) reported that accuracy in drawing individual facial features was not affected by disrupting holistic processing via face inversion. However, it is important to note that accuracy was measured by independent judges who provided Likert-type ratings that assessed the perceived accuracy of drawing these features. While this suggests that disrupting holistic processing via inversion has no effect on drawing individual facial features, it may be that (a) subjective accuracy judgments of this type are not sensitive enough to detect more objective differences in the appearance of features between upright and inverted face drawings and (b) that disrupting holistic processing via face misalignment might affect the accuracy of drawing individual facial features differently. It would be valuable for future research to develop an objective measurement method for assessing drawing accuracy for individual features and to employ them in face drawing experiments that disrupt holistic processing via both face inversion and misalignment.

The limited scope of our methods is also evident by the fact that we asked participants to draw faces, which have been theorized to be a relatively unique category of objects in that they are processed holistically whereas most other categories of objects appear to be processed non-holistically (Tanaka and Farah, 2003) (see Note 1). While our results suggest that holistic processing either facilitates or does not affect at all drawing performance, this can only be safely generalized to the drawings of the relative spatial positioning of facial features. It is possible that a strong attentional bias towards local visual information and away from global visual information could benefit drawing performance in the case of drawing non-face objects that are not normally processed holistically. For instance, a popular drawing instruction technique is the use of drawing grids. Drawing grids allow users to segment whole images into multiple cells, and create their drawing by focusing on reproducing the visual information one cell at a time. Presumably, this technique supports the users' ability to attend to local areas of the image and suppresses attention towards global aspects of the image. If the use of such grids is effective in increasing drawing accuracy (to date, no experimental validation of this technique has been attempted), then that would be convincing evidence that biasing visual attention towards local visual information is capable of facilitating drawing performance.

A final limitation to address relates to our conceptualization of the effects observed in this experiment (and in prior face inversion experiments discussed in this article) being due to the disruption of holistic processing. There is an unresolved debate in the face perception literature concerning the relationship between holistic and configural processing. Specifically, as Richler and Gauthier (2014) point out, the terms 'holistic processing' and 'configural processing' are often used as synonyms in the literature, assuming that they are the same perceptual process. They further point out that while holistic processing can facilitate configural processing, it does not necessarily indicate that configural processing is identical to holistic processing in terms of how they exert effects on face perception. In the current article, we adopted the perspective that face misalignment and face inversion disrupt holistic processing in such a way to affect the drawing of long-range as opposed to short-range spatial relationships. However, in light of the arguments provided by Richler and Gauthier (2014), this may not be an accurate conceptualization. While the results of the current experiment and past studies indicate that face inversion and misalignment detrimentally affect configural processing of long-range spatial relationships, this may not necessarily indicate that these effects are due to disrupted holistic processing. While this is an issue, we invite the readers to consider when interpreting the nature of the drawing-related effects of face misalignment and inversion, the current lack of consensus on this issue in the literature leads us to not take a strong position on this potential distinction.

4.2. *Concluding Thoughts*

In general, this study and discussion highlights the limitations of research that aims to determine the predictive relationship between drawing skill and performance biases that are observed in non-drawing tasks. Many studies that investigate such relationships assume, either explicitly or implicitly, that drawing is a general skill that is either associated or unassociated with the performance/biases that are measured using non-drawing tasks. This is evident by two common features of such studies: (1) drawing skill is commonly assessed using unitary measures of drawing performance and (2) the researchers select the type of object that serves as the model in a seemingly arbitrary fashion.

Such methodological strategies may mask the complexity of the relationship between drawing and non-drawing task performance for two reasons. First, drawing production is not a unidimensional behavior, as there are multiple components that must be successfully reproduced in order to produce a high-quality drawing (e.g., spatial proportions and positioning, line curvature, shading, appearance of individual features, linear perspective, etc.). It is by no means established that strong skill in reproducing one component of a model guarantees strong skill in reproducing other components (e.g., individuals may be able to successfully reproduce the relative spatial positioning of features, but may be less skilled in reproducing the appearance of individual features). Further, processes/biases observed in non-drawing tasks may be differentially associated with different components of drawing skill. Second, drawing skill may not generalize across different types of object categories within an individual. Individuals may be skilled in drawing one type of object, but less skilled in drawing other types of objects. For instance, Glazek (2012) observed differences in drawing skill for familiar vs unfamiliar object categories (e.g., a human eye vs a Chinese ideogram, respectively). Thus, when reporting that general drawing skill is associated with performance/biases observed in non-drawing tasks, it is unclear what specific components of drawing are associated with the non-drawing task performance of interest. Further, it is unclear if such associations generalize across the drawing of all types of model objects or only some types of model objects. We believe future research in this area would benefit from an attempt to specify which components of drawing and/or which categories of model objects are associated (vs non-associated) with performance/biases in non-drawing tasks.

Note

1. While outside of the scope of this article's focus, it is worth acknowledging the theoretical debate as to why this is the case. Some argue this holistic vs non-holistic difference is due to faces and non-faces being processed by distinct, domain-specific perceptual mechanisms (Kanwisher, 2000), whereas others argue that this difference is more generally related to different perceptual processing mechanisms existing for categories of objects individuals have vs do not have extensive experience in perceiving, with faces being an example of an object category most humans are 'experts' in perceiving (Bukach *et al.*; Tarr, 2006).

References

Bukach, C. M., Gauthier, I. and Tarr, M. J. (2006). Beyond faces and modularity: the power of an expertise framework,m *Trends Cogn. Sci.*, **10**, 159–166.

Chamberlain, R. and Wagemans, J. (2015). Visual arts training is linked to flexible attention to local and global levels of visual stimuli, *Acta Psychol.*, **161**, 185–197.

Chamberlain, R. and Wagemans, J. (2016). The genesis of errors in drawing, *Neurosci. Biobehav. Rev.*, **65**, 195–207.

Chamberlain, R., McManus, I. C., Riley, H., Rankin, Q. and Brunswick, N. (2013). Local processing enhancements associated with superior observational drawing are due to enhanced perceptual functioning, not weak central coherence, *Q. J. Exp. Psychol.*, **66**, 1448–1466.

Christman, S. D. (1993). Local–global processing in the upper versus lower visual fields, *Bull. Psychon. Soc.*, **31**, 275–278.

Cohen, D. J. (2005). Look little, look often: The influence of gaze frequency on drawing accuracy, *Percept. Psychophys.*, **67**, 997–1009.

Cohen, D. J. and Earls, H. (2010). Inverting an image does not improve drawing accuracy, *Psychol. Aesthet. Creat. Arts*, **4**, 168–172.

Cohen, D. J. and Jones, H. E. (2008). How shape constancy relates to drawing accuracy, *Psychol. Aesthet. Creat. Arts*, **2**, 8–19.

Day, J. A. and Davidenko, N. (2018). Physical and perceptual accuracy of upright and inverted face drawings, *Vis. Cogn.*, **26**, 89–99.

Drake, J. E. (2013). Is superior local processing in the visuo-spatial domain a function of drawing talent rather than autism spectrum disorder? *Psychol. Aesthet. Creat. Arts*, **7**, 203–209.

Drake, J. E. and Winner, E. (2011). Realistic drawing talent in typical adults is associated with the same kind of local processing bias found in individuals with ASD, *J. Autism Dev. Disord.*, **41**, 1192–1201.

Drake, J. E., Redash, A., Coleman, K., Haimson, J. and Winner, E. (2010). 'Autistic' local processing bias also found in children gifted in realistic drawing, *J. Autism Dev. Disord.*, **40**, 762–773

Feng, J. and Spence, I. (2014). Upper visual field advantage in localizing a target among distractors, *i-Perception*, **5**, 97–100.

Freire, A., Lee, K. and Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configural information: direct evidence, *Perception*, **29**, 159–170.

Glazek, K. (2012). Visual and motor processing in visual artists: Implications for cognitive and neural mechanisms, *Psychol. Aesthet. Creat. Arts*, **6**, 155–167.

Kanwisher, N. (2000). Domain specificity in face perception, *Nat. Neurosci.*, **3**, 759–763.

Kozbelt, A. (2001). Artists as experts in visual cognition, *Vis. Cogn.*, **8**, 705–723.

Kozbelt, A. (2017). Learning to see by learning to draw: Probing the perceptual bases and consequences of highly skilled artistic drawing, *High Abil. Stud.*, **28**, 93–105.

Leder, H. and Bruce, V. (1998). Local and relational aspects of face distinctiveness, *Q. J. Exp. Psychol.*, **51A**, 449–473.

Mitchell, P., Ropar, D., Ackroyd, K. and Rajendran, G. (2005). How perception impacts on drawings, *J. Exp. Psychol. Hum. Percept. Perform.*, **31**, 996–1003.

Niebauer, C. L. and Christman, S. D. (1998). Upper and lower visual field differences in categorical and coordinate judgments, *Psychon. Bull. Rev.*, **5**, 147–151.

Ostrofsky, J. and Kozbelt, A. (2011). A multi-stage attention hypothesis of drawing ability, in: A. Kantrowitz, A. Brew and M. Fava (Eds), *Thinking through drawing: Practice into knowledge. Proceedings of an interdisciplinary symposium on drawing, cognition and education* (pp. 61–66). Teachers College, Columbia University, New York, NY, USA.

Ostrofsky, J., Kozbelt, A. and Seidel, A. (2012). Perceptual constancies and visual selection as predictors of realistic drawing skill, *Psychol. Aesthet. Creat. Arts*, **6**, 124–136.

Ostrofsky, J., Kozbelt, A. and Cohen, D. J. (2015). Observational drawing biases are predicted by biases in perception: Empirical support of the misperception hypothesis of drawing accuracy with respect to two angle illusions, *Q. J. Exp. Psychol.,* **68**, 1007–1025.

Ostrofsky, J., Kozbelt, A., Cohen, D. J., Conklin, L. and Thomson, K. (2016a). Face inversion impairs the ability to draw long-range, but not short-range, spatial relationships between features, *Empir. Stud. Arts*, **34**, 221–233.

Ostrofsky, J., Kozbelt, A., Tumminia, M. and Cipriano, M. (2016b). Why do non-artists draw the eyes too far up the head? How vertical eye-drawing errors relate to schematic knowledge, pseudoneglect, and context-based perceptual biases, *Psychol. Aesthet. Creat. Arts*, **10**, 332–343.

Perdreau, F. and Cavanagh, P. (2011). Do artists see their retinas? *Front. Hum. Neurosci.*, **5**, 171. doi 10.3389/fnhum.2011.00171.

Quek, G. L. and Finkbeiner, M. (2016). The upper-hemifield advantage for masked face processing: Not just an attentional bias, *Atten. Percept. Psychophys.*, **78**, 52–68.

Richler, J. J. and Gauthier, I. (2014). A meta-analysis and review of holistic face processing, *Psychol. Bull.*, **140**, 1281–1302.

Rossion, B. (2013). The composite face illusion: A whole window into our understanding of holistic face perception, *Vis. Cogn.*, **21**, 139–253.

Sekunova, A. and Barton, J. J. (2008). The effects of face inversion on the perception of long-range and local spatial relations in eye and mouth configuration, *J. Exp. Psychol. Hum. Percept. Perform.*, **34**, 1129–1135.

Tanaka, J. W. and Farah, M. J. (2003). The holistic representation of faces, in: M.A. Peterson and G. Rhodes (Eds), *Perception of Faces*, *Objects*, *and Scenes:Analytic and Holistic Processes* (pp. 53–74). Oxford University Press, Oxford, UK.

Zito, G. A., Cazzoli, D., Müri, R. M., Mosimann, U. P. and Nef, T. (2016). Behavioral differences in the upper and lower visual hemifields in shape and motion perception. *Front. Behav. Neurosci.*, **10**, 128.

Zhou, G., Cheng, Z., Zhang, X. and Wong, A. C. (2012). Smaller holistic processing of faces associated with face drawing experience, *Psychon. Bull. Rev.*, **19**, 157–162.