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Do Graphic Long-Term Memories Influence the Production of Observational Drawings? The Relationship Between Memory- and Observation-Based Face Drawings

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based drawing abilities suggests that these two drawing behaviors are supported by functionally specialized, independent mechanisms.

However, the mechanisms supporting observation- and memory-based drawing performance in neurologically intact adults may interact with one another during the production of an observational drawing. According to this perspective, when attempting to reproduce a model from observation, drawing performance is argued to be influenced by both bottom-up visual information inherent in the model and top-down information inherent in stored LTMs. Thus, this perspective suggests that the individual variability in the appearance of observational drawings is partially caused by individual variability in LTMs that generally represent how to draw the object depicted in the model.

Empirical evidence has been reported that suggests an influence of LTM on the production of observational drawings. For instance, nonartist children and adults produce observational drawings of familiar objects less accurately than unfamiliar objects (Glazek, 2012; Moore, 1987; Phillips, Hobbs, & Pratt, 1978). Since individuals have established LTMs that represent how to draw objects they are familiar with, one may suggest that the drawing accuracy of familiar objects suffers due to the influence of processing information stored in memory that is not inherent in the models being drawn. In contrast, there are no established LTMs representing the graphic properties of unfamiliar objects that could potentially be activated and interfere with the ability to accurately draw the model. Thus, in addition to the perceptual-based information inherent in the model, nonartists' graphic representations of familiar objects stored in LTM appear to influence the production of an observational drawing to some degree.

With respect to the properties of such graphic LTMs, it is unlikely that familiar objects are identically represented across individuals. Rather, it is more likely that there is individual variability in the prototypical graphic representations of familiar objects. If such LTM representations influence the production of observational drawings, then one explanation of the individual variability in the appearance of such drawings would be that variable memory representations, each specific to a given individual, are activated and influence the production of an observational drawing. In order to evaluate this idea, Matthews and Adams (2008) asked participants to create two drawings of a cylinder. First, participants drew a cylinder from memory without being provided a model to guide their drawings. Such drawings were used to probe how each individual in the sample prototypically represents the graphic properties of a cylinder in LTM. Second, participants were asked to draw a standard model cylinder from observation. Objective measurements of six different spatial relationships of the memory- and observation-based cylinder drawings were made (e.g., height-to-width ratio of the whole object; the degree of roundness of oval-shaped portion located on the top or bottom of the cylinder).

found in the "average face," any reliable spatial deviations in the memory-based drawings from the "average face" can be considered biases in how the spatial properties of a face are represented in LTM. If systematic error biases present in the observational drawings of a face are partially influenced by long-term memory, one would predict that there should be congruent directional biases between the observation- and memory-based drawings (e.g., in both types of drawings, the eyes should be drawn too far up the head and/or the head should be drawn too round).

Having all participants complete the memory-based drawings first (as opposed to balancing the order of the two types of drawings across participants) was a strategic feature of this study that has precedent in the memory- and observation-based cylinder drawing study reported by Matthews and Adams (2008). If the order of the drawing tasks were balanced across participants, those who completed the observation-based drawings first may be influenced to some degree by a short-term memory (STM) of the model face when later creating their memory-based drawing. Since the memory-based drawings were intended to probe how faces are represented in LTM, the design adopted here was intended to minimize the influence of STM on the memory-based drawings as much as possible.

Measurements of Drawn Spatial Relationships and Errors

As illustrated in Figure 2, 12 spatial measurements, A through L (in cm), were made of the observation- and memory-based drawings, the model photograph used for the observational drawing task, and the 50 photographs of adult male Caucasian faces. These measurements were identical to those made by Ostrofsky et al. (2014). Specifically, I measured: (A) the length of the head from the top of the head (including hair) to the bottom of the chin, (B) the width of the head (with landmark points being at the point of the image where it appeared that the upper part of the ear connected to t2imp5.7(tfid2imp5.7(t(of)-225.7(t2imp5.7(t(facm),)p5.7(t(Cr))-225.7(t2imp5.7(tverntical)p5.7(tdistaence)-5.7(t(rtom)-225.7(t2i)]TJT*(to

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the left side of the face than it was in the model, $t(37) = -4.31$, $p < .001$, Cohen's $d = 0.70$. Finally, in the model photograph, the horizontal placement of the eyes with respect to the width of the face was slightly shifted to the right side of the face (from the observer's perspective) as indicated by the model value of the (J – K)/B ratio equaling + 0.04. The drawings reliably deviated from this right horizontal shift in the opposite direction, $t(37) = -4.32$, $p < .001$, Cohen's $d = 0.70$, resulting in a more average symmetrical placement that was minimally shifted to the left side of the face (mean value of (J – K)/B = −0.003).

Memory-Based Drawing Biases

Having found a number of directionally biased spatial errors in the observation-based drawings, one question that arises is whether these stereotyped errors are reflective of biases inherent in the LTMs that guide the production of memory-based face drawings. In order to determine this, the memory-based drawings and the collection of 50 photographs of males were measured according to the 13 spatial relation ratios defined in Figure 2. If one assumes that the mean values of the spatial relation ratios measured in the photograph collection closely approximates the central tendency of these relationships in the adult Caucasian male face population, then one can probe spatial memory biases by comparing the mean spatial relation ratio values between the memory-based drawings and the photograph collection. This was done by conducting 13 single sample *t* tests where the distributions of the spatial relation ratio values of the memory-based drawings were compared to a test value defined as the mean values of the spatial relation ratios of the photograph collection.

Table 3 displays the results of these analyses in addition to the means and standard deviations of the spatial relation ratio values of the memory-based drawings and the photograph collection. For the most part, the memory-based drawings reliably deviated from the average adult Caucasian male face in the same direction as the participants erred in the observation-drawing task. For 11 out of the 13 spatial relation ratios assessed in this study, the mean direction in which the memory-based drawings deviated from the photograph collection was the same as the mean direction of error in the observation-based drawings. Further, out of the five spatial relation ratios that were associated with a systematic direction of error in the observation-based drawings, four of them in the memory-based drawings were associated with a directionally congruent systematic deviation from the photograph collection (using a Bonferroni-corrected $\alpha = .004$). Specifically, in comparison to the photograph collection, the participants' memory-based drawings were biased to draw: (a) the head too round (B/A ratio), $t(37) = 7.76$, $p <$ .001, Cohen's [illegible] nose too narrow (I/B ratio), $t(37) = -6.84$, $p < .001$, Cohen's d = 1.11. Thus, these results indicate that there are some spatial biases inherent in LTM that are directionally congruent with the strongest error biases present in observational drawings, suggesting that these LTM biases might be related to the production of observational drawing errors.

Additionally, there were two spatial relationships depicted in the memory-based drawings that reliably deviated from the photograph collection that were not associated with a reliable direction of error in the observation-based drawings. Namely, participants were biased to draw: (a) the eyes too wide (G/B ratio), $t(37) = 4.87$, $p < .001$, Cohen's $d = 0.79$, and (b) the right eye too close to the right side of the head, $t(37) = -5.93$, $p < .001$, Cohen's d = 0.96. All other comparisons of the memory-based drawings to the photograph collection were not associated with reliable directions of bias ($p > .004$).

Co-Varying Relationship Between Observation- and Memory-Based Drawings of the Spatial Relationship Between Facial Features

To this point, the drawing errors and biases analyzed have been treated on the level of the sample and not on the level of individuals. Thus, it is not known whether a specific individual's direction and degree of bias in the memory-based drawings is similar to that of the errors they made in the observation-based drawings. Consider the finding that participants draw the head too round in the observation- and memory-based drawing tasks. Even though most participants are biased in this direction in the two different drawings tasks (84% of participants in the observation-based drawings and 97% of participants in the memory-based drawings), does this mean that the degree of roundness that the head is drawn is similar across the two types of drawings for individual participants? It is not known because a similar degree of bias between the two types of drawings across the sample does not necessarily indicate a similar degree of bias within specific individuals.

This is also the case for the spatial relationships that were not associated with a single reliable direction of error and bias in either of the two drawing tasks across the sample. Take, for example, the spatial relation ratios H/B (reflecting interocular distance) and L/A (reflecting the vertical position of the mouth) in the observation-based drawings. Even though these two ratios were not associated with a single reliable direction of error on average, this is not indicative of the fact that most participants were particularly accurate in reproducing these spatial relationships. Rather, it is indicative that some participants were biased to err in one direction and other participants were biased to err in the opposite direction. With respect to the H/B ratio, 58% of participants drew the eyes, on average, 28% (+/− 19%) farther apart from each other than

$r(36) = .33$, $p < .05$, (c) the width of the nose relative to the width of the face (I/B ratio), $r(36) = .65$, $p < .001$, and (d) the distance between the left eye and the left side of the head (J/B ratio), $r(36) = .32$, $p = .06$.

Relating to the one spatial relation ratio that was observed to have a reliable direction of error in the observation drawing task that was not observed to have a reliable direction of bias in the memory drawings, the degree of symmetry relating to the distances between the left and right eyes' distance from the sides of the face ([J – K]/B ratio) was positively correlated between the two drawing tasks, $r(36) = .40$, $p < .05$.

Finally, relating to the spatial relation ratios that were not associated with reliable directions of error or bias in the two drawing tasks, the degree to which the mouth was vertically positioned on the length of the face was positively correlated between the two drawings (L/A ratio), $r(36) = .54$, $p < .001$. Also, ticipants, by chance, to have a spatial relation value from the observation-based drawing that falls in between the spatial relation ratio values of the memory-based drawings and the model (a pattern that represents 2 out of the 6 possible rank ordinal patterns that could have been observed). It was observed that the percentage of participants whose spatial relation ratio values fell within this pattern was reliably greater than what one would expect by performance, one would expect to observe the positive correlations between observation- and memory-based drawings that were demonstrated here, that does not necessarily mean observing such correlations prove that LTMs directly influence observational drawing performance. However, one can rule out the possibility that observational drawing biases influence memory-drawing biases as participants in this study always produced their memory-based drawings before their observation-based drawings. However, our method does not allow us to rule out the possibility that the biases found in the two types of drawings are correlated due to unaccounted variables that might influence both types of drawings while the processes guiding the two types of drawings themselves are not causally related.

Another limitation of this study relates to differentiating the nature of the memory representation that is related to observational drawing performance. Here, the similarities in how the spatial relationships of features were depicted in the observation- and memory-based drawings were conceptualized as potentially indicating a relationship between LTM and observational drawing performance. However, because the observation-based drawings were produced immediately after the memory-based drawings, it is possible that a more short-term, priming-based memory established during the memory-based drawing task could account for the similarities between the two types of drawings. However, there is a reason to suspect that the observational drawing errors demonstrated in this study are not produced due to priming effects of the memory-based drawing. Many of the systematic error biases in the observational drawings observed in this study (drawing the head too round, the eyes too far up the head, the nose too narrow, and the left eye being too close to the left side of the head) have previously been observed when observational drawings are not produced before a memory-based drawing has been completed (Ostrofsky et al., 2014). Thus, it does not appear that these observational drawing biases are caused by priming of the memory-based drawings. Nevertheless, one could potentially test between LTM and short-term priming hypotheses by replicating this study where the time delay between the productions of the two types of drawings are manipulated. If the covarying relationship between these two types of drawings is related to influences of LTM, then manipulations of time delay should not affect the degree of similarity to which these spatial relationships are depicted in the two types of drawing tasks. In contrast, if the covarying relationship between these two types of drawings is related to influences of short-term priming processes, then longer delays between the productions of the two drawings should decrease or eliminate the similarity between them compared to shorter or immediate delays.

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