assumes that such transformations are not only enacted on the visual information supporting conscious perceptual judgments but also enacted on the visual information supporting drawing behaviors. Following this idea, the accuracy of observational drawings is argued to be intimately tied to perceptual judgment accuracy. Cohen and Bennett (1997) promoted this notion by hypothesizing that the major contribution to drawing errors is misperception of the model being drawn. Conversely, this view posits that skilled artists are able to process visual information in such a way as to reduce drawing errors via the reduction of perceptual transformations made on the sensory input.

There is some empirical evidence that artists are less susceptible to perceptual constancies than are nonartists. Perhaps the earliest was provided by Thouless (1931, 1932), who suggested that perceptions of the size and shape of objects *regress* to the real object. Thouless (1931) found that observers systematically misperceive object size, regularly judging farther objects as larger than their retinal projection would indicate; this demonstrates the effects of a scaling mechanism that is influenced by the presence of depth cues. Presumably, the function of this mechanism is to prevent an observer from judging the physical size of an object as changing as the size of its retinal projection varies as a function of its moving closer or farther away from the observer. He observed a similar constancy for shape perception: When asked to copy a circle seen at an angle, which projects to the retina as an ellipse, participants systematically drew the shape as more circular than it appeared, again showing that perception emerges through an interaction between retinal appearance and viewpoint-invariant object representations (for similar results, see Hammad, Kennedy, Juricevic, & Rajani, 2008). Interestingly, Thouless (1932) reported that trained artists showed smaller constancy effects, though they did not completely disappear.

More recent research has corroborated many of these basic findings on perceptual constancies and, more specifically, their relation to drawing accuracy. For example, Cohen and Jones (2008) had participants view images of a window embedded in a brick wall from various perspectives and match the shape of the window to a set of parallelograms. A negative correlation between freehand drawing accuracy and the degree of shape-constancy errors was observed, suggesting that accurate drawing is related to suppressing shape-constancy processes. A similar conclusion was reached by Mitchell et al. (2005), who utilized the Shepard illusion (Shepard, 1990). When one is presented with two identically-sized parallelograms side-by-side where the vertical and horizontal lines

(1960) argument implies that artists should be superior to non-artists at identifying and selecting the most relevant information to include in a depiction, to facilitate the illusion of three-dimensionality and promote object recognition. Indeed, Kozbelt (2001) suggested that artists might spontaneously emphasize such

In the *nondepth condition* (Figure 1, upper right), both circles were shown in a uniform shade of gray matching the overall value of the spheres in the depth condition. The background likewise maintained the same contrast of light and dark and included a similar texture as the depth condition; however, no depth cues were present. Here, participants could conceivably cheat by simply an octopus,[3] with a 15-min time limit. The photo was chosen for the same reasons as the photo of the elephant in the limited-line tracing task. The photo measured 6 × 7.75 in and was printed on a sheet of white 8.5- × 11-in paper. Participants were encouraged to draw as realistically as possible, using line, shading, erasures, and so on. Again, accurate realism, rather than creativity, was explicitly emphasized. As can be seen in Figure 3, participants again produced a wide variety of depictions.

Unlike the two perception tasks, which could be scored objectively, performance in the freehand drawing and limited-line tracing tasks requires the consensual assessment of qualified outside judges (see Amabile, 1982). Previous research has demonstrated cl,.0.1(ofied)ion clbyTJT*[(dehavg)-36043.4xpliert36043.4xticists anev

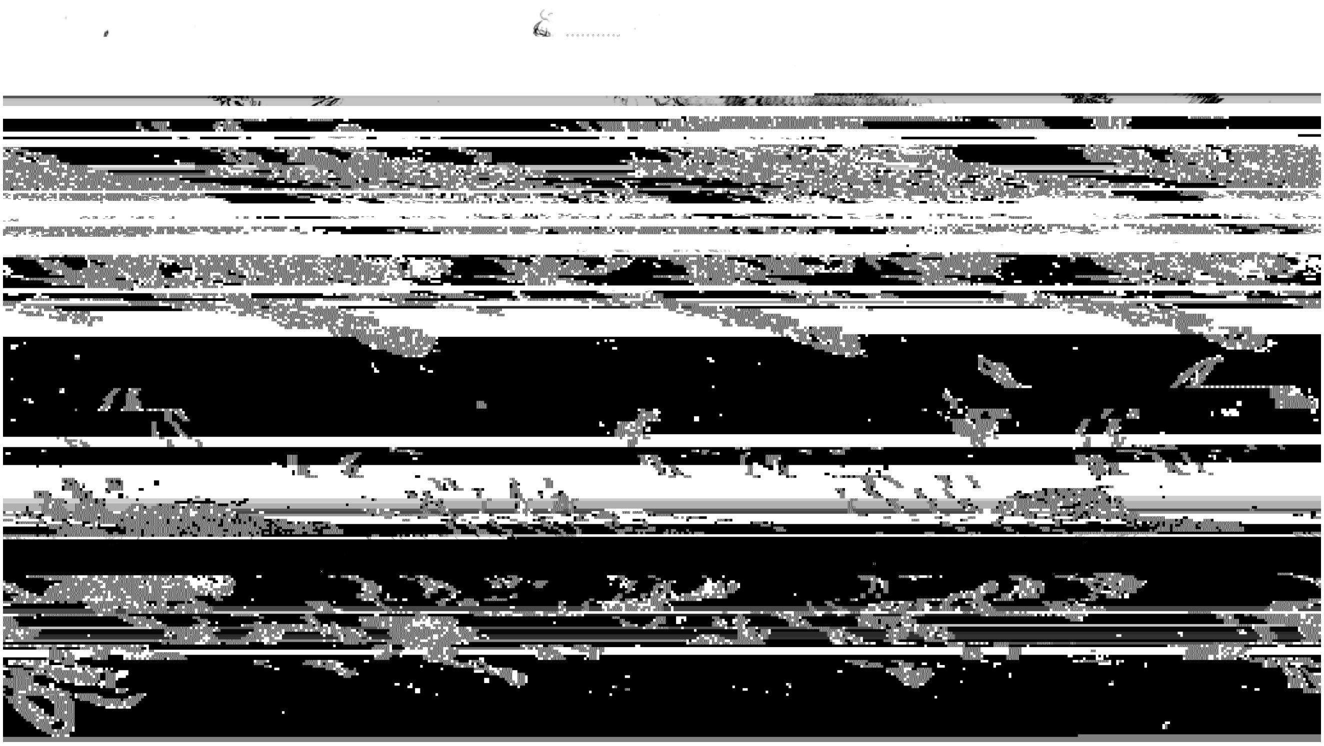

*Figure 3.* Six freehand drawings of a photograph of an octopus. Three high-rated drawings comprise the top row; three high-rated drawings comprise the bottom row.

differences between conditions and between artists and nonartists, as well as performance across different stimuli within each task. Next, group differences on the limited-line tracing and freehand drawing tasks are analyzed. Then, correlations among the tasks are reported, leading to a regression analysis predicting freehand drawing accuracy using the other tasks. Finally, we analyze the frequency artists' and nonartists' use of different types of vertices in the limited-line tracing task.

Data for the size-matching task were analyzed using a 2 (Group: Artist vs. Non-Artist) × 2 (Condition: Depth vs. Nondepth Cue) × 5 (Target Size: 156 vs. 208 vs. 260 vs. 312 vs. 364 pixel diameter) mixed-model ANOVA, to test for effects on size-matching errors. Cell means are represented in Figure 4. A significant main effect of group, $F(1, 47) = 12.17$, $p < .01$, partial $^{2} = .21$, was observed, indicating that, overall, artists produced smaller errors than nonartists. A significant main effect of condition, $F(1, 47) = 361.86$, $p < .001$, partial $^{2} = .89$, was also found, indicating that larger errors were produced in the depth cue condition, where participants reliably erred in judging the target sphere to be larger than it appeared compared with nondepth cue condition. Also, a main effect of target size, $F(1, 188) = 161.86$, $p < .001$, partial $^{2} = .78$ was observed, indicating that smaller errors were made on the trials where the target size was larger compared with small target size trials.

Significant Target × Group, $F(4, 188) = 4.06$, $p < .05$, partial $^{2} = .079$, Condition × Group, $F(1, 47) = 7.81$, $p < .01$, partial $^{2} = .14$, and Target × Condition, $F(4, 188) = 129.07$, $p < .001$, partial $^{2} = .73$, two-way interactions were observed. Finally, a significant Target × Condition × Group three-way interaction was found, $F(4, 188) = 3.44$, $p < .05$, partial $^{2} = .07$.

Follow-up 2 (Group: Artist vs. Non-Artist) × 2 (Condition: Depth vs. Nondepth Cue) quasi-$F$ tests were conducted at each level of target size to explain the three-way interaction. A


*Figure 4.* A comparison of artists (triangles) and nonartists (circles) in their performance on the depth (solid lines) and nondepth (dashed lines) cue conditions of the size-matching task. Participants' performance was calculated as the ratio between the sizes of the manipulated and target spheres/circles. A value of 1 indicates that the manipulated and target sizes were equal, and a value greater than 1 indicates that the manipulated sphere/circle was made larger than the target sphere/circle. This ratio is plotted as a function of the five different target sizes, measured as the diameter in pixels.

significant Group × Condition interaction was found at target size 156, $F$

consistent with each account was found. Most notably, performance in the depth condition of the size-constancy task (a bottom-up index) and the limited-line tracing task (a top-down index) showed equally strong relations with freehand drawing performance. Thus, within our narrowly defined top-down and

Post, 1978), standard stimulus exposure duration (Leibowitz, Chinetti, & Sidowski, 1956), and presentation of stimuli as photo-between artists and nonartists, and were negatively correlated with freehand drawing performance? Rather than just strategic selection processes, a more mechanistic attentional process must also be involved. Since greater size-matching errors were observed in the depth cue condition than the nondepth condition, the background information of the display, while technically irrelevant to the size-matching task, is clearly attended to and influences performance. Importantly, size-constancy errors also decreased with the increasing size of the target in the depth cue condition. An expla-