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Does categorical perception interfere with drawing accuracy?

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Does categorical perception interfere with drawing accuracy?

by

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Iowa State University

Ames, Iowa

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ABSTRACT

Drawing is a medium of expression engaged in by humans for centuries. However, very little research has been done on the drawing abilities of average adults. Some researchers (Cohen & Bennet, 1997; Thouless, 1931; Cohen & Jones, 2008) suggest that the way an object is perceived influences and disrupts a person's ability to draw that object accurately. The current experiments investigated whether participants are influenced by categorical coding of relations among the parts of an object and whether this categorical perception interfered with participants' drawing abilities. In experiment 1, we found that participants are influenced by categorical coding of the relative size of two shapes. We had participants draw images of two shapes of different sizes. Participants systematically made the smaller shape in these images too small in order to fit their categorical perception. In experiment 2, we found that participants' drawings of angles are distorted by a categorical coding system that uses the categories "perpendicular", "parallel", and "oblique" to code the angle of two lines. Participants in experiment 2 systematically drew 15 degree angles too large and 75 degree angles too small in order to fit their categorical perception, while drawing 45 degree angles with a mean angle that was not significantly different from 45. In experiment 3, we found partial evidence that participants are also influenced by categorical coding when drawing the relative position of two lines. Participants consistently drew a crossing line too far from the center of the main line that it was crossing. Overall, the current research supports the hypothesis that participants are influenced by categorical coding when attempting to accurately draw simple images.

CHAPTER 1: INTRODUCTION

Drawing is a medium of expression that has distinguished humans from other species for thousands of years. Although this activity has been studied extensively in children, few researchers have thought to investigate drawing in adults. Even fewer have thought to question the obvious: why are most adults awful at drawing? Considering how long this activity has been engaged in by humans and how much practice people have in childhood, it is remarkable that most people cannot accurately depict through drawing what they see in front of them. What factors contribute to this inability? Similarly, how are skilled artists able to overcome these factors and draw realistically?

Misperceptions in Drawing

Cohen and Bennet (1997) suggested that there are four factors that might contribute to an inability to draw accurately: a lack of the necessary motor coordination, an inability to make the best decisions about which aspects of the stimulus to represent in the drawing, inaccuracies in perceiving the stimulus to be drawn, and inaccuracies in perceiving the drawing and its realism. Cohen and Bennet (1997) concluded that misperception of the object to be drawn is the most substantial factor leading to drawing inaccuracies. Though Cohen and Bennet were pioneers in addressing the relevant questions, the only evidence they provided for their hypothesis was that they had empirical data falsifying the others.

Cohen and Bennet (1997) provided an explanation as to how an artist could misperceive the object he is trying to draw. They distinguished between two distinctive types of misperception: illusion and delusion. An illusion occurs unwillingly and typically cannot be overcome. It is a product of low-level processes of perception such as lateral inhibition in the retina. Illusions typically will not lead to drawing inaccuracies. Delusions, on the other hand, arise from higher-level processes, usually from previous knowledge of the stimulus being drawn, and can cause inaccuracies in drawing. Cohen and Bennet give the example of an artist painting a landscape that includes water. The artist may have previous knowledge that water is supposed to be blue, and therefore, he may paint blue water, even though the water is brown.

Thouless (1931) provided an example of another way an object might be misperceived. Thouless showed his participants oblique views of simple shapes, such as circles and rectangles. He asked the participants to match their view of the shape with a drawn outline on a card. Participants systematically overemphasized the ‘real’ shape of the object (see Figure 1), picking a card that was somewhere between the shape that would be projected on their retina by the stimulus and the shape of the object as it would be seen from a perspective perpendicular to the object. In other words, if participants viewed a circle from an oblique angle, the drawing they picked as being a match would have a shape that was not as elliptical as the true projection on their retina, but closer to a true circle. Thouless called this misperception “phenomenal regression to the real object.”

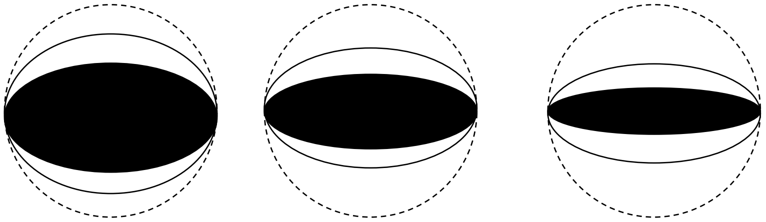


Figure 1: Example stimuli used in Thouless (1931). Dashed line shows “true” shape of object. Solid plane shows perspective shape of object. Solid line in middle shows average reproduction from participants.

Cohen and Jones (2008) conducted a similar experiment in which they showed that participants experience phenomenal regression when viewing images of rectangular windows. When asked to pick a line drawing of the outline of the window from varying angles (see Figure 2), participants would pick outlines which were closer to rectangular than the true outline. The number of errors made in this task was also found to be a predictor of the participant's drawing skill. This study further supported Cohen and Bennet's (1997) original claim that drawing inaccuracies are mostly due to a distorted perception of the object.

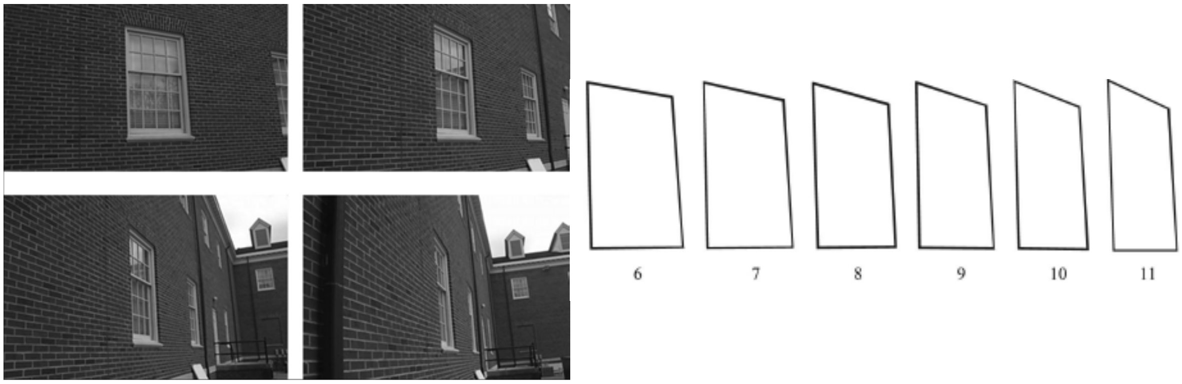


Figure 2: Left: Example images shown to participants in Cohen and Jones (2008) experiment. Right: Selection of choices participants could pick to match outline of window in image.

Mitchell, Ropar, Ackroyd, and Rajendran (2005) supplied further support for the claim that distorted perception causes drawing errors, showing that, while illusions can cause some drawing inaccuracies, delusions lead to much more potent errors. Mitchell et al. had participants view two different versions of the Shephard illusion (see Figure 3). In this illusion, two equal parallelograms are placed side by side, one vertical, and one horizontal. Due to the nature of the depth perception system, the vertical parallelogram seems to be longer and thinner than the horizontal parallelogram. When context cues, such as table legs, are added to these parallelograms, the misperception becomes much stronger. Mitchell and his colleagues showed that this pattern carried over to the participants’ attempts at drawing the parallelograms. Though they inaccurately drew parallelograms alone, their errors increased significantly when table legs were added. This increase could be due to the previous knowledge that participants had about tables and how they recede in the distance. In other words, a delusion, rather than an illusion, led to greater drawing errors.

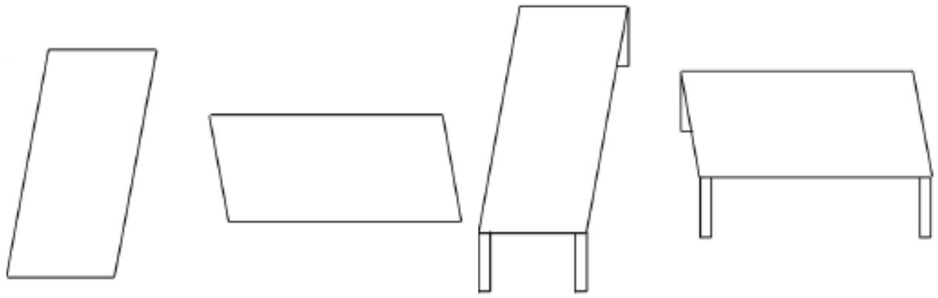


Figure 3: Stimuli used in Mitchell, et al. (2005) experiment. Left: Parallelograms with no context cues. Right: Parallelograms with table legs added.

Other Factors Contributing to Drawing Inaccuracies

Some researchers have shown that the other factors Cohen and Bennet (1997) rejected as possible explanations of drawing errors, as well as new factors, may be larger sources of error than previously shown. For example, Kozbelt and colleagues (2010) used an interesting methodology to show that, at least when trying to draw faces, it may be difficult for an unskilled artist to make the best decisions in regards to which aspects of the stimuli to represent through drawing. Kozbelt and colleagues gave participants an image of a face with a transparency over the image. They also gave participants a limited number of thin lines of tape and asked the participants to use the tape to trace the drawing. Unskilled artists were not able to create an image that was recognizable using this medium (see Figure 4). However, skilled artists were able to create recognizable images, suggesting that unskilled artists may not do well at deciding which parts of an image to represent in a drawing.

Figure 4: Example results from Kozbelt et al (2010) experiment. Top three faces were produced by skilled artists and can be recognized as a wrinkly old man. Unskilled artists produced bottom three faces. Although they are recognizable as a face, it is nearly impossible to tell anything about who the face belongs to.

Howard and Allison (2011) showed that the order in which the lines of a stimulus are drawn can change the overall accuracy of the drawing. Finally, Ostrofsky, Kozbelt, and Seidel (2012) argue that it is dichotomous and unnecessary to argue that there is only one factor contributing to drawing inaccuracies. As they point out, drawing is a very complex behavior, relying on many cognitive domains, making it likely that bottom-up and top-down processes contribute to drawing inaccuracies.

Categorical Perception

Categorical perception occurs when a continuously varying stimulus is perceived in discrete categories. For example, the human visual system parses the spectrum of light into discrete color categories even though this spectrum varies continuously

(Harnad, 1987). This perceptual system likely evolved because it allows the organism to overcome the variation among stimuli when trying to recognize them. When attempting to recognize an object, it can be viewed at an infinite number of angles, distances, and perspectives. Using a categorical system allows the receiver to extract the unvarying commonalities among all of these perspectives, allowing the organism to recognize novel objects and familiar objects from any perspective.

Huttenlocher, Hedges, and Duncan (1991) proposed a model of categorical effects and described how these effects may influence a person's recollection of the spatial location of an object. Their model posits that there are two representations of a stimulus in memory: a fine-grained representation and a categorically coded representation. The fine-grained representation is unbiased, meaning when error is present in recollection, this error is just as likely to be in one direction (such as too small) as it is to be in another (such as too large). The categorical representation, on the other hand, is biased due to two estimation processes. The first of these two processes is truncation resulting from boundaries. Boundaries occur at the endpoints of a category, but sometimes these boundaries can be vague. For example, blue is a category of color with many fine-grained shades within that category. However, the boundary between blue and green or between blue and purple is not exact. Therefore, a stimulus that is actually purple, but near blue, may be perceived as blue if it falls within the category boundary range. This crossing of stimulus between two categories due to an inexact category boundary is what Huttenlocher, Hedges, and Duncan referred to as truncation.

The second estimation process proposed by Huttenlocher, Hedges, and Duncan (1991) suggests that within each category, there is a prototype that most accurately represents the category. For example, there may be a particular shade of blue that most accurately represents the category of blue. When recollecting a stimulus that is not 100% accurate in memory and requires the use of some estimation, a person will tend to recollect a stimulus that is biased towards this prototype. So if a person is shown a picture of a blue sky and later asked to recall the exact shade of the sky, their recollection will be biased towards “sky blue”, even though the prototypical “sky blue” may not be the accurate color.

Though a categorical perceptual system is advantageous, it may interfere with accurate drawing. Some researchers have argued that humans perceive relations among parts of an object categorically (Hummel & Stankiewicz, 1996; Rosielle & Cooper, 2001). If this claim is true, when given a drawing task, participants may have a distorted view of the image to be drawn caused by categorical perception. An example of how this distortion could occur was given by Rosielle and Hite (2009). They had participants view images of two shapes of different sizes. Participants were asked to draw these shapes as accurately as possible. However, when viewing the shapes, participants were likely using a categorical system to code the relative sizes of the shapes. For example, if a circle and square were presented, with the circle having an area 25% larger than the area of the square, participants may have simply coded the circle as “larger than” the square rather than “25% larger than” the square. When asked to reproduce the images, participants exaggerated the categorical difference between the shapes, making the circle larger than it was supposed to be (see Figure 5).

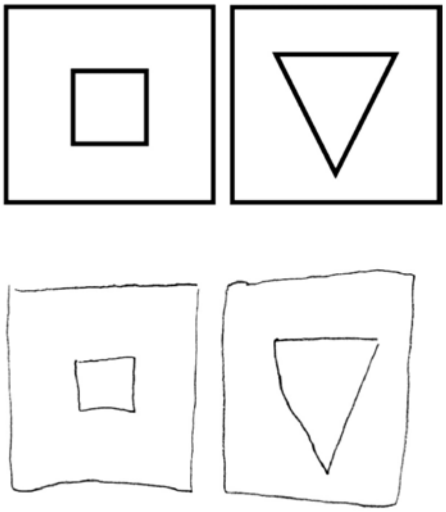


Figure. 5: Example images used in Rosielle and Hite (2009) experiment. Top panel shows the original image that participants saw. Bottom panel is one participant's reproduction of the

PURPOSE OF THE PROPOSED EXPERIMENTS

Research studying the drawing process of normal adults has slowly been increasing over the last two decades, but there are still tremendous gaps. Categorical perception is one capacity of the visual system that may interfere with accurate drawing in adults. Virtually no researchers have examined whether the categorical relations among the parts of an object lead to misperceptions of the to-be-drawn stimulus. The current research seeks to fill this gap.

The current research consisted of three experiments, each focused on a different type of categorical relations. These experiments will help us understand whether or not participants use categorical perception when drawing simple shapes and how this perception may lead to errors in accuracy. By understanding the causes of drawing inaccuracies, we may be able to develop methods that allow drawers to overcome categorical perception and its flaws, leading to more accurate drawing.

CHAPTER 2: EXPERIMENT 1

The purpose of experiment 1 was to determine whether categorical coding might lead to inaccuracies in reproducing the sizes of shapes within an object. As shown in Rosielle and Hite’s (2009) experiments, when presented with shapes of different sizes, participants may be using a categorical system to code the relative sizes between the shapes. In order to test this hypothesis, experiment 1 had two conditions for the relative size between shapes. In one condition, the two shapes had slightly different areas (small shape was 25% the area of the large shape). In the other condition, the two shapes had substantially different areas (the small shape was 75% the area of the large shape).

The categorical perception hypothesis makes specific predictions about how participants should draw the area ratios in these conditions. When the area difference between the two shapes is slight, participants should tend to draw the smaller shape too small. For example, if drawing an image of two squares, square A and square B, where square A is 75% the area of square B, participants should draw square A less than 75% the area of square B. The categorical perception hypothesis makes this prediction because slightly different sized shapes have a relative size that falls near the category of “same” but actually belongs to the category of “smaller than”. Because the slightly different sized shapes are close to this category boundary, participants will notice a discrepancy between the category perceived (smaller than) and their drawing if they draw square A too large. But if the participants draw square A too small, it will still fit their perception of being “smaller than” square B (see Figure 6).

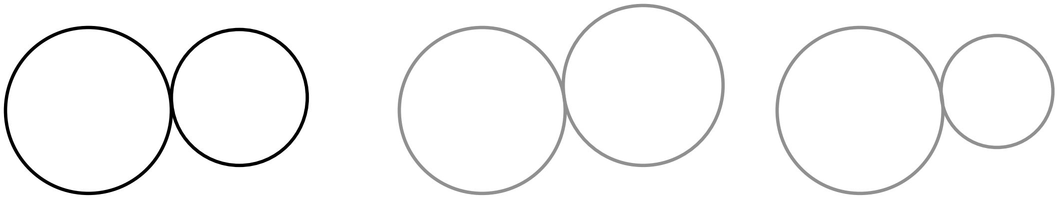


Figure. 6: Hypothetical drawings based on categorical perception. Left: Image participant would see. Middle: Drawing in which participant made smaller circle too large. It no longer fits their perception of being "smaller than". Right: Drawing in which participant made smaller circle too small. It still fits their perception.

However, when drawing the shapes that are substantially different, the ratio between the two shapes that the participants draw should not be different from the original ratio. The categorical perception hypothesis makes this prediction, because in the substantially different condition, the relative size between two shapes is not near a category boundary. Therefore, participants will be just as likely to draw square A too small as they are to draw it too large and the average of the participants' ratio for the area of the two shapes should not be significantly different from the original ratio of 0.25.

Method

Participants

Participants were 44 undergraduate students from the Iowa State University psychology participant pool. They were given 1 credit for 50 minutes of participation.

Apparatus

There were eight images in experiment 1. Each image contained two shapes of different sizes (i.e. two squares, one smaller than the other). Cooper and Kahl (2011) presented participants with similar stimuli (two shapes side by side) and asked participants to indicate which shape was larger. They found that certain pairs of shapes (e.g. circle and square) led to gross inaccuracies in recognizing the relative sizes of shapes. Participants systematically viewed triangles as being larger than squares and squares as being larger than circles even if the shapes had the same area. In order to avoid conflicts between the objective relative sizes of shapes and the subjective relative size experienced by participants, experiment 1 used pairs of same shapes in each image. In other words, squares were always paired with squares, circles with circles, etc (see Figure 7). The shapes were joined together.

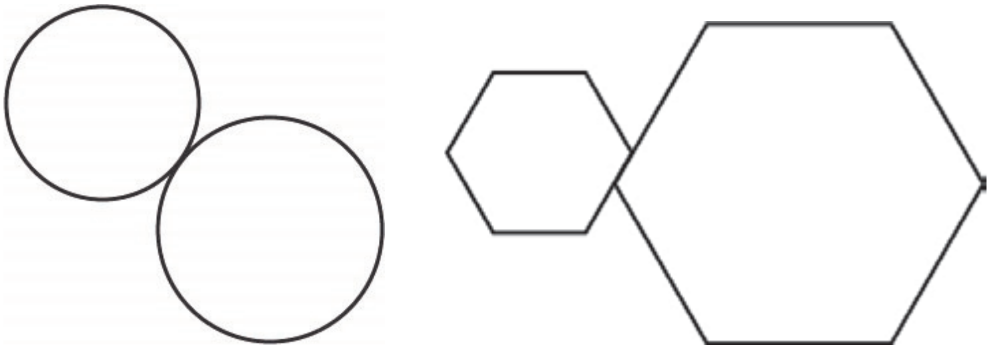


Figure. 7: Sample images for experiment 1. Left: Circles with slight difference in area. Right: Hexagons with substantial difference in area.

The relative sizes between the shapes were one of two categories: substantially different (smaller shape is 25% the area of the larger shape), or slightly different (smaller shape is 75% the area of the larger shape). The larger shape was presented in the right side of the image for half of the trials and in the left side of the image for the other half of the trials. These images were printed on standard printer paper and placed, one at a time, on a document camera (ELMO) that displayed the images on a projector screen at the front of the testing room, along with the images from experiments two and eight distractor images.

Procedure

Participants were tested in four separate groups, ranging in size from nine to 15. Participants were seated in a classroom with a projector screen at the front of the room.

They were given packets that contained the informed consent form, a demographic information sheet, and several pages of blank printer paper. These pages had a number on the upper left corner of the page, but otherwise were blank.

Participants were asked to read and sign the consent form and fill out the demographic information page. When all participants had finished, the experiment began. The order of the images were randomized once. Half the groups of participants saw images in this order, while the other groups of participants saw them in reverse order. Images were placed on the document camera so that they could be seen on the screen for 30 seconds. During this time, participants were asked to draw the image as accurately as possible on the corresponding blank printer page. They were also told that they could look at the image as often as they liked and could erase and redraw, if needed. After 30 seconds, the image was removed and there was a brief moment of blank screen; then the next image was displayed, and so on, until all images had been displayed.

Importantly, participants were not allowed to look at other participants' drawings and were only allowed to draw one image per page. Instructions emphasized the need to make the drawing as accurate as possible.

Results

All participants' images from experiment 1 were scanned onto a computer, using a standard size and resolution. For each image, a research assistant used Photoshop to fill in each of the two shapes. Then a pixel count was used to determine the area of each shape, and a ratio of the area of the smaller shape to the larger shape was calculated.

This ratio was compared to the original ratio of the stimuli that participants saw. For substantially different sized shapes, this ratio was 0.25; for slightly different sized shapes, this ratio was 0.75. For substantially different sized shapes, the participants' mean ratio was 0.323 and a one-sample t-test revealed that this mean was not significantly different from 0.25, t(43) =1.98, p =0.054, 95%CI[0.249, 0.397]. The mean for participants' drawings of slightly different sized shapes was 0.689. Again, a one-sample t-test was used to determine that the participants' mean was significantly different from 0.75, t(43) = -6.04, p < 0.0001, 95%CI[0.664, 0.707]. An example of a representative drawing for each condition is shown below (Figure 8).

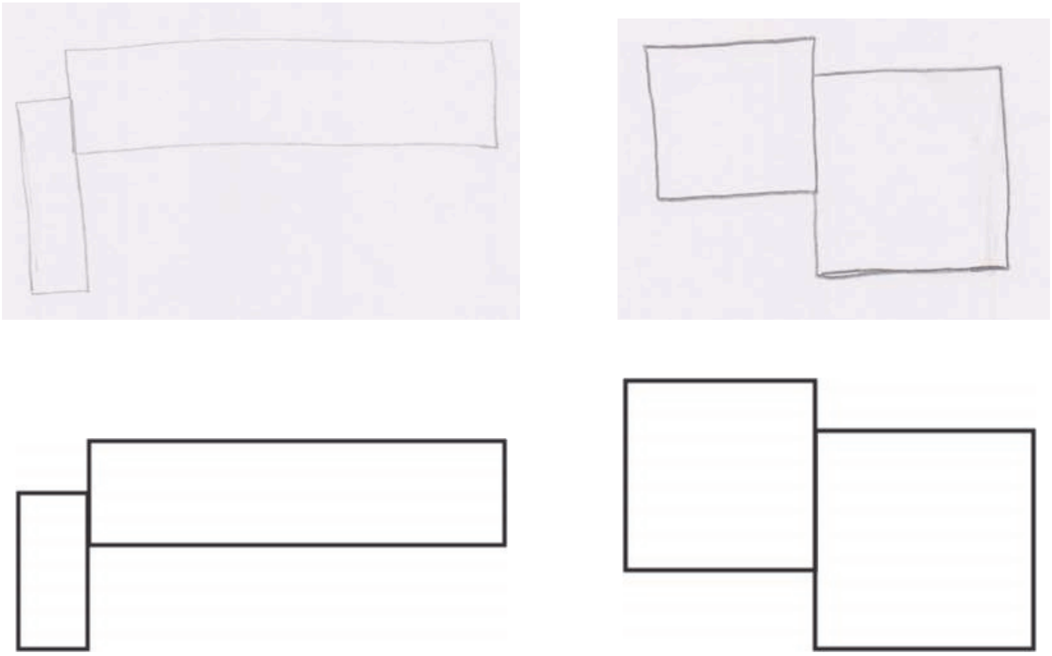


Figure. 8: Examples of drawings by participants with original stimulus below. Left: Drawing and original of substantially different sized rectangles. Right: Drawing and original of slightly different sized rectangles

Discussion

If participants had not been using a categorical system to code the relative size of the two shapes, then their mean ratio should not have been significantly different from 0.75, and instead, participants should have erred randomly, making the small shape too large at times and too small at other times. However, this pattern was not obtained. As predicted from the categorical perception hypothesis, participants drew the slightly different sized objects with a ratio that was smaller than the ratio of the shapes the participants saw. In other words, they drew the small shape in these images too small, relative to the larger shape.

Also in accordance with our hypothesis, participants did not draw the substantially different sized images with a ratio significantly different from the original. As the ratio of the size of the shapes approaches a category boundary (such as same size), participants are more likely to err on the side of the correct category (smaller than). For example, when shape A is smaller than shape B, but is close to being the same size, participants are more likely to draw shape A too small. But when the ratio is in the middle of two category boundaries, participants err randomly around the true ratio, sometimes drawing shape A too large and sometimes drawing it too small.

CHAPTER 3: EXPERIMENT 2

The purpose of experiment 2 was to determine whether or not participants use a categorical system to perceive the relative orientation of two conjoined lines. Object recognition theories (Biederman, 1987; Hummel & Biederman,1992) suggest that likely categories of orientation are parallel, perpendicular, and oblique (Rosielle & Cooper, 2001). These categories are computationally useful because they allow the observer to recognize an object even when the perspective of that object changes. In other words, if a person was observing an object that contained one part at a particular orientation relative to another part, the orientation of that part would vary as the perspective of the object changed. However, perpendicular orientations will always appear perpendicular, parallel orientations will always appear parallel, and oblique orientations will always appear oblique, despite the perspective the object is being viewed from.

According to the categorical perception hypothesis, participants' drawings of angles should be different than the original for the 15 and 75 degree conditions, but not for the 45 degree condition. This pattern should occur, because 15 and 75 degrees both fall near a category boundary. Fifteen degrees is close to being parallel and 75 degrees is close to being perpendicular, but both are actually oblique and will be coded by participants as oblique. Therefore, when drawing a 15 degree angle, participants will be unlikely to draw the angle too small, because it will then be coded as parallel and will conflict with their perception of the angle being oblique. However, if the participants draw the angle too large, it will still fit their perception. Similarly, participants will be unlikely to draw the 75 degree angles too large because the angle would then be coded as perpendicular and would conflict with their perception of the angle being oblique(see Figure 9). Because the 45 degree angle is not near a category boundary (in Huttenlocher, Hedges and Duncan's terminology, it is the prototype of "oblique"), participants will be just as likely to make this angle too small as they are to make it too large and the mean of the participants' angle will not differ from 45 degrees.

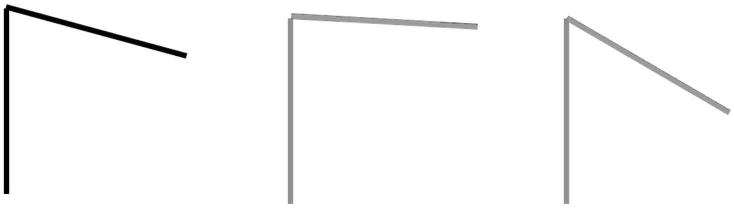


Figure. 9: Hypothetical drawings based on categorical perception. Left: Image participant would see. Middle: Drawing in which participant made angle too large. It no longer fits their perception of being “oblique”. Right: Drawing in which participant made angle too small. It still fits their perception.

Method

Participants

Participants were the same participants from experiment 1.

Apparatus

Each image in experiment 2 contained a target, which consisted of two lines forming an angle of either 15, 45, or 75 degrees. Experiment 2 had three images with 15 degree angles, three with 45 degree angles, and three with 75 degree angles, for a total of nine images. One of the lines that formed the angle was either vertical or horizontal. These lines were embedded in more complex drawings (see Figure 10), so that participants were not overly focused on the angle of the lines. The average length of lines within an angle were the same across conditions. Also, the average number of line segments in an image was controlled across conditions.

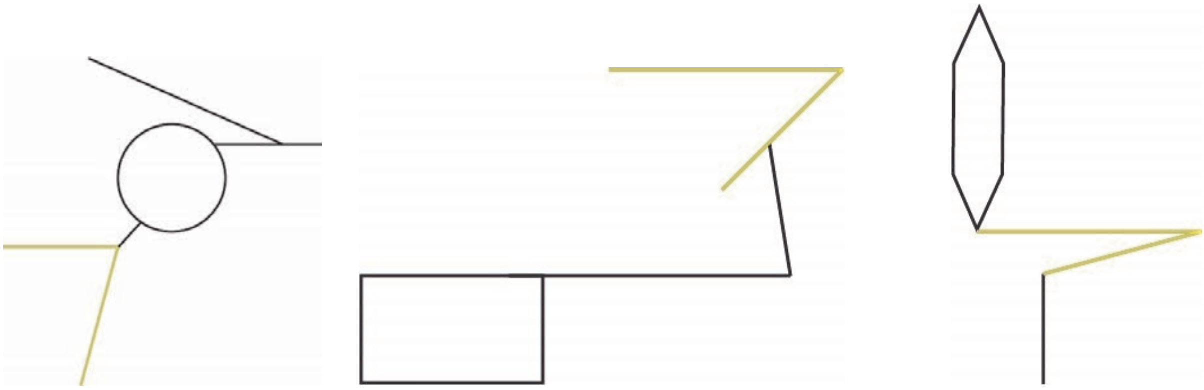


Figure. 10: Sample images for experiment 2 with target highlighted in each. Participant will see these images without the highlight. Left: Target angle is 75 degrees. Middle: Target angle is 45 degrees. Right: Target angle is 15 degrees.

Procedure

Experiment 2 followed the same procedure as experiment 1.

Results

For experiment 2, the angle in the participants' original drawings were measured by hand. Research assistants (RA) naïve to the hypotheses of the experiment were given the participants' drawings along with 4x3 in. pieces of tracing paper, a ruler, and a protractor. The RAs used a ruler and tracing paper to trace the target angles in the participant's drawings. Tracing was done for three reasons. First, participants did not always draw perfectly straight lines, which made measuring the angles of these lines difficult. RA's were instructed to place their tracing paper on top of the angle, and to draw a straight line that connected the end points of the participant's original line. Second, in order to make precise measurements with the protractor, the lines of the angle needed to be at least 2 inches long, or else they would not reach the tic marks on the protractor that allow precise measurements. Tracing the angle allowed the RA's to extend the length of participant's lines, which made for more precise measurements without affecting the variable of interest. Third, using tracings of the participant's drawings kept the images pristine so that multiple RA's could measure the same drawing.

The participants' mean angle in each condition was compared to the original angle (either 15, 45, or 75 degrees). The mean angle participants drew for the 15 degree angles was 23.432 degrees. For 75 degree angles, participants drew an angle with an average of 66.023 degrees and for 45 degree angles, participants drew angels with an average of 46.083 degrees. We performed one-sample t-tests for each of the three conditions and found that participants' drawings of 15 degree angles were significantly larger than 15, $t(43) = 13.62$, $p < 0.0001$, 95%CI[22.183, 24.681]. Participants' drawings of 75 degree angles were significantly smaller than 75, $t(43) = -9,51$, $p < 0.0001$, 95%CI[64.118, 67.927]. The mean degrees of participants' drawings of 45 degree angles was not significantly different from 45, $t(43) = 1.93$, $p = 0.06$, 95%CI[44.951, 47.216]. Examples of participants' drawings are in Figure 11.

Discussion

If drawing line orientation is influenced by categorical coding, participants should be more likely to draw 15 degree angles too large and to draw 75 degree angles too small, and in fact, this is the pattern we observed in experiment 2. Participants did not draw 45 degree angles significantly differently than the original angle, also supporting the idea that categorical coding is influencing drawing.

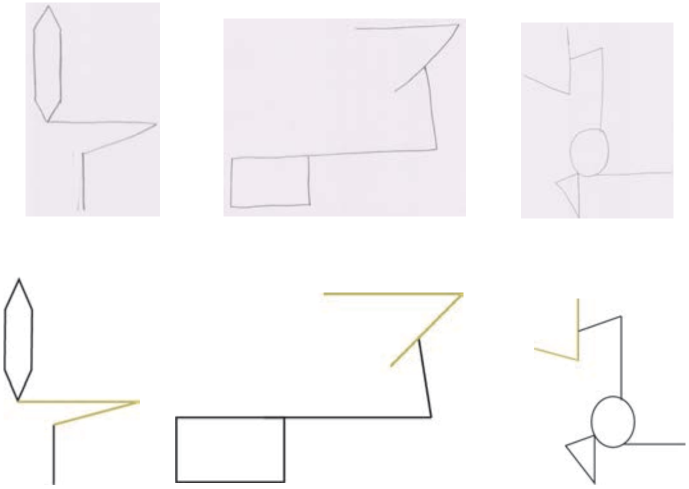


Figure. 11: Examples of drawings by participants with original stimuli below. Left: 15 degree angle. Middle: 45 degree angle. Right: 75 degree angle.

CHAPTER 4: EXPERIMENT 3

The purpose of experiment 3 was to determine if a categorical coding of relative position influences drawing. Some theories of object recognition (Biederman, 1987) posit that the relative position of two parts of an object are coded categorically as "above", "below", or "side of". This coding system is useful because it allows the observer to overcome variations in the appearance of an object at different perspectives. If one part of an object is above another part, this relation will be true no matter the perspective of the object. When viewing three-dimensional objects in every-day situations, parts are coded as side of, rather than left of or right of, because something that is side of could be either left of or right of depending on how the object is rotated. For example, the handle of a coffee mug could either be at the right of the object or the left of the object, depending on how it is rotated. However, for two-dimensional stimuli, such as the drawings in experiment 3, participants will likely code right of and left of, because the parts of two dimensional stimuli cannot alternate between right of and left of.

Experiment 3 has two separate conditions for the relative position of lines. In one condition, there is a line (the crossing line) crossing another line (the main line) near the center of the main line. In the other condition, the crossing line is far from center. If participants are using categories such as “right of center” and “below center” to code relative position, then the participants will be more likely to draw the crossing line in condition one too far from center. For example, if the crossing line is right of center but is near the center, then it will be close to the category of “at center” but will be coded by participants as “right of center.” If participants draw the crossing line too close to center, it will be coded as “at center” and this coding will conflict with their perception of the crossing line being “right of center.” However, if the participant draws the crossing line too far from center, it will still match their perception of being “right of center.” When the crossing line is far from center, as in condition two, participants will be just as likely to draw it too far from center as they are to draw it too near to center, and therefore, the mean distance of participants’’ crossing line will not differ from the original distance (see Figure 12).

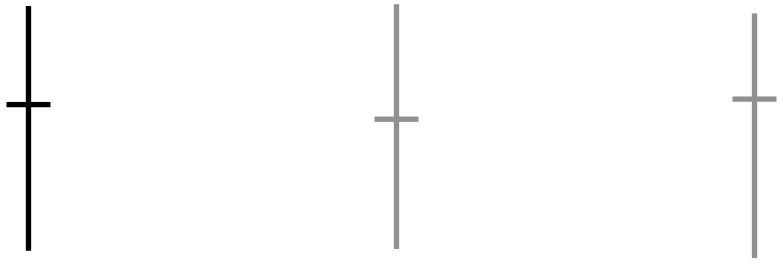


Figure. 12: Hypothetical drawings based on categorical perception. Left: Image participant would see. Middle: Drawing in which participant made crossing line too close to center. It no longer fits their perception of being “above center”. Right: Drawing in which participant made crossing line too far from center. It still fits their perception.

Method

Participants

Participants were 29 undergraduate students from Iowa State University. They were given 1 credit for 50 minutes of participation.

Apparatus

There were eight images. The images contained a target which consisted of two lines. One of these lines (the main line) was either vertical or horizontal. The other (the crossing line) crossed the first line, off center, perpendicularly. This crossing was either far off center (40% the length of the main line) or slightly off center (10% the length of the main line) and appeared to the left, to the right, above, or below center. Again, these lines were embedded in more complex images (see Figure 13) so that participants did not become overly focused on the target. The average length of the lines in the targets and the average number of line segments in the image were the same in both conditions.

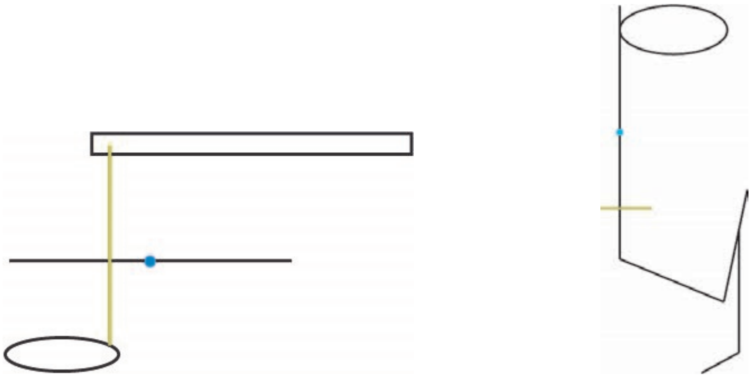


Figure. 13: Two sample images for experiment 3. Blue dot indicates center of line. Line in target position is highlighted in yellow. Participant will see these images without the dot or highlight. Left: Target is slightly left of center. Right: Target is far below center.

Procedure

Participants were tested in twelve separate groups, ranging in size from one to nine. Participants in experiment 3 only saw the eight images for experiment 3. Otherwise, experiment 3 followed the same procedure as experiments one and two.

Results

All participants' images from experiment 3 were scanned onto a computer, using a standard size and resolution. For each image, a research assistant used Adobe Illustrator to trace the target lines in each image. Participants were told to use the pen tool in Illustrator to make a line that connected the end points of the main line in each image and measure the length of this line. Then they traced a line over the point where the crossing line crossed the main line. Using tools in Illustrator, RA's found the center of the main line and measured the distance between this center point and the crossing line. The RA's then calculated the ratio of the distance from the center to the crossing line compared to the length of the main line.

The participants' mean ratio for the distance of the crossing line from the center of the main line was then compared to the original ratio for each condition (near center and far from center). Images with a crossing line far from center had an original ratio of 0.4, and images with a crossing line near center had an original ratio of 0.1. The average ratio of participants' drawings of images with far crossing lines was 0.352 and their mean for images with near crossing lines was 0.114. One-sample t-tests revealed that both of these ratios were significantly different from their originals. For images with far crossing lines, the mean was significantly smaller than 0.4, $t(28) = -8.94$, $p < 0.0001$, 95%CI[0.341, 0.363]. For images with a near crossing line, the mean was significantly larger than 0.1, t(28) = 2.34, p = 0.027, 95%CI[0.102, 0.127]. Examples of participants' drawings are shown below (see Figure 14).

The participants' mean error was calculated within each condition. To make this calculation, the participant's ratio for each image was subtracted from the original ratio. For example, if a participant drew a crossing line at a distance of 0.35 of the main line from the center for the far from center condition, then the participant's error would be 0.4 – 0.35 or 0.05. All negatives were dropped from these values so that the direction of error did not influence the mean error. Then a two-sample t-test was conducted which revealed that there was a significant difference in the magnitude of error between the two conditions. The far from center condition had a mean error of 0.05, while the near center condition had a mean error of 0.03. The difference between the error for the two conditions was 0.0241, t(56) = 3.4, p = 0.0012, 95%CI[0.01, 0.04].

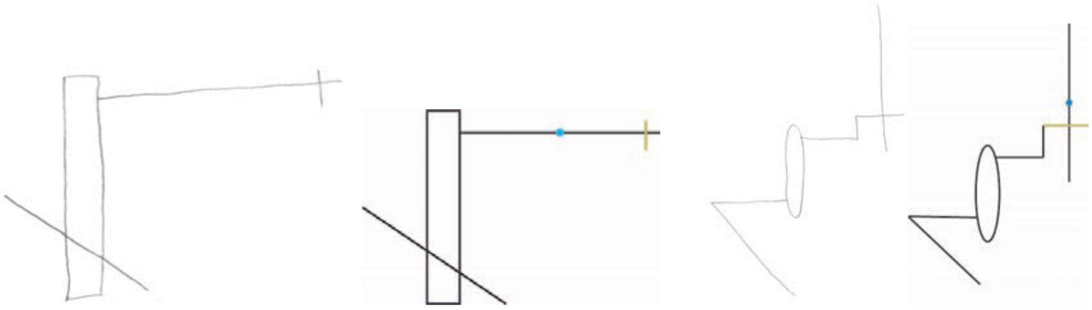


Figure. 14: Examples of drawings by participants with original stimuli. Left: Drawing of crossing line far right of center next original stimulus. Right: Drawing of crossing line near below center next to original stimulus.

Discussion

The results of experiment 3 are partially consistent with the predictions made in the introduction of the experiment. As predicted, participants consistently drew the crossing line in images with a near to center crossing line too far from center. However, though this difference was statistically significant, the participants' average ratio of 0.114 is not practically different from the original ratio of 0.1, and therefore, the crossing line in these images was not drawn as far from center as we would have predicted. Similarly, the results for the far from center condition do not agree with our predictions. Instead, there was a significant difference between the participants' drawings of the crossing lines and the original images. Specifically, participants drew the crossing line in the far from center condition too close to center.

Though the results of experiment 3 are not what were predicted, they are still consistent with the hypothesis that a categorical coding of relative position influences participants' drawings. However, the results suggest that the categories used to guide the predictions in experiment 3 are not the only categories that participants may have used to code relative position. Biederman's (1987) theory of object recognition suggests, on theoretical grounds, that possible categories are "at center," "below center," "right of center," etc., but this theory does not allow for the possibility that participants may impose more category boundaries than one that falls at the center of a line. For example, participants could also form categories based on the ends of the lines, so they would have categories such as "at end" or "right of end." This type of coding can explain the results of the "far from center" condition in experiment 3. Rather than coding the crossing line as "right of center" in this condition, participants may have coded it as "left of end." In order to avoid placing the crossing line "at the end" which would conflict with the participant's perception, the participant would have likely drew the line too far from the end, resulting in a crossing line that was closer to center than the original image.

CHAPTER 5: GENERAL DISCUSSION

Results from the three experiments show that people likely use a categorical system to code relations among parts of an object when drawing simple images. Experiment 1 showed that participants' drawings were distorted by categorical coding of the size of two shapes; experiment 2 supported the hypothesis that participants' drawings were influenced by the relative orientation of two lines and experiment 3 suggested that participants'' drawings were influenced by the categorical coding of the relative position of lines.

Our experiments further reveal that the use of a categorical system may interfere with peoples' abilities to accurately perceive the stimulus they are attempting to recreate. Participants were biased to exaggerate the categories which the images belonged to, leading to inaccuracies in their drawings. Understanding this categorical system, therefore, may help us develop methods for overcoming these inaccuracies. Some of these methods already exist in the drawing community, but with better understanding, these methods could be enhanced. For example, when drawing an image, artists sometimes use a method called the "grid method," in which they overlay transparent graph paper onto the image to be drawn, and instead of drawing the image as a whole, will work with one block of image at a time (see Figure 16). This method may allow the artist to ignore some of their categorical biases and focus on more precise details of the image being drawn.

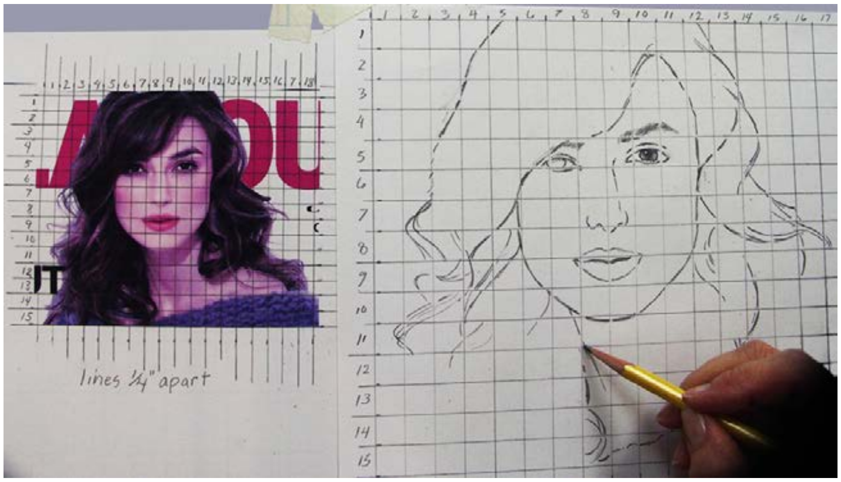


Figure. 16: Use of the “grid method” to draw accurately. Gridlines are drawn over to-be-drawn image. Then drawing is done on graph paper, one square at a time (Mattia, 2008).

Future research should first work to find the particular categories used for different types of relations. In the current research, we made assumptions about where category boundaries lie based on theoretical grounds. For example, we assume that the categories used for relative orientation are parallel, perpendicular, and oblique. Similarly, we assume that participants have categories such as ‘near center’ or ‘far from center’ that they use to code relative position. However, our results indicate that these assumptions may not be entirely accurate. Casner, Cooper, and O’Brien (2004) developed the “lightning bolt” method to find the category boundaries for coding relative orientation, but this method could be adapted to find the category boundaries for any type of perception.

Once these particular categories are uncovered, researchers can examine how these categories affect more complex types of drawing and other mediums of art. For example, researchers could have participants draw photographs of faces and other complex stimuli. They could also examine how categorical perception might impact more abstract forms of art and could even examine the use of categorical perception in music. This line of research could also be used to further understand the anatomical and neurological processes involved in visual perception.

REFERENCES

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review,* 94, 115-147.

Casner, G. E., Cooper, E. E., & O'Brien, A. (2004, November). Categorical coding of orientation in visual object perception. Talk presented at the meeting of Object Perception, Attention, and Memory. Minneapolis, MN.

Cohen, D. J. (2005). Look little, look often: The influence of gaze frequency on drawing accuracy. *Perception & Psychophysics,* **67(6),** 997-1009.

Cohen, D. J., & Bennet S. (1997). Why can't most people draw what they see? *Journal of Experimental Psychology: Human Perception and Performance,* **23,** 609-621.

Cohen, D.J., & Jones, H.E. (2008). How shape constancy relates to drawing accuracy. *Psychology of Aesthetics, Creativity, and the Arts,* **2(1)**, 8-19.

Cooper, E.E., & Kahl, J.T. (2011). Do people misperceive the area of regular polygons? Poster presented at the annual meeting of the Object, Perception, Attention, and Memory Society. Seattle, Washington.

Harnad, S. (1987). *Categorical perception: The groundwork of cognition*. (pp. 1-25). Cambridge: Cambridge University Press.

Howard, I.P., & Allison, R.S. (2011). Drawing with divergent perspective, ancient and modern. *Perception,* **40**, 1017-1033.

Hummel, J.E. & Biederman, I. (1992). Dynamic binding in a neural network for shape recognition. *Psychological Review*, **99**, 480-517.

Hummel, J. E., & Stankiewicz, B. J. (1996). Categorical relations in shape perception. *Spatial Vision*, *10*(3), 201-236.

Huttenlocher, J., Hedges, L.V., & Duncan, S. (1991). Categories and particulars: Prototype effects in estimating spatial locations. *Psychological Review*, **98(3)**, 352-376.

Kozbelt, A., Seidel, A., EBassiouny, A., Mark, Y., & Owen, D.R. (2010). Visual selection contributes to artists' advantages in realistic drawing. *Psychology of Aesthetics, Creativity, and the Arts,* **4(2)**, 93-102.

Mattia, M. (Photographer). (2008). [Untitled Photograph]. Retrieved March 14, 2014, from: http://maramattiaart.blogspot.com/2008/11/lesson-6-draw-face-using-grid-method_25.html

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.

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.

Rosielle, L. J., & Cooper, E. E. (2001). Categorical perception of relative orientation in visual object recognition. *Memory & Cognition*, *29*(1), 68-82.

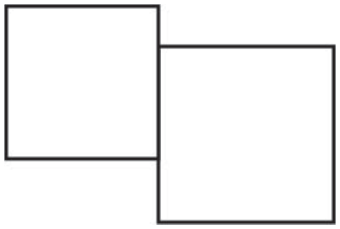
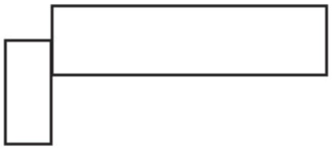
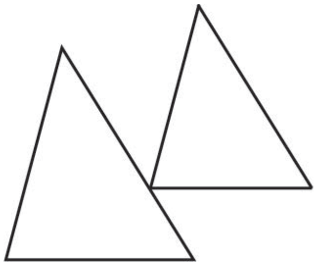
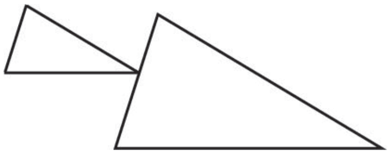
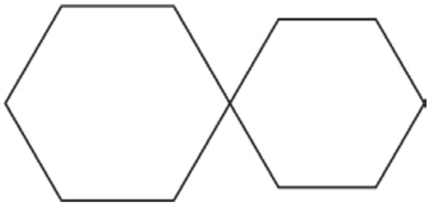
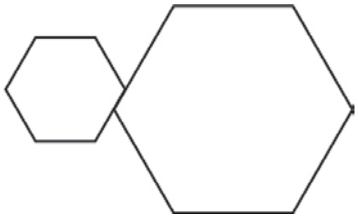
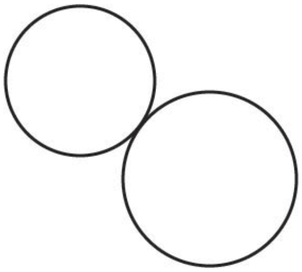
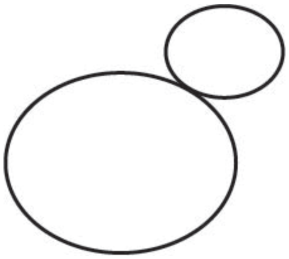
Rosielle, L.J., & Hite, L.A. (2009). The caricature effect in drawing: Evidence for the use of categorical relations when drawing abstract pictures. *Perception,* **38**, 357-375.

Thouless, R H.. (1931). Phenomenal regression to the real object. *British Journal of Psychology*, **21**, 339-359.

Quinn, P. C. (2004). Visual perception of orientation is categorical near vertical and continuous near horizontal. *Perception-London,* ***33***, 897-906.

APPENDIX A

Stimuli

Slightly different size	Substantially Different Size
	
	
	
	

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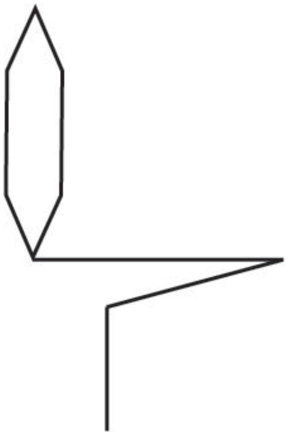
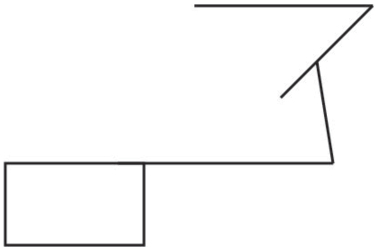
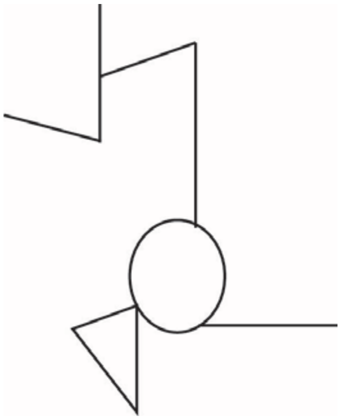
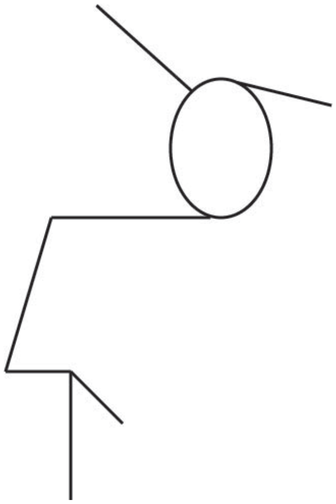
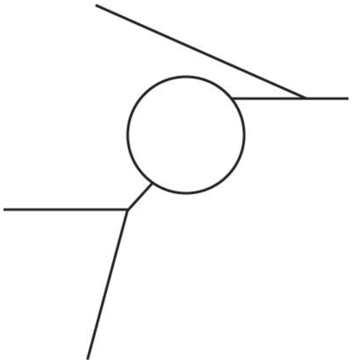
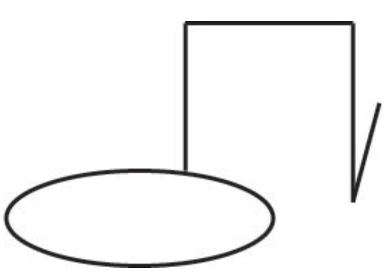
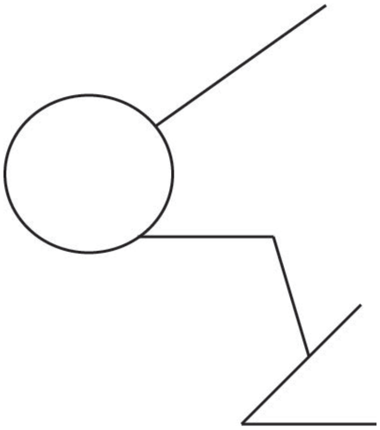
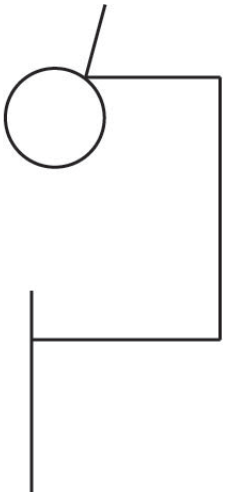
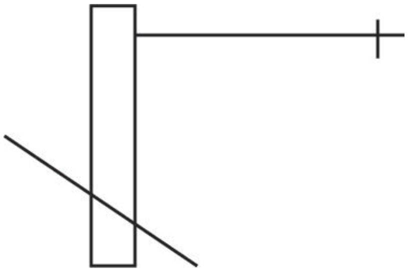
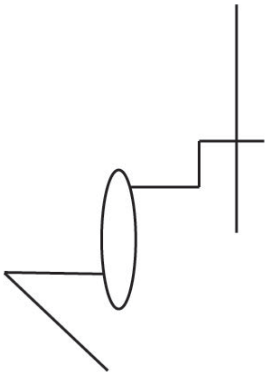
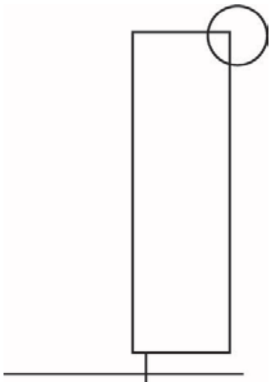
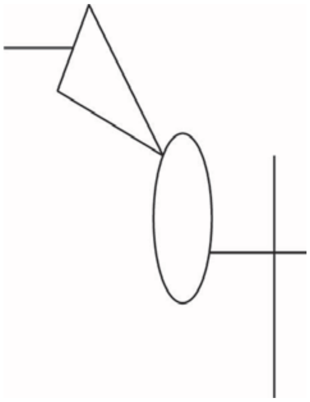
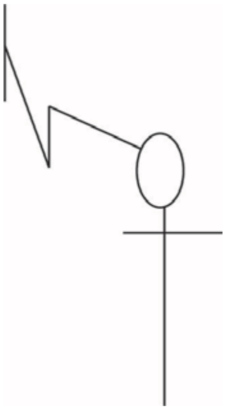
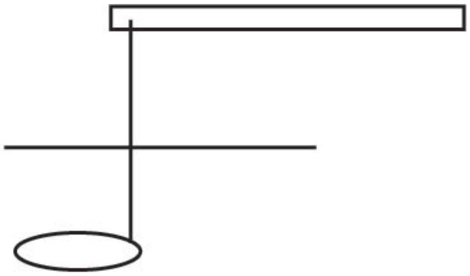
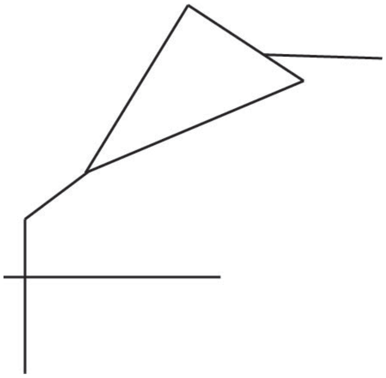
		
		
		

Far from Center	Near Center
	
	
	
	

APPENDIX B

Instructions

Thank you for participating in this experiment. In this study, you will be asked to draw 26 simple line drawings as accurately as possible. These images will be displayed, one at a time, on the screen at the front of the room. Each image will be numbered. Please draw the image on the corresponding numbered paper in your packet. You will have 30 seconds to complete each drawing. Please draw the image as accurately as possible. You may erase mistakes and redraw your image, but it is important that you finish the entire image within 30 seconds. The first image is a practice drawing to familiarize you with the procedure.

Please do not talk to other students or look at their papers throughout the experiment. Please silence or turn off your cell phone and any other electronic devices. If you have questions, please ask the experimenter.