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Observing and engaging in purposeful actions with objects influences estimates of their size

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A ladle was recalled as being taller by participants who observed tedious removal of sand from it with a small teaspoon than by those who observed removal with a larger spoon. A second experiment showed that the number of darts thrown in order to hit a target correlated negatively with memory estimates of the size of the target, a finding replicated in a third experiment with size estimates made while the target was visible. The first two experiments suggest that the way an object is used can influence memory of its size. The third experiment supports the hypothesis that in vivo size estimation of familiar objects may employ a mechanism that derives size from memory and that size memory can be distorted by the way an object was used.

A small construction project completed by the first author included several examples of the importance of size perception. He first selected a piece of scrap wood of an appropriate size to serve as the base of the gadget he intended to build. Later, he selected, from a box of assorted-sized nuts, one that would correctly fit a bolt. He reached for the nut, separating his thumb and forefingers to approximate the size of the nut he was going to grasp. After observing that the nut was too small, he compared the small nut with others in the box, to help select a larger one.

Recent conceptualizations of size perception reject earlier assumptions that all of the above activities employ the same process of size assessment (e.g., Treisman, 1988, saw size as a primitive). The evaluation of the size of objects appears to occur in at least two anatomically and functionally distinct cortical systems. In one system, often referred to as the *dorsal stream*, size perception is necessary in the control of grasping and other actions (Goodale, Milner, Jakobson, & Carey, 1991). Size estimates involving the grasping of the nut in the example above would be under dorsal control. The second system, the *ventral stream*, is involved intimately in object recognition and, in that role, appears to assess different aspects of the size of an object than does the dorsal stream (Kassubek et al., 1999). In the example above, the ventral stream would control functions related to the selection of appropriately sized materials. In this article, we focus on the process of size assessment controlled by the ventral stream.

The ventral system may assess size in more than one manner. Evidence suggests separate processing for estimates of relative size (e.g., which of these nuts is larger?) and for size estimates of single objects (e.g., how large is this piece of wood?). In vivo size comparisons of two or more objects are very accurate and may depend only on the visual angle subsumed by the object (Gibson, 1950) or on heuristics that use the horizon as a reference (Bertamini, Yang, & Proffitt, 1998). Estimation of the size of a single object appears to be less accurate (Bolles & Bailey, 1956), and traditional theories about this system have assumed that estimation of the size of a novel object may require data on the size of the retinal image of the object and an estimate of the distance to the object (Gregory, 1963; Holway & Boring, 1941). We will further limit our discussion of size estimation to processes that assess the size of single objects and will refer to this process as *size estimation*.

At least two recent reports (Haber & Levin, 2001; Wesp, Peckyno, McCall, & Peters, 2000) have proposed that size estimates of familiar objects are not dependent on on-line information about retinal size and distance but, instead, are driven by higher order memory processes. Haber and Levin showed higher accuracy for size estimates of familiar objects that tend not to vary in size from a prototype than for estimates of the size of objects for which there is a wider range of sizes. They proposed that size estimates of familiar objects begin with recognition of the object and that, subsequently, recall of past experience with the object category serves to formulate a size estimate of the object.

Wesp et al. (2000) showed that errors in size estimates of common objects were larger than errors in size estimates of uncommon objects. Those who estimated the size of the familiar objects (e.g., a key, a dollar bill, or a textbook) made significantly larger errors in size estimates than did those who viewed undefined objects of the same dimension, pattern, and color. Estimates from memory were less accurate than those made when the object was present. They hypothesized that size estimates of the familiar objects were based on memory of the size of the objects, and the memory of the objects' sizes appeared to be influenced by the interpretations about size that developed from using or observing the use of the objects.

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Familiarity based on experience with an object has been shown to serve as a depth cue (Fitzpatrick, Pasnak, & Tyer, 1982; Ittelson, 1951). However, few researchers have considered how the type of experience with an object influences size estimates of the object. Bruner and Goodman (1947) found that children overestimated the size of coins, but not the size of cardboard cutouts of the same shape and size. They found that *poor* children made larger overestimations than did *rich* children. The authors concluded that the *value* of an object influenced the perception of its size. Coins were more valuable to poor children, and this led them to see the coins as larger. Interest in the topic seemed to wane following a critical review paper by Pastore (1949).

Cavalier and Wesp (1997) described a teaching demonstration that showed that students regularly overestimated by about 50% the size of a classroom trashcan. Overestimation of height is not unusual in size estimates of common objects, and Chapanis and Mankin (1967) used evidence of height estimate errors for objects in their normal environments to show real-life examples of the horizontal–vertical illusion. We showed a lesser but significant overestimation of the height of a trashcan when it was presented on its side, undermining the theory that the overestimation was caused solely by the process that underlies the horizontal–vertical illusion (Wesp, Cavalier, Clough, & Rancourt, 1996). Furthermore, we showed that overestimation of the height of a cardboard cutout of the can was smaller than the overestimation of the actual can, suggesting that there was something about the can that created the more extreme distortion of height estimates (Wesp et al., 1996). These findings led us to consider whether the very large overestimation of the height of a trashcan was a function of the way that trashcans are often seen as being used (they should be big to hold trash).

Our work and the work of others who have examined the way in which experience with how an object is used has influenced size estimates have involved post hoc explanations of the influence that a purposeful interaction might have had on size estimation. For example, we believed that the trashcan was seen as something that should hold a lot of trash and, therefore, observers estimated its height as larger than it was. These post hoc assessments raise problems. Would we have justified underestimates of size by suggesting that the can was holding material that was not important? One could make a more convincing argument about the relationship between the characteristics of the interaction with an object and the accuracy of size estimation if size estimates changed as a result of interactive experiences introduced by the experimenter.

We conducted three experiments in which we explored whether we could predict errors in size estimates of objects on the basis of the type of purposeful object-related action the participants engaged in or observed. In the first experiment, we compared estimates from memory of the size of a container after participants had observed removal of sand from a ladle. We predicted that those who observed a tedious process of removal using a very small spoon would estimate that the container held more sand and, thus, would recall it as being larger than would participants who observed a less tedious process of sand removal. In the second experiment, we examined the relationship between how difficult it was to hit a target with a dart and the subsequent estimation of the size of the target from memory, predicting that those who had a difficult time hitting the target would see the target as smaller. In the third experiment, we assessed experiential influences on in vivo size estimates by replicating the second experiment, but with the target in view. We also compared the findings with a condition in which size estimation of the target preceded dart throwing, a condition in which dart-throwing experience could not influence size estimates.

EXPERIMENT 1

Method

Participants. Thirty-three male and 33 female introductory psychology students volunteered to participate. The experimenter explained to the participants that they would be part of a study on the accuracy of perception that would take less than 5 min but provided no other information about the procedure until all the participants had completed the experiment.

Apparatus and Setting. The participants observed the experimenter use a metal tablespoon or a quarter teaspoon (from an Ekco Model 34059 measuring spoon set) to remove sand from a stainless steel ladle (America Cooks Model 7418, with a scoop that was 88 mm wide and 31 mm high).

The participants sat next to each other along the side of a 2.44-m-long table facing the experimenter, who stood centered along the other side of the table. The experimenter stood approximately 2 m away from the participant who was seated at the center of the table. When the experimenter displayed the ladle, he held the handle of the ladle so that the bottom of the scoop of the ladle was approximately 1 m above the floor and was held over a bucket that was placed on a chair in front of him.

The participants estimated the size of the ladle scoop by selecting a match from 25 different-sized cross-sectional depictions of the ladle (without a handle). All of the depictions were shown together as black hemielipses on a 74 × 21.6 cm white display board. The width of the depictions varied from 59 to 127 mm ($M = 88.6$), the height varied from 22.5 to 36 mm ($M = 29.7$), and the 25 depictions were randomly placed on the display board.

Procedure. We randomly assigned groups of 4 or 5 participants to one of two conditions. The experimenter explained to all the participants that the task required that they observe the experimenter conduct several activities and then answer questions about what they remembered seeing. The experimenter then lifted the ladle filled with sand from the bucket, held it in front of him, and began to remove sand from the ladle with a spoon. The participants in a tedious removal condition (16 men and 17 women) observed the experimenter use the quarter teaspoon to spoon sand out of the ladle into the bucket. The tedious removal procedure was designed to call attention to the repetitive removal of sand, which would suggest that the ladle held a large amount of sand. Sixty rounded spoons of sand were removed over approximately a 1-min period. The participants in a movement condition (16 women and 17 men) observed the experimenter use the tablespoon to spoon sand out of the ladle into the bucket. The movement condition was designed to focus on the movement of sand without emphasizing a relationship between the movement and the volume of sand in the ladle. In the movement condition, the experimenter removed a level spoon of sand to about

10 cm above the ladle scoop, poured it back into the ladle, and repeated that action four more times; the experimenter then used the spoon to remove a level tablespoon of sand into the bucket. He repeated the six spoon movements 9 more times, taking approximately 1 min to complete the activities. The experimenter moved sand from the ladle with the spoon 60 times in order to replicate the number of spoon movements made in the tedious removal condition.

Following the experience with the ladle, the experimenter told the participants that they would be asked three questions and instructed them to write the numbers 1 through 3 on a piece of copy paper and answer the questions in sequence next to the numbers. The experimenter asked the participants to estimate the width in inches of a typical stop sign. After all had recorded an answer, he asked the participants to estimate the diameter in inches of a typical dinner plate. We asked these two questions to delay recall of the size of the ladle. After the participants had estimated the size of the plate, the experimenter showed the participants the display board that depicted the different-sized ladles. The experimenter asked the participants to identify the picture that was closest in actual size to the ladle they had just seen and record the number that was next to the picture they had identified.

Results

We recorded the horizontal (width) and vertical (height) dimensions of the depiction of the ladle each participant identified as the size of ladle they had observed. We used a t test to compare the width estimates of those in the tedious removal condition with estimates made by those in the movement condition and a second t test to compare the height estimates. An alpha level of .05 was used in all analyses. Those in the tedious removal condition made height estimates ($M = 34.3$ mm, $SD = 2.5$) that were significantly taller than the estimates of those in the movement condition [$M = 32.5$ mm, $SD = 3.9$; $t(64) = 2.32$, $p < .05$]. Those in the tedious removal condition made width estimates ($M = 88.7$ mm, $SD = 6.9$) that were not significantly different from the estimations from those in the movement condition [$M = 89.8$ mm, $SD = 10.7$; $t(64) = 0.62$, n.s.].

Both groups appeared to overestimate the vertical dimension of the ladle. t-Test comparisons between size estimates and actual size showed that those in the movement condition made height estimates that were significantly larger than the actual height of 31 mm [$M = 32.5$ mm, $SD = 3.9$; $t(32) = 2.18$, $p < .05$]. Those in the tedious removal condition also made height estimates that were significantly larger than the actual height [$M = 34.3$ mm, $SD = 2.5$; $t(32) = 7.63$, $p < .01$]. Estimates of the width were not significantly different from the actual width of 88 mm in either the tedious removal [$M = 88.7$, $t(32) = 0.58$] or the movement [$M = 89.8$, $t(32) = 0.96$] condition.

The filler item estimation procedure did not appear to have a differential influence on the ladle estimates. We noted no evidence of correlations for each condition between the size estimates of each of the filler objects and of the ladle (all rs were n.s.). T tests showed no differences between group estimates of the size of the filler objects (ps $> .05$).

Discussion

Those who observed the tedious removal of sand made larger estimates of the height of the ladle than did those in the movement condition. We believe that the overestimation occurred because the participants in the tedious removal condition recalled the ladle as being larger than it was since it needed to be larger, because the manipulation made it appear to hold a large amount of sand. The results showed that the ladle's height was overestimated in both conditions, a finding that replicated previous findings about height judgments of some common objects (e.g., Chapanis & Mankin, 1967). Overestimation of height may be the result of processes that create the horizontal–vertical illusion, but the participants' experience with our manipulation caused more extreme errors for those in the tedious removal condition. We found errors in estimates of height, but not of width, replicating Cavalier and Wesp (1997), who found that the height, but not the width, of a trashcan was overestimated. This experiment lends more credence to theories that suggest that experience with an object influences memory of size, because it showed that a change in the way the object was seen being used led to a change in recall of the object's size.

EXPERIMENT 2

In the first experiment, we examined errors in the estimate of the size of a three-dimensional object that was familiar to most of the participants (the ladle). In the second experiment, we examined whether a change in the way one interacted with something other than a ladle would influence memory estimates of size. We also wanted to show that a purposeful interaction with an object that had little specific association with any particular activity would influence memory of the size of the object. We selected as an object to evaluate a simple line drawing of a circle, because it was something with which the participants had little specific experience (circular elements are included in a wide variety of objects).

Others have reported size estimation errors that lend themselves to the interpretation that specific experiences with an object may cause these errors. For example, McBeath, Neuhoff, and Schiano (1993) investigated size estimates of basketball hoops and found that observers underestimated their sizes. A basketball hoop is twice the diameter of a basketball, but few whom we have asked have believed it to be much larger than one and a half times the diameter of the ball. These observations could be interpreted as showing that the way the hoop is seen relative to making a basket influences the perception of its size—a basket is hard to make, so the hoop must be about the same size as the ball.

Taking into account our hypothesis that basketball hoops may be seen as smaller than they are because it is difficult to make a basket, we employed a task that required aiming at a target, asking the participants to aim darts at a circle. We predicted that those who had a more difficult time hitting the target would estimate that the target was smaller (because it was harder to hit). Since we were unable to manipulate participant accuracy without manipulating other factors that also might influence size perception (e.g., distance, use of binocular vs. monocular vision, or movement of the target), we simply correlated the ease of hitting the target with the estimate of its size.

Method

Participants. Twenty-seven introductory psychology students (10 women and 17 men) volunteered to participate. The experimenter explained to the participants that they would be part of a study on the accuracy of perception that would take about 2 min and would require them to hit a target with darts but provided no other information about the procedure until all the participants had completed the experiment.

Apparatus and Setting. The students who volunteered were tested individually in a classroom that adjoined their classroom and were taken from class to participate. All the participants were tested during a single class session, to reduce the possibility that those who participated would describe the experiment to subsequent participants.

During testing, the participants sat in a chair placed with its side against the side of a desk. The participants looked down over the edge of the desk at a 40×40 cm platform positioned below the top of the desk and placed next to the desk on the side perpendicular to the side against which the chair was placed. The edge of the platform was aligned with the edge of the desk that the chair was placed against. A target sheet was placed on the platform. As they rested their dart-dropping arm across the edge of the table, their wrist was 25 cm above the target. The experimenter placed a board between the target and the participant, to protect the participant's leg and foot from errant darts. The board did not block the view of the target.

The target was a 5-mm-diameter circle printed in black ink on a 10.5×7 cm piece of paper placed on fiber ceiling tile soft enough to allow the darts to stick. We provided each participant with 15 miniature darts (each 5 cm long) with which to hit the target circle.

The participants made size estimates by selecting a circle from a size selection sheet, which was a 21.5×28 cm piece of white paper that included 3 each of 14 different-sized circles. The sheet included replicas of the 5-mm target, 6 other circles smaller in steps of 0.4 mm, and 7 other circles larger in steps of 0.4 mm. The circles were distributed randomly over the paper.

Procedure. The experimenter directed each participant to sit in the chair, hold a dart, and place his or her forearm on the desk. The experimenter then explained that the task involved aiming darts at a target and told the participant to shift forward to allow his or her hand to extend over the edge of the desk to a position above the target.

The experimenter instructed the participant to drop one dart at a time and try to hit the target. Once the participant hit the target, the experimenter told him or her to stop and recorded the number of darts it took for the participant to hit it. The experimenter recorded "16" attempts if the participant threw all 15 darts and did not hit the target. Next, we introduced an irrelevant intervening maze completion task that served to provide time between observing the target and identifying the target size. The experimenter gave the participant a drawing of a maze, instructed him or her how to complete it, and told the participant that he or she would have 30 sec to complete as much of the maze as possible. After 30 sec, the experimenter removed the maze, informed the students that they would next estimate the size of the target, and placed a size selection sheet on the desk. The experimenter instructed the participant to circle the one circle that he or she thought was the same size as the target circle and recorded the size of the circle selected.

Results

We used a Pearson product–moment correlation to evaluate the relationship between the size of the circle the participant selected and the number of darts he or she dropped. We found a significant negative correlation between the number of darts thrown and the estimated target size [$r(25) = -.66, p < .01$].

Discussion

The participants who hit the target in later trials or not at all perceived the circle to be smaller, and those who hit it with fewer attempts saw it as larger. Size estimates appeared to be negatively correlated with how difficult it was for the participants to hit the target. The results demonstrated the influence of experience on size estimates with a two-dimensional object that had no specific association with a particular experience. Furthermore, we showed that active involvement in purposeful action (in Experiment 1, the participants passively observed) influences size estimates.

EXPERIMENT 3

The first two experiments showed that the type of experience one has with an object influences the estimate of the size of the object from memory. We found that when objects were observed or used in a way that made them appear larger or smaller, size estimates of the objects from memory were similarly adjusted. We were interested to see whether experience also would influence size estimates when the object was present. If hypotheses that posit that estimates of the size of familiar objects use size estimates stored in memory (Haber & Levin, 2001; Wesp et al., 2000) are correct, the errors we showed in Experiments 1 and 2 should also occur when the object is present. We replicated the procedures we used in the experiment in which the participants threw darts (Experiment 2), but the participants judged the size of the target while the target was visible.

We also evaluated whether the relationship we found in Experiment 2 could have been caused by other processes that linked dart-throwing skills with the types of size estimation errors the participants made (e.g., accurate dart throwers might naturally tend to see things as larger). To consider the possibility that other factors may have led to the correlation we found in Experiment 2, we tested a second group of participants, who estimated the size of the target first and then dropped the darts. We predicted that if experience had caused the observed negative correlation, we should not see a negative correlation if the experience came after the participants estimated the size of the target.

Method

Participants. Fifty-two introductory psychology students (32 women and 20 men) volunteered to participate. The experimenter explained to the participants that they would be part of a study on the accuracy of perception that would take about 2 min and would require them to throw darts at a target but provided no other information about the procedure until all the participants had completed the experiment.

Procedure. We tested volunteers by following the same general procedures as those in Experiment 2. The participants did not complete the maze, and more important, they estimated size while the target was in full view. Half of the participants, who were in the experience group, threw darts at the target and then estimated the target size by identifying a matching circle on the size selection sheet. The other half of the participants, who were in the no-experience group, first estimated the size of the target and then threw the darts.

The participants in both groups estimated the size of the target with the target positioned on the platform and the size selection sheet placed on the desk. The experimenter told the participants not to use their hands or other objects to help compare sizes but explained that they could visually compare the target with the circles on the selection sheet for as long as they wished.

Results

We used a Pearson product–moment correlation to evaluate the relationship between the size of the circle the participant selected and the number of darts he or she dropped. The experience group showed a significant negative correlation between the number of darts thrown and the estimated size of the target [$r(24) = -.45$, $p < .05$]. The no-experience group showed no significant relationship between the number of darts thrown and the estimated size of the target [$r(24) = .32$, n.s.]. The correlation coefficient for experience group was significantly different from the correlation coefficient for the no-experience group ($z = 2.77$, $p < .01$).

Discussion

Those who threw darts before they estimated the target size showed a negative correlation between ability to hit the target and size estimates of the target. This showed that the negative correlation we found in Experiment 2 held when the object was in view. Those who threw darts after making the size estimation of the target showed no significant correlation between ability to hit the target and size estimates, and the correlations for the no-experience and the experience groups were significantly different. This finding makes alternative explanations, such as that the relationship occurred because those who did not hit the target had poor eyesight and that it was the poor eyesight that caused both inaccuracies and poor size estimates, less viable, strengthening our contention that the relationship is causal. We believe that those throwing more darts estimated the target size as smaller because they concluded that the target was hard to hit because it was small. The size estimate of the target changed as a result of the purposeful experience with the target.

GENERAL DISCUSSION

Research on the influence of experience with an object on estimates of the object's size conducted prior to these three experiments relied on assumptions about past experience with the objects. Rather than simply observing a relationship between size estimates and assumed past experience, in our experiments, we observed changes in size estimates following manipulations of the way participants used an object or saw an object being used. In both the experiment involving the movement of sand and those in which participants aimed darts, we found that estimates of size were influenced by the purposeful experience with the object in the direction that we predicted. Those in the tedious removal condition offered larger memory estimates of the height of the ladle than did those who saw it removed with a larger spoon. Those who had a difficult time hitting a target viewed the target as smaller than did those who hit the target. We observed the latter in both memory and in vivo observation conditions.

We selected the tasks on the basis of our beliefs about their influence on perception of size estimates. In the first experiment, the tedious process of removing the sand from a ladle with a small spoon gave the appearance that the ladle was taller than it was. In the second and third experiments, those who found it difficult to hit the target may have justified their inability to hit the target by seeing the target as smaller than it was. The demonstration of the relationship between size estimates and the experience with the dart task was not as convincing an argument as the experiment that changed the ladle function, because it simply showed that a relationship existed after a manipulation was introduced. However, the findings of the two manipulations were compatible, and the results of the dart-throwing studies could be explained the same way as the results of the ladle studies. The demonstration that size estimates of the target when the target was in view were negatively correlated with success at the dart-throwing task was more convincing, in that we found no evidence of a correlation when the participants made the size estimates first and threw darts second and the correlation for the two conditions was significantly different. Our speculation that exposure to purposeful object actions influences both in vivo and recalled size estimates is supported by our present findings and those from other size estimation studies in which both recollection from memory and estimates made while an object was observed were examined (e.g., Bruner & Goodman, 1947; Wesp et al., 2000).

We do not resolve how an unfamiliar object's size is determined but provide further support for the notion that size estimates of familiar objects may be derived from memory. As Haber and Levin (2001) have pointed out, use of memory data for assessment of the size of familiar objects is logically compatible with the function of the ventral stream. We believe, however, that the system does not rigidly employ stored size data. If it did, the influence on size estimates would have been stronger. It is not clear what determines whether a particular size estimate is made on the basis of memory or on-line data.

These findings, which show that experience with purposeful actions influences estimates of an object's size, appear similar to those observed when participants estimate distance. For example, Kosslyn, Pick, and Fariello (1974) found that observers overestimated distances of routes that included barriers and underestimated the same distances when the barriers were absent. Cohen, Baldwin, and Sherman (1978) replicated the effect in a naturalistic environment and suggested that recollection of distance increased proportionately to the physical effort required to traverse a pathway. Other studies have shown overestimates of distance when routes included a stairway (Hanyu & Itsukushima, 1995) or when participants carried heavy loads (Proffitt, Stefanucci, Banton, & Epstein, 2003).

Size estimation errors also appear to be similar to distortions in assessment of geographical slant. Proffitt, Bhalla, Gossweiler, and Midgett (1995) showed that observers tend to overestimate the angle of hills. Those who anticipate additional effort (e.g., those carrying heavy backpacks or in poor health) to climb a hill report larger overestimates of the slant of the hill (Bhalla & Proffitt, 1999).

The finding that memory of size influenced estimates of size should not be surprising and is an implicit assumption of several related observations. For example, characteristics of the distribution of sizes of an object to which an individual has been exposed can influence subsequent size estimates of objects within the distribution (Huttenlocher, Hedges, & Vevea, 2000). Memory used to create visual images of familiar objects includes representation of both size and distance (Hubbard, Kall, & Baird, 1989). Brenner, van Damme, and Smeets (1997) suggested that the initial size observed is maintained in memory and is used in subsequent analyses of depth. Thus, there is support for the idea that we maintain memory representations of size and may use that size representation from memory in subsequent analyses even when an object is present. Also, accurate descriptions of two-dimensional spatial arrays at a distance may be disrupted by visual information (Amorim, Loomis, & Fukusima, 1998), suggesting that the memory of images interacts with visual perception when shape and size are estimated.

Practical demonstrations of the strong influence memory has on size estimation are compatible with our observations. For example, Nelson, Biernat, and Manis (1990) investigated the role of sexual stereotypes in size estimates by asking participants to estimate the height of seated individuals. They found that, even when participants were warned that reliance on the target's gender as a cue to a model's height would result in less accurate judgment, the participants still overestimated the height of males and underestimated the height of females.

Our interpretation of the data has assumed a constructivist approach to perception. An ecological approach might suggest that these size estimates were a function of affordances (Gibson, 1979) of the ladle and target. Greeno (1994) suggested that perception of more complex characteristics of objects are more difficult to justify as being the result of direct perception and are better seen as the result of what Neisser (1994) referred to as recognition. Several recent theories have proposed that although ecological models of perception explain visually guided action, representationally based theories explain ventral stream processing better (see Norman, 2002, for a review). Our findings and interpretation are in accordance with these recent conceptualizations regarding ventral processing. All three of our experiments involved identification of characteristics of the object, tasks we see as under ventral stream control, and the estimates appeared to have been influenced by the memory of the experience with the object. Future work will determine whether experience will similarly influence guided movement or, instead, be more sensitive to the immediate environment.

It appears to us that if memory of the size of an object is available, memory processes likely play a significant role in the maintenance and interpretation of the size of familiar objects when we observe them. Because most objects we observe do not change in size, ventral stream processing can rely on the memory of the size of a familiar object that we continue to observe or observe again at a later time. This seems to us to be a more efficient process than continuous reassessment of the object's size. This conceptual representation of how the size of familiar objects is processed would explain what is referred to as *size constancy*; we maintain a relatively constant representation of size because we are basing our size assessment on memory (of the object and then its size), rather than on the object's current stimulus value. Constancy may simply be a by-product of this efficient system.

We demonstrate that errors in size perception can occur as a result of experience with an object, a downside of a memory-driven size perception system. In a discussion of the absence of a clear demonstration of perfect size constancy, Gogel (1998) argued that cognitive factors may disrupt a clear Euclidean representation of visual arrays. The cognitive factors are quite likely those that influence the memory of the size of the object. The unlikely alternative is that memory of size is immune to the distortions from schematization common with other memories.

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