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Effects of Implied Motion and Facing Direction on Positional Preferences in Single-Object Pictures

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Abstract

Palmer, Gardner, and Wickens studied aesthetic preferences for pictures of single objects and found a strong inward bias: Right-facing objects were preferred left-of-center and left-facing objects right-of-center. They found no effect of object motion (people and cars showed the same inward bias as chairs and teapots), but the objects were not depicted as moving. Here we measured analogous inward biases with objects depicted as moving with an implied direction and speed by having participants drag-and-drop target objects into the most aesthetically pleasing position. In Experiment 1, human figures were shown diving or falling while moving forward or backward. Aesthetic biases were evident for both inward-facing and inward-moving figures, but the motion-based bias dominated so strongly that backward divers or fallers were preferred moving inward but facing outward. Experiment 2 investigated implied speed effects using images of humans, horses, and cars moving at different speeds (e.g., standing, walking, trotting, and galloping horses). Inward motion or facing biases were again present, and differences in their magnitude due to speed were evident. Unexpectedly, faster moving objects were generally preferred closer to frame center than slower moving objects. These results are discussed in terms of the combined effects of prospective, future-oriented biases, and retrospective, past-oriented biases.

Keywords

visual aesthetics, spatial composition, motion, perceptual organization

Among the many aspects of a picture that contribute to people's aesthetic appreciation, one of the most important is spatial composition (Arnheim, 1954, 1983). Spatial composition refers to the positional arrangement of the depicted objects relative to each other and to the surrounding frame (e.g., Alexander, 2002; Arnheim, 1983). Perhaps the single aspect of spatial composition that has received the most scientific attention is horizontal balance: The perception of how equally and evenly the pictured objects are distributed to the left

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and right of the frame's center (e.g., Locher, 2003; Locher, Overbeeke, & Stappers, 2005; Locher, Stappers, & Overbeeke, 1998; McManus, Edmondson, & Rodger, 1985). The usual supposition is that horizontally well-balanced pictures are aesthetically preferable to horizontally poorly balanced ones.

Palmer et al. (2008) studied one of the simplest of compositional choices: People's preferences for the position of a single object within a rectangular frame. If balance were the primary factor governing people's aesthetic preferences for such single-object pictures, the object would always be preferred at or near the frame's center, where its spatial extent is about equally distributed left and right of center. Palmer et al. indeed found this to be true, but only for bilaterally symmetric objects that were facing forward, toward the viewer. Rightward- and leftward-facing objects, in contrast, were strongly preferred when they were positioned off-center so that they faced into the frame: Pictures of right-facing objects were better liked when they were positioned left of center, and pictures of left-facing objects were better liked when they were positioned right of center. Palmer et al. (2008) called these two mirror-image effects the *inward bias* because in both cases, viewers preferred the object to face into the frame more than out of the frame. Bertamini, Bennett, and Bode (2011) replicated this effect by showing an aesthetic bias for pictures of animals to have more space in front of them than behind them, although they called it the *anterior bias*. These inward biases are very robust and have been replicated and extended in further studies (e.g., Sammartino & Palmer, 2012a, 2012b), including a recent analysis of the frame-based position of the faces of main characters in action films (Bode, Bertamini, & Helmy, 2016). Such findings provide clear evidence that balance—at least in its usual interpretation of physical balance—is not the dominant factor in spatial composition that it is usually portrayed as being.

The present article considers another factor that may be as important, if not more so, in determining people's preference for unbalanced spatial compositions: namely, implied motion. Pictures are by definition static, so actual motion cannot be directly represented. There are nevertheless a number of ways in which motion can be implied in a picture of an object, including the depiction of an object's characteristic direction and speed of motion as well as the existence of motion blur in the object or the background. Any or all of these features might influence compositional preferences. For example, most objects that move—including people, cars, and horses—tend to move in a particular object-based direction: namely, with their front surfaces facing in the direction of motion. The facing direction of a movable object therefore strongly implies a likely direction of motion: forward. This correlation suggests that people may prefer moving objects to have more space in front than behind them within a frame to provide the object with more "room to move" in a forward direction. If so, implied motion of forward-moving objects would induce preference biases that coincide with the inward-facing bias. Indeed, the inward-facing bias might actually be determined, at least in part, by implied motion. Palmer et al. (2008) tested this possibility by measuring the inward bias for objects that characteristically move forward (e.g., a person, dog, and car) versus objects that are characteristically stationary but nevertheless have a well-defined front (e.g., a chair, daisy, and teapot). They found no differences between the two groups of objects and therefore concluded that the inward bias does not depend on motion.

Why might an inward bias be present in static pictures depicting single objects that moved or faced rightward or leftward in the picture plane but not for the same objects when they moved or faced forward? Sammartino and Palmer (2012b) proposed an *affordance space* hypothesis to account for this pattern of results. The key idea is that every object is surrounded by a virtual spatial envelope, which they called its *affordance space*, whose distribution reflects its affordances: that is, its opportunities for action and interaction with respect to the viewer (Gibson, 1977). The shape of the affordance space is hypothesized to represent the spatial extent or importance of functions that take place in corresponding regions around the object, due to the object's own behavior (for moving objects, such as a person, dog, or car), the behavior of the observer with respect to the object (for facing objects that do not move, such as a chair, flower, or teapot), or both. The affordance space of a chair, for example, would be more spatially extended around its front and top because those are the regions around chairs of greatest importance when one uses them for their most important affordance of being *sittable upon*. The crucial additional assumption of the affordance space hypothesis for predicting preferences in spatial composition is that people prefer pictures in which the affordance space, rather than the physical extent of the object, is centered within the frame. This account implies that objects whose affordance spaces are symmetrical in the picture plane will be preferred when positioned in the center of the frame (e.g., a front-facing person or chair), whereas the same objects will be preferred facing inward when their affordance spaces are asymmetrical in the picture plane, due to having a larger region in their affordance spaces around the surfaces most associated with relevant affordances, which usually means their front surface.

This account squares well with Palmer et al.'s (2008) finding that objects that move forward produce an inward bias comparable to that of objects that merely face forward when shown in profile. However, the movable objects in that study were portrayed in stationary poses: for example, a standing person rather than a walking or running one. Might pictures that actually depict objects in motion produce an inward-moving bias that is conceptually distinct and experimentally dissociable from an inward-facing bias?

In this article, we study the effects of implied motion of a single target object on people's aesthetic preferences for pictures of that object when depicted in motion. We consider the two fundamental aspects of such motion: its direction in Experiment 1 and its speed in Experiment 2. The primary question of Experiment 1 is whether motion direction and facing direction have dissociable effects on compositional preferences. Secondarily, we investigate whether motion or facing effects dominate when they conflict. The primary question of Experiment 2 is how speed might modulate the implied motion effects we demonstrate in Experiment 1. Would pictures of faster moving objects produce larger inward biases, as would be expected from a straightforward *prospective* interpretation of the affordance space hypothesis (i.e., how the object is expected to move in the near future) or would they produce smaller inward biases, as would be expected from a *retrospective* interpretation of the affordance space hypothesis (i.e., how far the object has moved in the recent past)?

Experiment 1: Directional Effects of Implied Motion Versus Facing

Most objects characteristically move in a forward (i.e., front facing) direction, meaning that their motion vector points in the same direction as their front surface faces. There are notable exceptions, of course, such as the species of crab that locomote sideways, but forward motion is by far the norm. Even so, there are circumstances in which objects that characteristically move forward actually move in other directions—whether intentionally or otherwise—and sometimes even in the opposite direction. In the present experiment, we dissociated facing direction from moving direction by studying forward versus backward motion events that depict people in the process of diving or falling. Because the images we used of the divers and fallers showed them far enough along their motion trajectories for viewers to discriminate easily between forward and backward implied motion, their faces were actually facing somewhat downward for the forward divers and fallers and upward for the backward divers and fallers. Nevertheless, their bodies were clearly facing right or left, coincident with the direction of motion for the forward divers and fallers but opposite the direction of motion for the backward divers and fallers. Based on previous results with pictures of stationary objects, we expected an inward facing bias in people's aesthetic preferences, but we also expected an inward motion bias, such that the combined inward bias would be greater for the forward-moving figures (for whom the inward-facing and inward-moving biases reinforce each other) than backward-moving figures (for whom the inward-facing and inward-moving biases conflict with each other). It is unclear whether the inward-facing or inward-moving bias will dominate in the backward motion conditions, however, where any net result is possible, depending on the relative strength of the two competing biases.

We measured aesthetic biases using a "drag-and-drop" task, in which participants were asked to *drag* the target object into and around the background image using a computer mouse until they found the most aesthetically pleasing position for it and to *drop* it by pressing a mouse button. (see Leyssen, Linsen, Sammartino, & Palmer, 2012, for another study of spatial composition using this method). The position at which the target object's center was located when dropped was taken to be the most aesthetically preferred spatial composition. It differs from the two-alternative forced-choice paradigm used by Palmer et al. (2008) in that the drag-and-drop task involves comparisons between different possible placements that are implicit and memory based, but the drag-and-drop task is far more efficient in terms of the number of trials required (see Palmer, Schloss, & Sammartino, 2013, for a methodological review of measuring aesthetic preferences). Dragging and dropping an object into a desired location also seem to be a more natural production task, mimicking the kind of decision process ones performs in editing images for composition in computer programs, such as *Adobe Photoshop*.

Methods

Participants

Twenty undergraduate students (6 men, 14 women) participated at the University of California, Berkeley, through the psychology department's research participation pool for course credit. All participants reported having normal or corrected-to-normal spatial vision. All gave informed consent, and the committee for the protection of human subjects at the University of California, Berkeley, approved the experimental protocol.

Design

The experimental design consisted of the orthogonal combination of two motion directions (left moving and right moving) and two facing directions (left facing and right facing), with eight image exemplars (six divers and two fallers) in each of the 2×2 facing or moving direction conditions. Participants performed a drag-and-drop task, in which they were instructed to *drag* each object into a background image and to *drop* it in the most aesthetically pleasing location (see later for details).

Stimuli

The stimuli consisted of 16 pictures that showed people either diving or falling in a direction that was either forward (toward their front side) or backward (toward their back side). Representative examples are shown in Figure 1. Each image was presented in both its

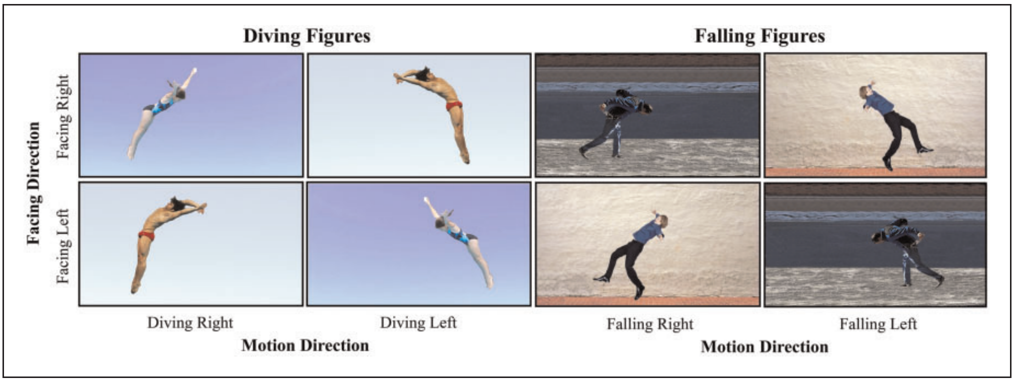

Figure 1. Representative examples of the stimuli used in Experiment 1. Divers and fallers had either the same facing and motion directions (forward divers and fallers) or opposite facing and motion directions (backward divers and fallers). These figures are shown in the average positions chosen by participants.

original and its left- or right-reversed versions to manipulate facing direction. This stimulus design—2 facing directions (left or right) × 2 motion directions (left or right)—allowed us to investigate inward versus outward biases in compositional preferences due to facing direction, motion direction, and their integration in both consistent and conflicting combinations. For example, forward divers or fallers have consistent facing and motion directions, whereas backward divers or fallers have conflicting facing and motion directions. All of the target figures (12 divers and 4 fallers) were taken from naturalistic nonproprietary photographs found on the Internet, and they were shown in their original background contexts whenever possible to maintain realism. The target objects were isolated and removed from the picture using *Adobe Photoshop* software, and the background was processed to fill in the regions in which the target objects had originally appeared with pixels from neighboring regions that were consistent with corresponding parts of the depicted background such that the original position of the object was undetectable. Each picture was presented in color. The background was positioned at the center of the screen, and the target object was initially placed at random on either the left, right, top, or bottom border of the background image such that half of it extended out of the boundary of the background image.

All backgrounds were 786 pixels wide × 436 pixels high. The diving and falling figures ranged from 195 to 329 pixels in width and 248 to 367 pixels in height. There was some unintended systematic variation in the widths of the forward-moving versus backward-moving figures, in that the average width of the forward-moving figures was 268.5 pixels and that of the backward-moving figures was 246.4 pixels. Nevertheless, there was a great deal of overlap in the image widths of the forward-moving and backward-moving figures.

Procedure

Participants viewed a computer screen from about 70 cm inside a darkened booth. They were shown images of each of the objects and were instructed to place it in the background image at the location in which they found it to be the "most aesthetically pleasing." The target object was initially positioned with its center at the midpoint of one of the four sides. Participants could then move the object freely with the mouse to any location within the background image, but not beyond its borders. The x axis of the mouse was therefore restricted to the range of −250 to +250 pixels horizontally in all cases. Once they placed the object in what they considered to be the most aesthetically pleasing location, they were instructed to left click the mouse to *drop* the object at that position. If participants were not satisfied with their choice, they could repeat the procedure as many times as they wanted by clicking on a *back* button on the screen. Participants were shown all 32 images of the different divers and fallers with their corresponding backgrounds in random order.[1] The horizontal position of the center of each target object was recorded.

Results and Discussion

The primary analyses were conducted on the average *x*-axis coordinates corresponding to the horizontal positions of the object centers computed across all eight exemplars within the 2×2 design: facing direction (left or right) and motion direction (left or right). The results (see Figure 2) show a very large effect of motion direction, $F(1, 19) = 76.22$, $p < .0001$, $\eta = .800$, due to a strong bias to prefer the target objects to be positioned moving inward, toward the center of the frame. There was also a reliable, though weaker, effect of facing direction, $F(1, 19) = 21.97$, $p < .0001$, $\eta = .536$, reflecting a bias to prefer objects facing inward, toward the center (i.e., with right-facing objects positioned farther to the left and left-facing objects positioned farther to the right). The inward bias for motion direction is so much stronger than the inward bias for facing direction, however, that the net bias for backward divers or fallers was for them to face *outward* from the center, with less space

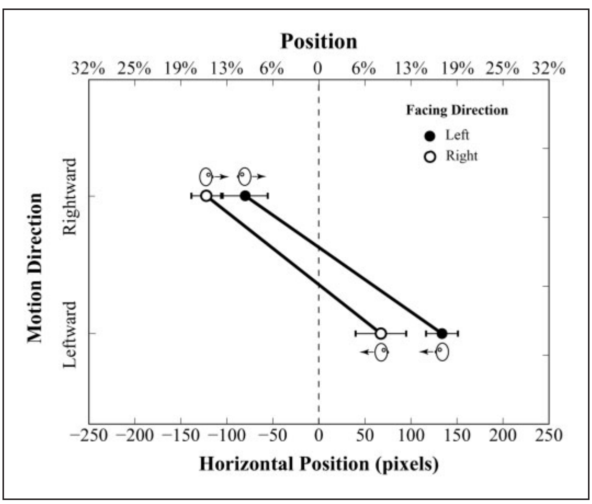

Figure 2. Results of Experiment 1. Average horizontal placement (*x* axis) is plotted for rightward-moving divers or fallers (upper points) and leftward-moving divers or fallers (lower points), who are facing rightward (open circles) or leftward (filled circles). The top horizontal axis shows the percentage of the background image width from the center. The horizontally outermost points, indicating larger inward biases, represent the results for forward fallers or divers, whereas the inner points, indicating smaller inward biases, represent the results for backward fallers or divers. Arrows next to the face icons represent the direction of motion and the locations of facial features represent the direction of facing. Error bars indicate the standard errors of the mean. (Note that the canonical roles of the *x* axis and *y* axis are reversed in this graph to facilitate its interpretation.)

in front than behind them! There was a small, but significant, interaction between motion direction and facing direction, $F(1, 19) = 5.76$, $p < .027$, $\eta = .233$, due to the fact that the difference between leftward- and rightward-facing directions was slightly larger when the divers and fallers were moving leftward than when they were moving rightward.

The results show that whereas forward divers or fallers tend to be placed so that they both move and face inward (toward the center of the image with more space in front than behind them), backward divers or fallers tend to be placed so that they move inward, but face outward. This result indicates that, although both motion direction and facing direction have reliable effects, motion direction has the much larger influence. One reason why the effects of motion direction might be so much stronger than the effects of facing direction is that the present facing directions are not as directly lateral as the motion directions: As mentioned earlier, the forward divers and fallers tend to be facing somewhat downward and the backward divers and fallers tend to be facing somewhat upward rather than directly leftward or rightward. We doubt that this difference is sufficient to account for the much larger motion-facing bias, but there is no evidence in the present data to rule out the possibility.

The images of the forward-moving divers and fallers were slightly wider horizontally (268.5 pixels) than the backward-moving divers and fallers (246.4 pixels). Although this stimulus difference of 22.1 pixels is less than 3% of the 786-pixel lateral extent of the background, we were nevertheless concerned that it might have influenced the magnitude of the motion or facing effects. If, for example, an influential factor were the distance between the back edge of the figural image and the closest edge of the frame, one would expect a negative correlation between image width and distance from the center of the frame to the center of the figure (i.e., the center of wider images would be closer to the center of the frame). Instead, we found a significant *positive* correlation between image width and absolute distance from the center ($r = +.52$, $p < .005$). This might be interpreted as indicating that participants tended to place wider figures closer to the closest frame edge than the narrower images, as would be expected if the more influential factor were the distance of the front of the figural image from the center. This is not the only explanation or even the most plausible one. A more consistent alternative is that the positive correlation between image width and strength of inward bias is actually due to the fact that there is a greater net inward bias for the slightly wider forward-moving figures, because their motion and facing biases are consistent, than there is for the slightly narrower backward-moving figures, because their motion and facing biases conflict.

To control for this image-width confound statistically, we analyzed the effects of facing direction, motion direction, and image width on the preferred horizontal positions with linear mixed-effects models using the lme4 package in the R environment. In the model, we specified subjects as the random factor in order to control for their intraclass correlation using random intercepts for each subject (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2014). Facing direction, motion direction, and image width were specified as the fixed factors. We performed statistical significance tests using Type II Wald chi-squared tests of the fixed effects in the model. The results indicate that there are still main effects of motion direction (Wald $\chi^2 = 504.23$, $p < .0001$) and of facing direction (Wald $\chi^2 = 24.62$, $p < .0001$), but no interaction between them (Wald $\chi^2 = 3.07$, $p = .08$). There is no main effect of width (Wald $\chi^2 = 1.46$, $p = .23$), no interaction between width and facing direction (Wald $\chi^2 = 0.95$, $p = .33$), and no three-way interaction among width, facing direction, motion direction (Wald $\chi^2 = 0.27$, $p = .60$). There was, however, a reliable motion direction $\times$ width interaction (Wald $\chi^2 = 11.37$, $p < .001$), indicating that width had a significantly different effect on the preferred position of all the rightward-moving divers and fallers (i.e., both the forward and backward right-moving figures) when compared with the left-moving figures, regardless of facing direction. We are not sure how to interpret this result.

The present results thus confirm that both implied motion direction and facing direction influence the spatial composition of single-object pictures and that both factors produce biases opposite their own direction: Rightward motion and rightward facing both favor leftward placement of the object and leftward motion and leftward facing both favor rightward placement of the object. These biases reinforce each other for forward-moving objects to produce a very large combined inward bias, but they conflict with and partly cancel each other for backward-moving objects. We have demonstrated these effects for human figures because it is relatively easy to depict implied forward versus backward motion through bodily poses. We presume that the results would be similar for inanimate moving objects (e.g., forward-and backward-moving cars), but this hypothesis is not easily tested because such objects, being rigid, look very much the same when moving forward versus backward in static pictures.

Experiment 2: Speed Effects of Implied Motion

The results of Experiment 1 showed that the direction of implied motion strongly biases the preferred spatial composition of single-object pictures and that its effects are substantially more powerful than the bias due to facing direction, at least with those images. In Experiment 2, we ask whether the speed of implied motion in a static picture might modulate these effects and, if so, how. Perhaps the most obvious prediction is that higher speeds might simply amplify the inward motion bias, as if more empty space in front of the moving object were required to accommodate the displacement of faster moving objects over a fixed future duration. This possibility implies that a picture of a left- or right-facing person would produce an increasingly larger inward motion bias when depicted standing, walking, jogging, and sprinting. There is another possibility, however. If observers were to conceive of the space *behind* the moving object as depicting the distance it had traveled in a fixed period of past time, the pattern of compositional biases would be reversed, with pictures of faster moving objects being preferred with less inward bias than more slowly moving objects. We investigated these possibilities by manipulating the speed and direction of implied motion for three types of objects—people, horses, and motor vehicles—using a variety of static cues to convey implied object speed, including the characteristic speed range of different types within the category (e.g., a tractor vs. a race car), bodily poses of living objects (e.g., a galloping vs. a walking horse), and the degree of motion blur in the background and certain moving parts of the objects.

Methods

Design

The experiment consisted of a three-way factorial design: 3 object categories (person, horse, and motor vehicle) $\times$ 4 motion speeds (stationary, slow, medium, and fast relative to that object category) $\times$ 2 motion or facing directions[2] (rightward and leftward). We used three different images in each cell of the 3 categories $\times$ 4 motion speeds design for a total of 36 images (see Figure 3). All participants performed two tasks. The first was a drag-and-drop task that was the same as described in Experiment 1: to place each object into a background image in the "most aesthetically pleasing" location (see later for details). Following completion of all trials in the drag-and-drop task, participants rated the relative speed of

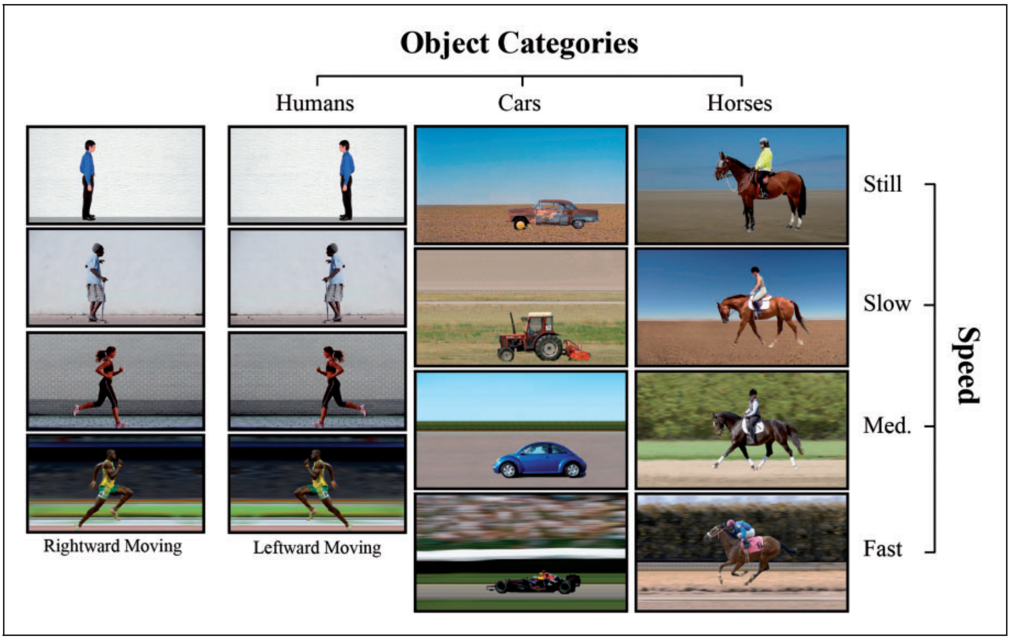

Figure 3. Examples of the images that were used in Experiment 2. Objects and background images were initially separate in the task but integrated by participants when they dragged-and-dropped it. The objects are shown in the average horizontal positions that were selected by participants in the drag-and-drop task. Note the tendency to place faster moving objects closer to the center of the frame, which is most evident in comparing the still and the fast examples for each object category. (Rightward-directed examples are shown only for the humans to save space.)

each object using a slider scale below the image as a manipulation check to see if our participants did, in fact, perceive the differences in relative speeds of implied motion.

Stimuli

Three object categories were used—human figures, horses, and motor vehicles—with three different objects sampled within each category at each speed. Four different speeds of implied motion were depicted relative to the characteristic range of speeds for the given object category: stationary, slow, medium, and fast. For the horse category, images of a motionless standing horse, a walking horse, a trotting horse, and a galloping horse were used to convey four different implied motion speeds. For the human figures, the implied speeds were conveyed with images of a stationary person standing, a person walking with a cane, a jogger, and a sprinting competitive runner. Finally, for the motor vehicle category, images of a broken-down car, a tractor, an ordinary passenger car, and a formula-one race-car were used. In each case, the specific examples of the object category at the different speeds were different (see Figure 3 for examples.) To further convey the medium- and fast-implied motion speeds of images for all three object types, *Adobe Photoshop* was used to alter the backgrounds of the images by adding an appropriate degree of motion blur, augmented in the case of the faster moving cars by adding radial blur to the wheels. Rightward- and leftward-directed moving or facing versions of each image were also created by reflection about the central vertical axis in *Photoshop*, for a total of 72 images. Images of all objects were nonproprietary naturalistic photographs found on the Internet. To maintain the realism of the original photographs, the original backgrounds of the objects (or the motion-blurred versions that were manipulated in *Adobe Photoshop*) were used in the drag-and-drop experiment. The regions where the objects originally appeared in the photographs were filled with pixels from neighboring regions in the image background using tools from *Adobe Photoshop* in order to make them consistent with corresponding parts of the depicted background.

The dimensions of the background images were identical for the cars and horses (900 pixels in width and 500 pixels in height). The cars and horses were all equal in width (400 pixels), although to preserve the correct aspect ratio, the heights of these objects varied (i.e., the slower car images are taller than the formula-one race cars). Being 400 pixels in width, the center of these objects could be placed no more than 250 pixels to the left and no more than 250 pixels to the right before one of their ends touched the bounding edge of the frame. The experimental program therefore did not permit participants to place any object beyond the −250 to +250 pixel range horizontally. The dimensions of the background images for the human object category were 749 pixels in width and 416 pixels in height, and the human images themselves ranged from 67 pixels to 249 pixels in width.

Procedure

Participants viewed the same computer screen from the same distance (about 70 cm) inside the same darkened booth as in Experiment 1.[1] They performed two tasks: First "dragging and dropping" the focal object of a picture to the position at which they found it most aesthetically pleasing (as in Experiment 1). Following a practice trial, participants were shown each of the 72 images of the different objects with their corresponding backgrounds in random order (intermixed with the objects and background images from Experiment 1). Only the horizontal (x axis) position of the center of each object was recorded on each trial.

Once participants completed the drag-and-drop task for all images, they were shown each of the objects in its rightward moving or facing version (in the center of the background used in the drag-and-drop task for that object) and were asked to make a slider scale rating to indicate how fast the object appeared to be moving. Participants rated the objects corresponding to each of the categories separately because we were primarily interested in people's perceptions of the relative speeds of the different objects within that category (rather than their absolute speeds) and wanted the range of speed judgments for each category to span the entire rating scale. The slider scale ranged from 0 to 500 pixels and was located below the image. The scale was labeled *Slowest* on the left end and *Fastest* on the right end. We rescaled the data to range from 0 to 100.

Results and Discussion

We initially analyzed the ratings of speed (on the 0–100 scale) as a manipulation check to be sure that our participants perceived the speeds of the objects as intended. Indeed, the speed ratings, averaged over objects, increased monotonically from stationary (mean = 2.8), to slow (mean = 22.9), to medium (mean = 57.0), to fast (mean = 92.2). A two-way analysis of variance showed that the speed ratings were indeed significantly different, $F(3, 54) = 687.5$, $p < .0001$, $\eta = .974$. There was no significant effect of category, $F(2, 36) = 2.97$, $p = .064$, $\eta = .142$, but there was an interaction between speed and category, $F(6, 108) = 4.44$, $p = .0001$, $\eta = .198$. This interaction results from slight nonparallelism of the speed ratings for the slow and medium speeds for the different object categories. These results generally corroborate the fact that our manipulation of the four speed conditions was successful and that the differences between the category conditions were relatively minor.

Analyses of the drag-and-drop placements were conducted on the average of the recorded x-axis coordinates corresponding to the horizontal positions of the centers of the three examples of each object in the drag-and-drop task. We analyzed the effects of object category, motion or facing direction, speed, and image width on the preferred horizontal positions with linear mixed-effects models using the lme4 package in the R environment. In all of the models, we specified subjects as the random factor in order to control for their intraclass correlation using random intercepts for each subject. Motion or facing direction, speed, and image width were specified as fixed factors for the main model we used to test the effect of implied speed. We included width as a fixed factor in order to test for effects of motion or facing direction and speed while controlling for variations in the horizontal extents (widths) of the target images, even though differences in target width were only present in the images of people. Horse and car images had a fixed width of 400 pixels. We performed statistical significance tests using Type II Wald chi-squared tests of the fixed effects in the model.

The results of the experiment are plotted in Figure 4. The pattern of the data is quite clear and systematic. Inward biases are evident for every condition, but somewhat surprisingly, they are larger for the objects perceived as moving at slower speeds. In fact, the largest inward bias is evident for the stationary conditions. Statistical analyses corroborated this pattern in the results.

In keeping with previous findings, we observed a strong inward-moving or facing bias (Wald $\chi^2 = 691.56$, $p < .0001$), showing that participants preferred leftward-moving or facing objects to be placed right-of-center and rightward-moving or facing objects to be placed left-of-center. This result replicates the robust inward bias previously reported for aesthetic preferences for the spatial composition of static, single-object pictures inside a frame (Bertamini et al., 2011; Palmer et al., 2008; Sammartino & Palmer, 2012a, 2012b; and Experiment 1 of this article). No main effect of speed was evident, because of the cancelling effect when the left- and right-moving or facing versions were averaged (Wald $\chi^2 = 5.94$, $p = .11$), but a significant motion or facing direction × speed interaction was observed (Wald $\chi^2 = 47.25$, $p < .0001$), resulting from the fact that the inward-moving or facing bias becomes weaker as the object is seen as moving faster. There was no main effect of image width (Wald $\chi^2 = 0.0116$, $p = .91$), no interaction between motion or facing direction and width (Wald $\chi^2 = 0.089$, $p = .77$), and no interaction between speed and width (Wald $\chi^2 = 1.21$, $p = .75$). There was, however, a significant three-way interaction among motion or facing direction, velocity, and width (Wald $\chi^2 = 10.88$, $p = .012$). The data in Figure 4 are averaged over the three object categories because there was no main effect of category (Wald $\chi^2 = 2.84$, $p = .24$), no category × facing interaction (Wald $\chi^2 = 3.02$, $p = .22$), and no category × speed interaction (Wald $\chi^2 = 4.62$, $p = .59$). There was a significant category × motion or facing direction × speed interaction (Wald $\chi^2 = 18.19$, $p < .01$) due to the fact that the shapes of the speed curves are not parallel for the different object categories. The pattern of the data does not seem to be systematic in ways that suggests a coherent, meaningful interpretation, however, except for showing smaller speed effects for the horse images than for the people or car images (see Figure S1 in the Supplementary Material). This might result from people simply being less familiar with the speeds at which horses move at different gaits.

Finally, we computed the correlation between the average magnitude of the speed ratings for each of the pictures and the average magnitude of the inward motion or facing bias in the drop-and-drag task. The results showed a reliably negative correlation ($r = -0.60$, $p < .0001$),

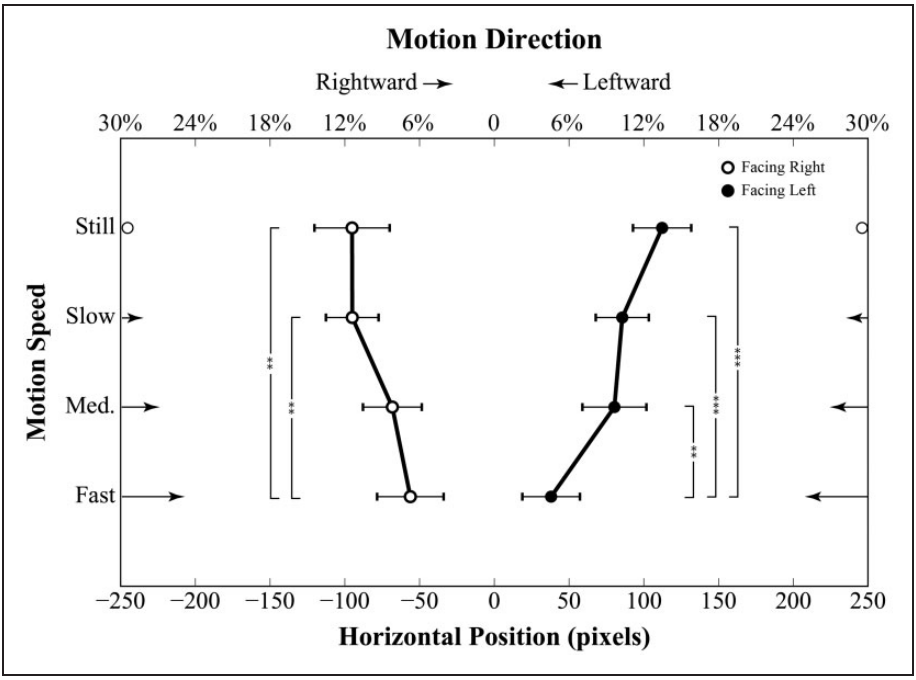

Figure 4. Results of Experiment 2. Average horizontal position (*x* axis) of the center of target objects at their chosen positions is plotted as a function of moving or facing rightward (open circles) versus leftward (filled circles) and implied object speed (*y* axis). The top horizontal axis shows the percentage of the background image width from the center. (Because the width of the background images for the human figures was different from the width of the background images for the horses and the cars, this shows the percentage of the average background image width from the center). Asterisks represent statistical significance of specific comparisons as indicated, using Bonferroni corrections for multiple comparisons (** $\rightarrow p < .05/12 = .004$). Error bars show the standard error of the mean for each speed condition, for each facing direction.

indicating that pictures of objects with higher speed ratings were preferred in positions closer to the center (i.e., with smaller inward biases). This negative correlation is the opposite of what we originally expected, given our initial hypothesis that increased speed would amplify the inward-moving bias obtained in Experiment 1.

General Discussion

The results of the experiments described here replicate and extend the inward bias in aesthetic preference for spatial compositions of pictures (Palmer et al., 2008; Sammartino & Palmer, 2012a, 2012b; also called the ‘‘anterior bias’’ by Bertamini et al., 2011). It occurs for pictures of a single object in a rectangular frame when the object faces leftward or rightward in the picture plane and produces a preference for the object to be positioned on the side of the frame opposite to the direction it faces. Here we explored the inward bias further by investigating whether an analogous effect is also present for implied motion of the depicted object.

In Experiment 1, we showed that although the inward bias due to the facing direction of objects (the inward-facing bias) is still evident in people’s aesthetic preferences for composition of moving objects, it can be overpowered by an inward-*moving* bias when the object is moving backward. That is, when the facing and motion directions are the same, as in forward motion, people favor compositions exhibiting a strong inward bias in which the object both moves and faces inward. When the facing and motion directions are opposite, however, as in backward motion, they favor compositions in which the object is moving into the frame but facing (somewhat) out of the frame. These effects were found using images of forward and backward human divers and fallers because it was relatively easy to convey a clear direction of motion through diving and falling poses that could easily be perceived as forward or backward motion. Finding a case in which the inward-facing bias is overwhelmed by another factor (motion direction) was somewhat unexpected. Both the inward-facing bias and the inward-moving bias are potentially compatible with the affordance space hypothesis, given that asymmetries are likely to arise in the shape of the affordance spaces of divers and fallers due to both the direction that they are looking (the facing bias) and the direction they are moving (the inward-moving bias). The results of Experiment 1 show that these two compositional biases are largely additive. One theory about the inward-facing bias is that the preferred displacement of a side-facing object is to be off-center, facing inward, because people are actually centering an object's *affordance space*, which is suggested to extend farther in the front-facing direction of an object than in other directions for most objects (Sammartino & Palmer, 2012b). The results of Experiment 1 are compatible with an affordance space hypothesis, provided that the affordance space on an object can differ dynamically, depending on the perceived movement and action of the object in the depicted event.

Experiment 2 investigated how the inward-moving bias might be modulated by the implied speed of the depicted object. Although the inward-moving or facing bias held in this experiment as well, varying the speed of implied motion showed that faster-moving objects exhibited a smaller inward bias than slower-moving objects. In other words, faster objects were preferred closer to the center than objects that appeared still or moving slowly. We further validated these results by collecting ratings from the same participants on how fast the objects appeared to be moving and found that these ratings were negatively correlated with the magnitude of the inward-moving or facing bias (i.e., faster moving objects produced smaller inward biases).

The results of Experiment 2 thus replicate the robust inward motion or facing bias in aesthetic preferences demonstrated in the inward motion bias of Experiment 1, but they also reveal a somewhat surprising reduction in that bias for objects depicted as moving faster. The reduction is surprising because the data from Experiment 1 clearly imply that people systematically prefer more space to be present in the direction of implied motion. We take a "room-to-move" hypothesis to be the most straightforward explanation of the directional bias effects reported in Experiment 1. By extension, however, this account predicts that *more* (i.e., faster) implied motion should produce a *larger* inward bias to provide *more* space in front of a faster moving object than a slower or stationary one. Unfortunately, we observed the opposite in the speed effects obtained in Experiment 2: Faster objects were preferred with *less* space in front of them and *more* space behind them. There is a coherent rationale for these speed effects in Experiment 2, however. Perhaps people prefer the spatial position of an implicitly moving object to represent how far it has traveled in some fixed amount of time in the recent past from an off-center reference position. If the inward bias for a stationary object is taken as a baseline, this "distance-traveled" hypothesis thus implies that the inward bias will progressively diminish as the speed of the object increases. Perhaps the simplest way to conceptualize the relation between these two hypotheses is that room-to-move is a future-oriented principle of motion foresight, whereas distance-traveled is a past-oriented principle of motion hindsight. The results of Experiment 1 thus seem to conflict with those of

Experiment 2 in the sense that the directional bias so evident in Experiment 1 suggests a future-oriented (room-to-move) account of implied motion effects, whereas the speed effects apparent in Experiment 2 support a past-oriented (distance traveled) account.

How might this conflict be reconciled? It seems unlikely to be due to differential context effects, because the data for both studies were collected in a single session with the same participants and with the trials randomly intermixed,[1] precisely to avoid such context-specific strategic effects. One possible reconciliation is that people's compositional preferences are determined by two different processes, one that depends on the perceived direction of motion and the other on the perceived speed of motion. Initially, the viewer may identify a reference position for a picture of a stationary object that might move based on the directionality of its characteristic motion as depicted by its facing direction. This initial reference position exhibits a strong inward bias with an expanse of empty space ahead of it where it might be located in the near future (i.e., representing room-to-move). This initial reference position is then modified according to the object's perceived speed, including an expanse of space behind it to represent where it had been located during a fixed period of time in the recent past (i.e., representing distance traveled). This two-process account seems to be a plausible explanation for the pattern of results obtained in these two experiments. The present data thus appear to provide evidence of biases in aesthetic preferences for the spatial position of a single object that are based on assumptions about both the prospective and retrospective motion of the depicted object.

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Notes

1. The drag-and-drop trials from Experiments 1 and 2 were randomly intermixed to reduce biases that might arise if participants realized that all of the images in Experiment 1 differed only in the direction of implied motion and all of those in Experiment 2 differed only in the speed of implied motion.

2. Facing direction and motion direction are completely confounded in this experiment because all objects are perceived as moving forward. Even in the stationary condition this confound is present because the object is facing in the same direction that it would characteristically move, if it were moving. Because of this confound and the results of Experiment 1 demonstrating that facing and motion are two distinct effects, we call this factor ''motion/facing direction'' in the present experiment.

Supplemental Material

The online supplementary material is available at http://journals.sagepub.com/doi/suppl/10.1177/0301006617694189

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