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ORIENTAÇÃO E ALOCAÇÃO DE UM OBJETO-ALVO[1]

Timothy L. Hubbard[2]
Texas Christian University

Resumo: Neste estudo foram medidos os efeitos provenientes da orientação-alvo na alocação em memória de um alvo quadrado ou retangular em movimento. A orientação dos alvos em relação ao seu percurso era variada; os efeitos de orientação-alvo em uma alocação futura foram observados para o alvo retangular, mas não o foram para o alvo quadrado; Os resultados mostraram-se consistentes com a hipótese de que os efeitos da orientação-alvo (a) podem ser observados em alvos que não têm uma trajetória claramente definida ou uma orientação prototípica em relação à direção do seu movimento, e (b) podem influenciar a alocação futura quando as coordenadas espaciais dos contornos do alvo não são constantes ao longo de mudanças na orientação do alvo em relação à direção do movimento.

Palavras-chave: Orientação; objeto-alvo retangular; objeto-alvo quadrado; alocação.

AN EFFECT OF TARGET ORIENTATION ON REPRESENTATIONAL MOMENTUM

Abstract: The effects of the target orientation on displacement in memory for the location of a moving rectangular or square target were measured. The orientation of a target relative to its path of motion was varied; the effects of target orientation on forward displacement were observed for the rectangular target and not for the square target. The data were consistent with the hypotheses that the effects of target orientation (a) can be observed in targets that do not have a clearly defined direction of pointing or prototypical orientation relative to their direction of motion, and (b) can influence the forward displacement when the spatial coordinates of the contours of the target are not invariant across changes in target orientation relative to the direction of motion.

Key-words: Orientation; retangular target; square target; allocation.

Introduction: An observer's memory for the final position of a moving target is usually displaced slightly forward in the direction of target motion, that is, a target is remembered as having traveled slightly farther than it actually did. This forward displacement has been referred to as *representational momentum* (Freyd & Finke, 1984; Hubbard, 1995b), and is influenced by numerous variables including target velocity and acceleration (Finke, Freyd, & Shyi, 1986), expectations regarding future target motion (Hubbard, 1994; Verfaillie & d'Ydewalle, 1991), conceptual knowledge regarding target identity (Reed & Vinson, 1996; Vinson & Reed, 2002), allocation of attention (Hayes & Freyd, 2002; Kerzel, 2003), attributions regarding the source of target motion (Hubbard & Favretto, 2003; Hubbard & Ruppel, 2002), motion of the surrounding context (Hubbard, 1993; Whitney & Cavanagh, 2002), direction of target translation (Hubbard & Bharucha, 1988) or axis of target rotation (Munger, Solberg, Horrocks, & Preston, 1999), direction of target motion relative to a landmark (Hubbard & Ruppel, 1999) or implied gravitational attraction (Hubbard, 1997, 2001), and for the special case of a visual target exhibiting continuous motion, by whether observers track the target or fixate a stationary point (Kerzel, 2000, 2003).

One variable that could potentially influence forward displacement of a moving target is the orientation of that target relative to its direction of motion. Target orientation relative to the direction of motion influences displacement for arrows (Freyd & Pantzer, 1995) and for abstract animated "creatures" (Freyd & Miller, 1992), but does not influence displacement for triangles (Cooper & Munger, 1993). Arrows and creatures might be perceived as more strongly pointing (facing) a specific direction, and so in such targets, perhaps direction of pointing rather than target orientation per se influenced displacement.

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[2] Endereço para correspondência: Timothy Hubbard, Department of Psychology, TCU Box 298920, Texas Christian University, Fort Worth TX 76129, E-mail: t.hubbard@tcu.edu.

Nagai and Yagi (2001) reported displacement was not influenced by whether a target moved in a typical or atypical direction (not influenced by target orientation relative to the direction of motion), but was influenced by the direction the target pointed. Vinson and Reed (2002) suggested object-specific effects such as pointing are more likely to influence displacement if a target is prototypical of its category and associated with a strong typical motion. Even so, it is not clear why displacement of only some targets is influenced by the direction the target points or by knowledge regarding typical motion of that type of target, and it is difficult to disentangle effects of orientation from effects of pointing or from background knowledge regarding a given type of target.

One way to begin to disentangle effects of pointing from effects of target orientation would be to present a target that would not be interpreted as pointing in a specific direction or as having a prototypical orientation relative to its direction of motion. In such a case, orientation of the target might influence forward displacement if the orientation influences the magnitude of perceived friction or resistance on that target. Increases in implied friction lead to decreases in forward displacement of a target, and this decrease has been referred to as *representational friction* (Hubbard, 1995a, 1998). Momentum of a moving physical object is independent of the orientation of that object, and so representational momentum per se should be independent of orientation; the decrease in forward displacement in memory for the location of a target would result from a combination of representational momentum and representational friction. A target oriented to experience more implied friction (a target less streamlined) should therefore exhibit less displacement forward along the axis of motion than would a target oriented to experience less implied friction (a target more streamlined).

Such a hypothesis suggests differences in implied friction would only be found if changes in the orientation of a target relative to that target's path of motion were not *contour invariant*, that is, if spatial positions of the target contours relative to the path of motion changed with changes in the orientation of the target. As shown in Figure 1, a rectangle does not exhibit contour invariance after a 90-degree rotation (spatial positions of the contours relative to the path of motion changed after rotation), but a square does exhibit contour invariance after a 90 degree rotation (spatial positions of the contours relative to the path of motion do not change after rotation). Of course, a target might exhibit contour invariance for some rotations and not other rotations (a rectangle would exhibit contour invariance for a 180 degree rotation), and only a circle (in two dimensions) or a sphere (in three dimensions) exhibit contour invariance for all rotations. If a target exhibited contour invariance with changes in its orientation relative to its path of motion, then different orientations of that target would presumably experience the same amount of implied friction; however, if a target did not exhibit contour invariance with changes in its orientation relative to its path of motion, then different orientations of that target would presumably not experience the same amount of implied friction.

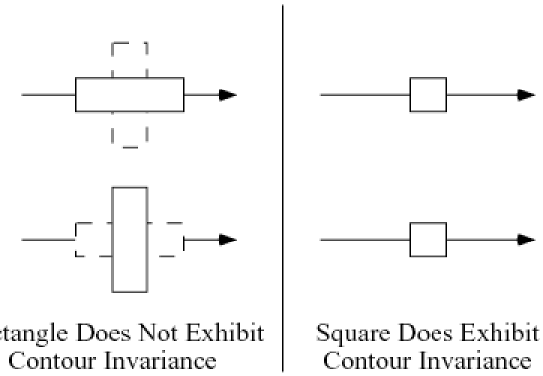

Fig. 1: An illustration of contour invariance. In the top row, the major axis is aligned with the direction of motion, and in the bottom row, the minor axis is aligned with the axis of motion. The target is drawn in solid lines, and a target rotated 90 degrees from that is drawn in dashed lines. The rectangle does not exhibit contour invariance with a 90 degree rotation (the dashed lines are visible), whereas the square does exhibit contour invariance with a 90 degree rotation (the dashed lines are not visible).

In the experiments reported here, the orientation of a moving target relative to the path of target motion was varied, and displacements in memory for the location of the target along the axis of motion and along the axis orthogonal to motion were measured. The target was a rectangular or square shape, and these shapes were used because they (a) should not be perceived as pointing a specific direction or having a standard orientation relative to a path of motion, and (b) provided different levels of contour invariance. Given that implied friction influences displacement along the path of motion, it could be predicted that targets that did not exhibit contour invariance (rectangles) should exhibit effects of orientation on forward displacement along the axis of motion, whereas targets that did exhibit contour invariance (squares) should not exhibit effects of orientation on forward displacement along the axis of motion. It is not clear whether differences in contour invariance would lead to differences in displacement along the axis orthogonal to target motion.

Experiment 1

Observers viewed upward, downward, leftward, or rightward translations of a rectangular target. On half of the trials, the path of motion was parallel to the major axis of the target, and on half of the trials, the path of motion was parallel to the minor axis of the target. The target vanished without warning, and after the target vanished, observers indicated the judged vanishing point. A rectangular figure does not exhibit contour invariance across its major and minor axes; a rectangle in which motion is parallel to the minor axis would present a less streamlined shape that would presumably encounter more friction than would a rectangle in which motion is parallel to the major axis. The literature on representational friction suggests forward displacement should be decreased if the target encounters more implied friction, and so targets in which motion is parallel to the minor axis should exhibit less forward displacement than do targets in which motion is parallel to the major axis.

Method

Participants

The observers were 12 undergraduates from Texas Christian University who participated in return for partial course credit in a psychology course.

Apparatus

The stimuli were displayed upon and data collected by an Apple Macintosh IIsi microcomputer equipped with an Apple RGB color monitor. The target stimulus was a filled black rectangle presented on a white background. The minor axis of the target measured 20 pixels (approximately 0.83 deg) in length, and the major axis of the target measured 60 pixels (approximately 2.50 deg) in length. The display area measured 640 pixels x 460 pixels (approximately 26.67 deg x 19.17 deg). On each trial, the target emerged from the approximate midpoint of the left, right, top, or bottom edge of the display and moved toward the opposite side of the display. On half of the trials, the major axis of the target was parallel to the direction of target motion, and on half of the trials, the minor axis of the target was parallel to the direction of target motion. The center point of the target crossed between 35-65% of the display before the target vanished without warning; vanishing point was defined in terms of the center of the target in order to be consistent with previous research.[1] Target velocity was constant within a trial and varied between trials, and was controlled by shifting the target 1, 2, or 3 pixels between successive presentations (resulting in a velocity of approximately 5, 10, and 15 deg/sec, respectively). Each participant received 240 trials (2 target orientations x 4 directions x 3 velocities x 10 replications) in a different random order.

Procedure

Observers were given 12 practice trials at the beginning of the session, and practice trials were drawn randomly from experimental trials. The observers initiated each trial by pressing a designated key, and after a one second pause the target emerged from either the left, right, top, or bottom edge of the display and traveled toward the opposite side of the display. Observers were instructed to watch the target, and eye movements were not monitored or controlled. The target vanished without warning. The cursor, in the form of a plus sign, appeared near the center of the display, and observers positioned the center of the cursor over where the center of the target had been when the target vanished. The cursor was positioned by movement of a computer mouse, and after positioning the mouse, observers clicked a button on the mouse in order to record the display coordinates of the cursor. Observers then initiated the next trial.

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[1] The use of the center point of the target as the vanishing point coordinate resulted in the leading edge of a target whose major axis was parallel to the direction of motion traversing a slightly greater distance (20 pixels or approximately 0.83°) than the leading edge of a target whose minor axis was parallel to the direction of motion, but this additional distance would not have contributed to the displacement. The magnitude of forward displacement may decrease slightly with increases in the distance traveled by a target (Hubbard & Bharucha, 1988), but this decrease is opposite to the predicted increase, and so would not produce a greater forward displacement for targets whose motion was parallel to the major axis.

Results

Differences between the true vanishing point and the judged vanishing point (in pixels) along the *x*- and *y*-axes were calculated for each target. Consistent with previous reports, differences along the axis of target motion (the *x* axis for horizontal motion, the *y* axis for vertical motion) were referred to as *M displacement*, and differences along the axis orthogonal to target motion (the *y* axis for horizontal motion, the *x* axis for vertical motion) were referred to as *O displacement*. Positively signed M displacement indicated a judged vanishing point beyond the true vanishing point (leftward of a target moving leftward, above an ascending target), and negatively signed M displacement indicated a judged vanishing point behind the true vanishing point (rightward of a target moving leftward, below an ascending target). Positively signed O displacement indicated a judged vanishing point above (for horizontally moving targets) or to the right (for vertically moving targets) of the true vanishing point, and negatively signed O displacement indicated a judged vanishing point below (for horizontally moving targets) or to the left (for vertically moving targets) of the true vanishing point.

M displacement scores were analyzed with a 2 (target orientation) x 4 (direction) x 3 (velocity) analysis of variance (ANOVA) and are displayed in Figure 2. M displacement was significantly larger when motion was parallel to the major ($\underline{M} = 20.16$) axis than when motion was parallel to the minor ($\underline{M} = 14.52$) axis, $\underline{F}(1,11) = 13.23$, $\underline{MSE} = 173.54$, $\underline{p} < .004$. Direction significantly influenced M displacement, $\underline{F}(3,33) = 5.51$, $\underline{MSE} = 218.05$, $\underline{p} < .004$; a planned comparison revealed that M displacements for rightward ($\underline{M} = 21.34$) and leftward ($\underline{M} = 20.30$) motion were significantly larger than were M displacements for ascending ($\underline{M} = 13.13$) and descending ($\underline{M} = 14.59$) motion. Faster targets also exhibited larger M displacement, $\underline{F}(2,22) = 38.45$, $\underline{MSE} = 47.15$, $\underline{p} < .001$, and a post hoc Newman-Keuls test ($\underline{p} < .05$) revealed that all pairwise comparisons of the slow ($\underline{M} = 12.88$), medium ($\underline{M} = 17.59$), and fast ($\underline{M} = 21.56$) velocities were significant. The Direction x Velocity interaction was significant, $\underline{F}(6,66) = 4.04$, $\underline{MSE} = 35.53$, $\underline{p} < .002$, and as shown in Figure 2, M displacement increased faster with increases in target velocity for horizontally moving targets. No other effects reached significance.

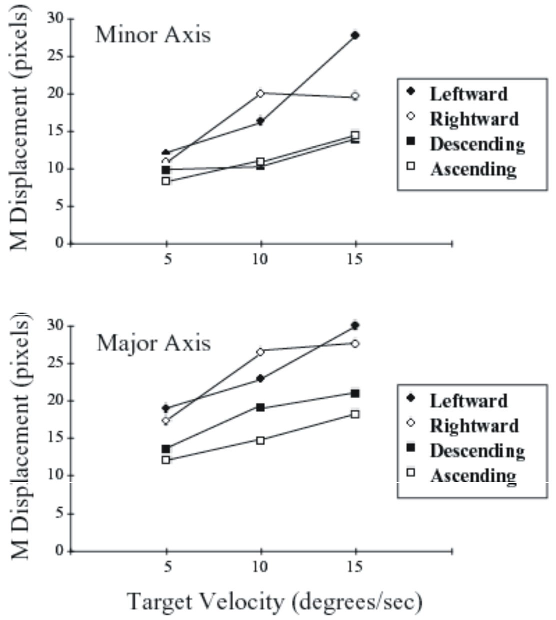

Fig. 2: M displacement as a function of target velocity in Experiment 1. Data from when the minor axis was aligned with the direction of motion are shown in the top panel, and data from when the major axis was aligned with the direction of motion are shown in the bottom panel. Data for leftward targets are plotted with filled diamonds, and data for rightward targets are plotted with open diamonds; data for descending targets are plotted with filled squares, and data for ascending targets are plotted with open squares.

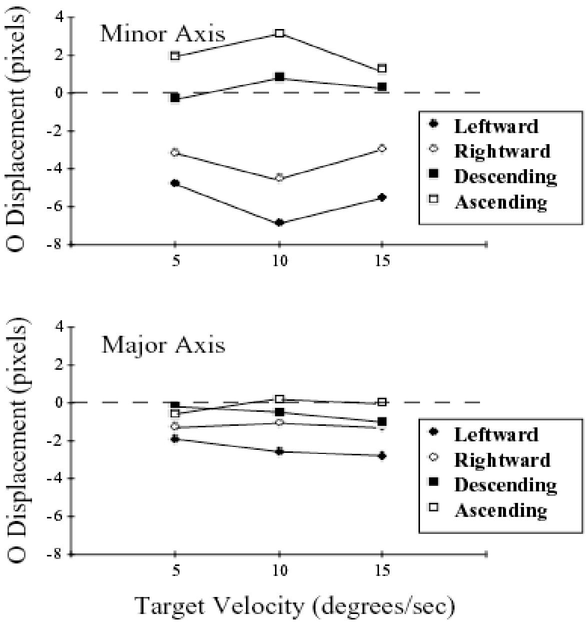

Fig. 3: O displacement as a function of target velocity in Experiment 1. Data from when the minor axis was aligned

with the direction of motion are shown in the top panel, and data from when the major axis was aligned with the direction of motion are shown in the bottom panel. Data for leftward targets are plotted with filled diamonds, and data for rightward targets are plotted with open diamonds; data for descending targets are plotted with filled squares, and data for ascending targets are plotted with open squares.

O displacement scores were analyzed with a 2 (target orientation) x 4 (direction) x 3 (velocity) ANOVA and are displayed in Figure 3. Direction significantly influenced O displacement, $F(3,33) = 6.32$, $MSE = 58.73$, $p < .002$; a planned comparison revealed that O displacements for rightward ($M = -4.11$) and leftward ($M = -2.31$) motion were significantly more negative than were O displacements for ascending ($M = 0.99$) and descending ($M = -0.15$) motion. Additionally, Direction interacted with Target Orientation, $F(3,33) = 7.08$, $MSE = 18.07$, $p < .001$. As shown in Figure 3, differences in O displacement between horizontal and vertical motion increased when the minor axis of the target was parallel to the direction of motion. No other effects reached significance.

Discussion

M displacement was larger when target motion was parallel to the major axis of the target than when target motion was parallel to the minor axis of the target. This pattern is consistent with the hypotheses that (a) the orientation of a moving target can influence forward displacement of that target, and (b) a target presenting a smaller or more streamlined face in the direction of motion would exhibit larger forward displacement than would a target presenting a larger or less streamlined face in the direction of motion. Additionally, horizontal motion led to larger M displacement than did vertical motion, faster targets exhibited larger M displacement than did slower targets, and effects of velocity increased faster for horizontal motion than for vertical motion; the velocity and direction effects replicated previously reported patterns (Hubbard, 1990; Hubbard & Bharucha, 1988).

The larger negative O displacement for leftward or rightward motion replicates previous patterns and is consistent with *representational gravity*, a displacement of the target in the direction of implied gravitational attraction (Hubbard, 1995b, 1997). The increase in the difference between O displacements for horizontal targets and O displacements for vertical targets when motion was parallel to the minor axis was not predicted. One possible explanation involves the contribution of representational gravity to O displacements for leftward or rightward targets; when the minor axis was parallel to the direction of motion, a more streamlined profile along the axis of implied gravitational attraction would have occurred, and this could have contributed to the increased displacement in the direction of implied gravitational attraction (contributed to a slightly larger negative displacement).

A second possible explanation for the Direction x Target Orientation interaction in the O displacement data is that when the direction of target motion was parallel to the minor axis of the target, then a greater average proportion of the implied mass (or surface area) of the target was located further from the axis of motion. As the average distance of mass from the center of the target along the axis orthogonal to motion increased, the average distance of mass from the center of the target along the axis parallel to motion decreased. As the average distance of mass (from the center of the target) along the orthogonal axis increased, it could have contributed to an increased magnitude of displacement along that axis. Such an account might also be generalized to explain why M displacement was larger in targets in which motion was parallel to the major axis than in targets in which motion was parallel to the minor axis: as the average distance along the axis of motion increased (when motion was aligned with the major axis), forward displacement increased.

Experiment 2

The results of Experiment 1 were consistent with the hypothesis that changes in the spatial coordinates of the contours of the target relative to the direction of motion were necessary in order for changes in target orientation to influence forward displacement of that target. To test this notion more explicitly, it was necessary to present a target whose contour was invariant across changes in target orientation. Accordingly, the target in Experiment 2 was a moving square outline. Three sides of the square were drawn using solid lines, and the fourth side was drawn using a dotted line (Davi & Proffitt, 1993). In order to maximize differences in target orientation relative to the path of motion, the dotted line was on either the leading edge or the trailing edge of the target. If target orientation influences displacement along the axis of motion in Experiment 2, then that would not support the hypothesis that effects of orientation require that a target not exhibit contour invariance.

Method

Participants

The observers were 15 undergraduates from the same participant pool used in Experiment 1, and none of the observers had participated in Experiment 1.

Apparatus

The apparatus was the same as in Experiment 1.The target stimulus was an outline square shape 20 pixels (approximately 0.83 deg) in width. Three of the sides of the square were solid lines. The remaining side was depicted by a series of 3 dots, and each dot was spaced 5 pixels from the nearest dot or from the nearest side of the square. As in Experiment 1, the target emerged from the approximate midpoint of the left, right, top, or bottom edge of the display and moved toward the opposite side of the display, and the center of the target crossed between 35-65% of the extent of the display before it vanished without warning. On half of the trials, the dotted side was the leading edge of the square, and on half of the trials, the dotted side was the trailing edge of the square. Target velocities were the same as in Experiment 1. Each participant received 240 trials (2 target orientations x 4 directions x 3 velocities x 10 replications) in a different random order.

Procedure

The procedure was the same as in Experiment 1.

Results

M and O displacements were calculated as in Experiment 1, and were analyzed in separate 2 (target orientation) x 4 (direction) x 3 (velocity) repeated measures ANOVAs. The displacements are displayed in Figures 4 and 5.

Whether the dotted line was the leading (M = 12.88) or trailing (M = 12.36) edge did not influence M displacement, $F(1,14) = 0.27$, $p > .61$, although target orientation interacted with Direction x Velocity, $F(6,84) = 2.98$, $MSE = 21.69$, $p = .01$. As shown in Figure 4, Direction, $F(3,42) = 23.60$, $MSE = 133.35$, $p < .001$, Velocity, $F(2,28) = 107.59$, $MSE = 26.03$, $p < .001$, and Direction x Velocity, $F(6,84) = 2.45$, $MSE = 33.31$, $p < .04$, were all significant. Post hoc Newman-Keuls tests ($p < .05$) showed that M displacements for rightward (M = 18.79) and leftward (M = 16.15) motion were significantly larger than were M displacements for descending (M = 9.69) and ascending (M = 5.85) motion, and that all pairwise comparisons between slow (M = 7.68), medium (M = 12.85), and fast (M = 17.33) velocities were significant. Additionally, when the dotted line was on the leading edge of the target, M displacement increased faster with increases in velocity for horizontal motion than for vertical motion. The direction and velocity effects were consistent with previous findings. No other effects reached significance.

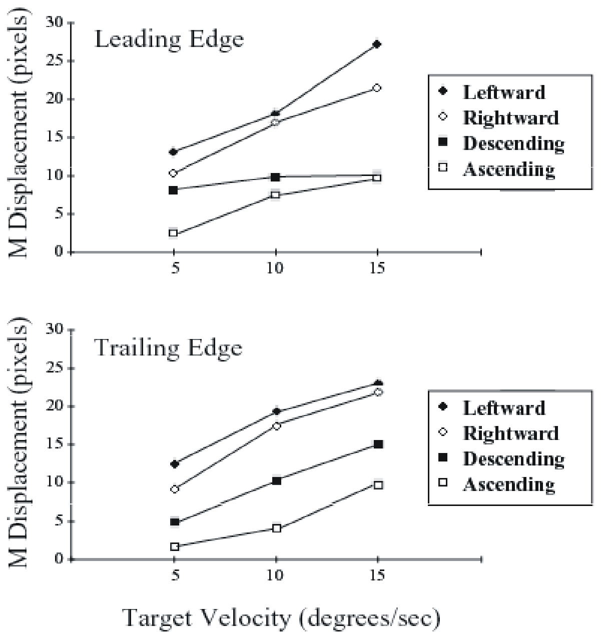

Fig. 4: M displacement as a function of target velocity in Experiment 2. Data from when the base of the target was the leading edge are shown in the top panel, and data from when the base of the target was the trailing edge are shown in the bottom panel. Data for leftward targets are plotted with filled diamonds, and data for rightward targets are plotted with open diamonds; data for descending targets are plotted with filled squares, and data for ascending targets are plotted with open squares.

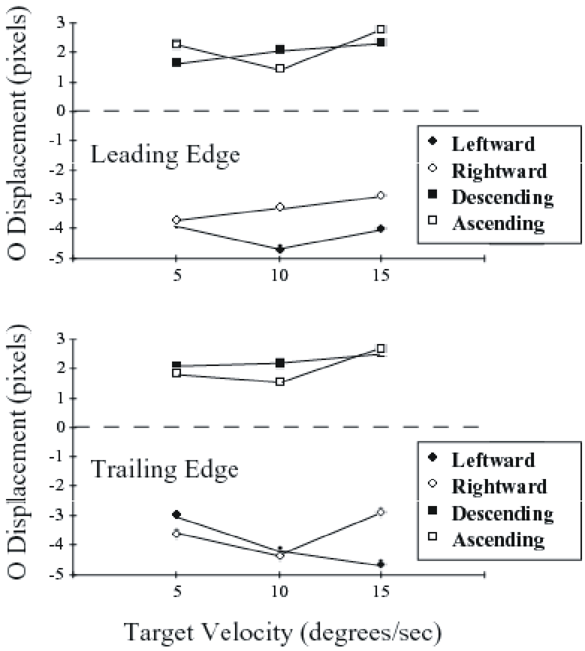

Fig. 5: O displacement as a function of target velocity in Experiment 2. Data from when the base of the target was the leading edge are shown in the top panel, and data from when the base of the target was the trailing edge are shown in the bottom panel. Data for leftward targets are plotted with filled diamonds, and data for rightward targets are plotted with open diamonds; data for descending targets are plotted with filled squares, and data for ascending targets are plotted with open squares.

O displacement. Direction significantly influenced O displacement, $F(3,42) = 23.39$, $MSE = 44.60$, $p < .001$; a planned comparison revealed that O displacements for rightward ($M = -4.08$) and leftward ($M = -3.47$) motion were significantly more negative than were O displacements for descending ($M = 2.13$) and ascending ($M = 2.07$) motion. Velocity influenced O displacement, $F(2,28) = 3.67$, $MSE = 3.53$, $p < .04$; a post hoc Newman-Keuls test ($p < .05$) revealed the medium ($M = -1.18$) velocity produced more negative O displacement than did the fast ($M = -0.52$) velocity, and neither the medium nor the fast velocity differed from the slow ($M = -0.81$) velocity. No other effects reached significance.

Discussion

Whether the dotted line was the leading edge or the trailing edge of the target did not influence forward displacement along the axis of motion for that target. Target orientation interacted with Direction x Velocity, though, such that when the dotted line was the leading edge of the target, velocity had a smaller influence on displacement for ascending or descending motion. One possible explanation is that observers perceived the target as a container, with the dotted side being more open (or permeable) than were the three solid sides. A descending target with an open bottom might be perceived as more likely to decelerate because of resistance from being filled with whatever medium the target was passing through (as an open parachute slows a descending skydiver). Similarly, an ascending target with an open top might be perceived as more likely to decelerate because of being filled (as a dipped cup becomes heavier as more water is scooped into it). Of course, when the dotted line is the trailing edge, then such a target would not be perceived as being filled by forward motion of the target.

Interpretation of the target as a container is only possible if the dotted line is interpreted as being different from the other sides of the target, but this would seem to contradict the notion of contour invariance described earlier. However, the contour invariance notion addresses the relative spatial positions of the contours, and does not address nonspatial characteristics of a contour at a given spatial position. If the relative spatial positions of contours are maintained (as in Experiment 2), then the only way to introduce differences in target orientation is to modify nonspatial characteristics of a contour (as in Experiment 2). Given the focus of the contour invariance notion on relative spatial position, the lack of a main effect of target orientation in Experiment 2 is consistent with the notion that orientation of the contour is primarily responsible for effects of target orientation on forward displacement, and is also consistent with the hypothesis that effects of orientation can be observed when targets do not exhibit contour invariance.

Unlike targets in Experiment 1, the spatial coordinates of the contours of targets in Experiment 2 relative to the direction of motion were invariant across changes in target orientation. However, target orientation did interact with direction and velocity, such that M displacement increased faster with increases in velocity for horizontal motion than for vertical motion. The diminished effect for vertical motion might result from an increased salience of resistance along the vertical axis because more perceived effort or work might be required to raise or lower targets that were "open to being filled" than to move such targets leftward or rightward. Perceived work or effort (and target size) influence displacement along the axis aligned with the direction of implied gravitational attraction (Hubbard, 1997), and so perhaps interaction of target orientation with direction of target motion was due to influences of representational gravity rather than to influences of representational friction. Effects of direction, velocity, and Direction x Velocity in M displacement, and effects of direction in O displacement, replicated Experiment 1 and were consistent with previous reports.

The orientation of a moving target can influence forward displacement in memory for the location of that target, even if the target is not perceived to point in a specific direction or possess a prototypical orientation relative to its direction of motion. When the relative spatial positions of the contours of the target changed (a rectangular target in which direction of motion was parallel to either the major or minor axis), effects of target orientation on forward displacement were observed, whereas when the relative spatial positions of the contours of the target did not change (a square target in which either the leading or trailing edge was different from the other sides), effects of target orientation on forward displacement were not observed. More concisely, target orientation influenced displacement along the path of motion when changes in target orientation were not contour invariant (Exp.1), but not when changes in target orientation were contour invariant (Exp. 2). Additionally, target orientation influenced displacement along the orthogonal axis when changes in target orientation were not contour invariant such that influences of direction were larger when the minor axis was parallel to the path of motion (and the major axis was orthogonal to motion).

The larger magnitude of forward displacement along the axis of motion when the major axis of the target was parallel to the direction of target motion can be accounted for in at least two different ways. One possible explanation is that observers perceived targets in which motion was parallel to the major axis as experiencing less resistance or friction than did targets in which motion was parallel to the minor axis. Less resistance or friction would result in a greater magnitude of forward displacement (Hubbard, 1995a, 1998). Confidence in such an explanation, though, is challenged by Cooper and Munger's (1993) finding that the magnitude of forward displacement of a triangular target was not influenced by whether the target moved point-first (was more streamlined) or base-first (was less streamlined).[2] A second possible explanation is that observers perceived targets in which motion was parallel to the major axis as moving faster than did targets in which motion was parallel to the minor axis (Brown, 1931; Oppenheimer, 1935). Faster velocities lead to greater forward displacement (Freyd & Finke, 1985; Hubbard & Bharucha, 1988), and so if targets in which motion was parallel to the major axis were perceived as traveling at a faster velocity, then those targets would have exhibited greater forward displacement.

The magnitude of forward displacement exhibited by a moving target can be influenced by the orientation of that target relative to the direction of motion, and such influences can occur without the target's perceived pointing and without knowledge of a prototypical orientation of the target relative to the direction of motion. However, the influence of target orientation in such a case might occur only when changes in target orientation are not contour invariant relative to the path of motion. The present data were consistent with the hypothesis that a constant representational momentum (which is not influenced by target orientation) combined with a variable representational friction (which is influenced by target orientation) to produce forward displacement (and the differences in forward displacement). Alternatively, the level of representational momentum may have been variable if targets at different orientations were perceived as exhibiting different velocities, and the changes in perceived velocity produced the differences in displacement. Elaboration of the mechanism of the orientation effect, and how orientation interacts with pointing, awaits future study.

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[2]Previous evidence for representational friction has been found with targets that interacted with other stimuli, but evidence for representational friction has not been found for targets moving through a medium. It may be that differences between these diffferent sources of friction, play a role in whether representational friction influences displacement, but resolution of this issue awaits further study.

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