Misrepresentation of motion direction causes prediction errors in multiple object tracking

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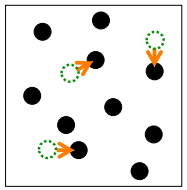
Introduction

When people keep track of multiple moving objects, what information do they use?

Position Hypothesis: People only use their memory of the last known locations of the targets (dashed dots) to determine which objects in the current display (black dots) are the targets.

Motion Hypothesis: In addition to memory for position, the motion of the object (arrows) is used during tracking to help disambiguate targets from distractors.



In previous work, we added moving texture to the moving objects to determine whether conflicting motion information would impair tracking (St.Clair, Huff & Seiffert, 2010). Tracking performance was worse when the texture moved in the opposite direction of the object, or orthogonal to the object, than it when it moved in the same direction as the object.

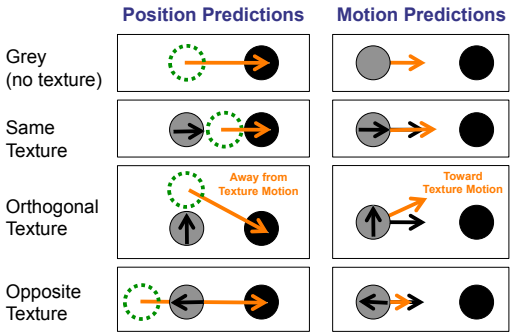
While this suggests that motion is used during tracking, it is also possible that the texture motion affected position perception. Objects are mislocalized in the direction of texture motion (Ramachandran & Anstis, 1990). Conflicting texture motion may have impaired tracking by shifting perception of the last known location of the target in the direction of the texture motion.

Direction Estimation in Tracking

People are able to accurately report the direction of a target (Horowitz & Cohen, 2010; Shooner, Tripathy, Bedell & Öğmen, 2010). We examined whether moving textures affect direction reports of targets.

Position Hypothesis: Conflicting texture motion may shift the perceived location of the target (dashed dot) relative to its actual location (grey dot) in the direction of the texture motion during the tracking period. When the last known location of the target is compared to its final stationary position (black dot), the direction of the target (orange arrow) is determined.

Motion Hypothesis: Texture motion may be combined with the target motion to produce a combined motion (orange arrow) during the tracking period. Memory for this combined motion is used to report the target's direction when it is stationary at the end of the trial (black dot).

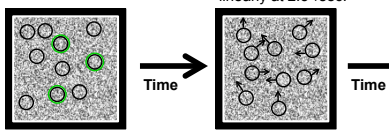


Methods

Multiple Object Tracking Task

Cue Period (2 sec): 3 dots were cued as targets.

Tracking Period (4 sec): Ten 1° dots moved linearly at 2.5°/sec.

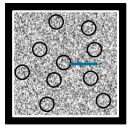


Black outlines were removed during motion.

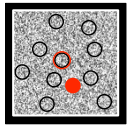
Texture Conditions

Condition name:	Grey	Same	Orthogonal	Opposite
Texture direction:		→	↑	←
Object direction:	→	→	→	→

Object speed was always 2.5°/sec. Texture speed was always 5 °/sec.



Response: Dots and textures were stationary.



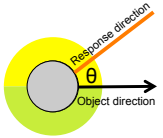
Exp. 1a: Observers indicated the direction of motion by rotating a 2.6° blue line around the probed object. One target was probed.

Exp. 1b: Observers rotated a red dot that was 2.6° away from the target to match the future location of the target.

Exp. 2: Observers performed two tasks on every trial. The direction task was the same as Exp. 1a except distractors were also probed. In the probe task, observers indicated whether the probed dot was a target or distractor.

Response Measures

Direction Task



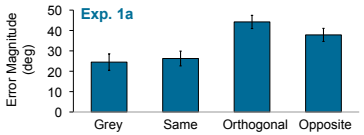
Response errors (θ) were measured as the acute angle between the response direction and the direction of the object. Counter-clockwise angles were positive (yellow) and clockwise angles were negative (green). Error magnitude was the absolute value of response errors.

Probe Task

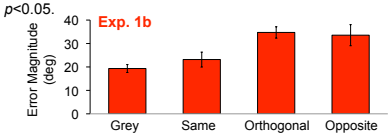
Tracking accuracy was measured as the proportion of trials that the probed dot was correctly identified. This task was employed in Experiment 2 only.

Experiment 1

Were direction errors higher for objects with conflicting texture motion?



Compared to grey dots, opposite textures had larger errors, $t(12) = -4.88$, $p<0.05$ as did orthogonal textures, $t(12) = -5.62$, $p<0.05$.

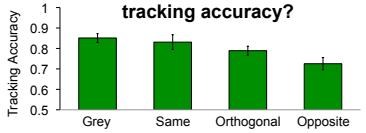


Compared to grey dots, opposite textures had larger errors, $t(10) = -4.12$, $p<0.05$ as did orthogonal textures, $t(10) = -5.65$, $p<0.05$.

YES, conflicting texture motion increased direction error. However, these results include responses to targets that may have been lost during tracking.

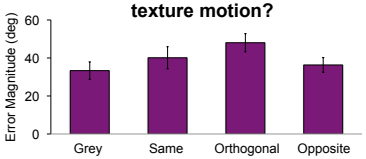
Experiment 2

Did texture motion affect tracking accuracy?



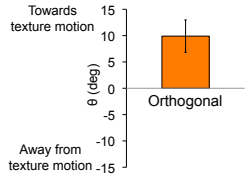
Yes, texture direction affected tracking accuracy, $F(3, 45) = 11.75$, $p<.05$, similar to our previous work.

Were direction errors higher for tracked targets with conflicting texture motion?



Yes, but only orthogonal textures had larger errors than grey dots, $t(15) = -3.25$, $p<0.05$.

Are direction errors biased in one direction for orthogonal textures?



Yes, direction errors were biased TOWARD the direction of the orthogonal texture motion for correctly tracked targets, $t(15) = 3.23$, $p<0.05$. No other conditions had response errors significantly different from zero.

The direction of the response errors are consistent with the motion hypothesis but not the position hypothesis.

Conclusions

Consistent with the proposed motion hypothesis, these results suggest that texture motion is combined with object motion during tracking. This combined motion is used to make predictions about future target locations. Errors in tracking occur because the predicted locations are incorrect.

References

Horowitz, T. & Cohen, M.A. (2010). *Attention, Perception, & Psychophysics*, 72(7), 1765-1775.

Ramachandran, V., & Anstis, S (1990). *Perception*, 19(5), 611-616.

Shooner, C., Tripathy, S.P., Bedell, H.E., & Öğmen, H. (2010). *JOV*, 10(6):8, 1-20.

St.Clair, R., Huff, M., & Seiffert, A.E. (2010). *JOV*, 10(4):18, 1-13.

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