Shape influences target recovery after a blank in multiple object tracking

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Introduction

People can keep track of multiple targets moving among identical distractors.

Previous work has found a small benefit of unique surface features to this ability, likely because targets were less confusable with distractors (Horowitz et al., 2007; Makovski & Jiang, 2009).

Surface features, then, may be help with recovery of the targets after they are lost.

We investigated how a surface feature would affect target recovery, when the feature was not unique, but consistent with the object's direction of motion.

When most objects move, such as a car, person or animal, they change their orientation to match their direction of motion.

Question

Is orientation used in target recovery?

General Methods

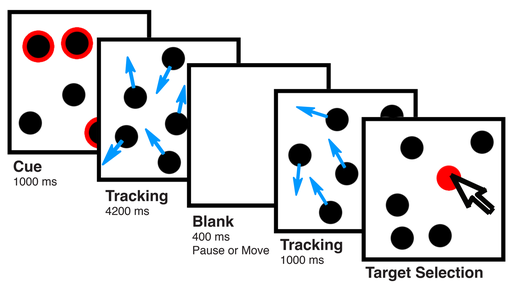
Multiple Object Tracking

A subset of identical objects are cued as targets to track. The objects move, and at the end of the trial observers try to select the targets. Accuracy is calculated as proportion of correct selections.

Target Recovery

In this modification of multiple object tracking all objects briefly disappear. Tracking resumes when objects reappear.

Objects can either **Pause** (do not move) or **Move** along their trajectories during the blank.



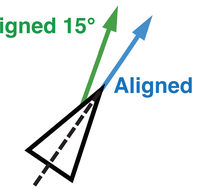
Tracking accuracy declines more when objects **Move** than when they **Pause** (Keane & Pylyshyn, 2006).

Experiment 1

Does orientation affect target recovery?

Triangle Alignment

When an object is misaligned from its trajectory, people misjudge its direction of motion (Morikawa, 1999). We varied the alignments of the triangles' orientations with their trajectories.



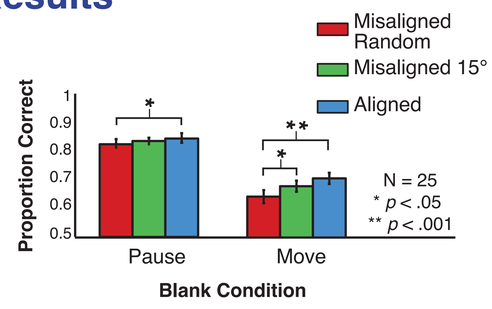
Method

Observers tracked 3 of 10 identical triangles with a base of 0.6° (visual angle) and height of 1.3°, within a 21x21° box. Triangles moved independently of each other at 10 °/sec and could occlude each other.

Aligned | Misaligned 15° | Misaligned Random

All triangles in a trial had the same alignments. **Random** misalignments ranged from 22 to 135°.

Results



Target recovery was more difficult when targets moved than when they paused, $F(1,24) = 185.3$, $p < .0001$.

We found a main effect of alignment, $F(2,48) = 8.5$, $p < .005$, and an interaction between alignment and Blank condition, $F(2,48) = 3.4$, $p < .05$.

The more aligned a triangle is with its trajectory, the better observers are at recovering it.

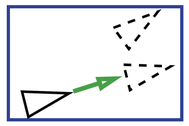
Orientation can help target recovery.

Experiment 2

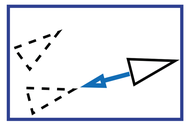
When is orientation used?

People could use orientation information **before** or **after** the blank.

Prediction: The visual system uses the orientation of a target before the blank to predict location after the blank.

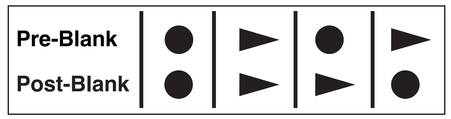


Postdiction: The visual system uses the orientations after the blank to extrapolate backwards in time to match the object locations stored in memory.



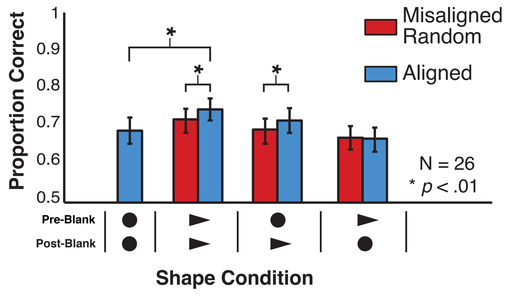
Method

All objects were triangles or dots. If the shapes were triangles, they were **Aligned** or **Misaligned Random**.



During the blank all objects always **moved**. Speed was on average 7 °/sec.

Results



Target recovery is better when the Post-Blank shape is an **Aligned**, rather than **Misaligned**, triangle, $t(25) = 3.134$, $p < .005$. Performance was not significantly improved by alignment when only the Pre-Blank shape was a triangle.

This evidence supports the **Postdiction** hypothesis.

People can use orientation after the blank to help target recovery.

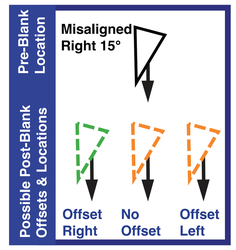
Experiment 3

Does the effect of orientation depend on reliable motion information?

In our prior experiments, motion provided a reliable cue to future locations of all objects. Here we manipulated the integrity of motion information by adding an offset.

Method

We manipulated post-blank **Offset** (No Offset, Left, Right) and **Alignment** (Aligned, Left 15°, Right 15°).

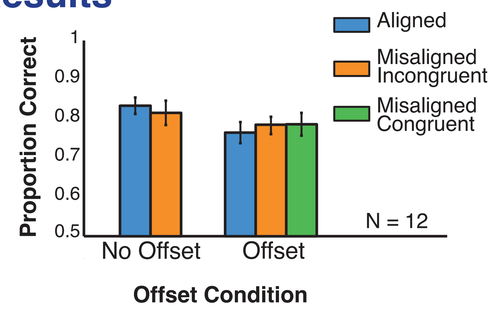


We vary the congruency between Offset and Alignment. A triangle aligned Right 15° (see figure) is **Congruent** with a Right offset and **Incongruent** with Left Offset and No Offset.

We test whether Congruent conditions help target recovery.

During the blank all objects always moved. Observers tracked 4 of 10 triangles moving 7 °/sec.

Results



Target recovery is affected by the interaction between Congruency and Alignment, $F(1,11) = 15.3$, $p < .005$. But recovery of Offset targets was not improved when they were misaligned towards the offset direction.

It is unclear how motion and orientation information interact in target recovery.

Conclusions

We have demonstrated that, in addition to spatiotemporal proximity, the visual system can use orientation during target recovery. Target features matter.

Horowitz TS, Klieger SB, Fencsik DE, Yang KK, Alvarez GA, Wolfe JM (2007). *Perception & Psychophysics, 69*(2), 172-84.
Keane B & Pylyshyn Z (2006). *Cognitive Psychology, 52*, 346-368.
Makovski T & Jiang YV (2009). *Visual Cognition, 17*, 180-194.
Morikawa K (1999). *Perception & Psychophysics, 61*(1), 134-143.

This work was supported by P30-EY008126