Visually guided self-motion does not impair multiple object tracking

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Previous Work

People often track objects while they are moving through the environment (e.g. driving in traffic, playing sports). This research is designed to investigate the relationship between object tracking and self-motion.

Our ability to track multiple objects declines if we simultaneously move through the environment (Thomas & Seiffert, 2010).

As we move, we must update a representation of our own changing position, a process known as spatial updating. Spatial updating and object tracking rely on the same spatial processes.

What visual information reduces the cost of self-motion during tracking?

Visual Guidance of Self Motion

People cannot help but keep track of their own position as they move.

- Spatial updating occurs whenever there are cues to self-motion, whether updating is task-relevant or not (Farrell & Robertson, 1998; Farrell & Thomson, 1998).
- Visual information alone can elicit spatial updating (Riecke, & Bulthoff, 2004; Riecke, von der Heyde, & Bulthoff, 2009).

Navigation can be assisted with visual guides.

- People can effectively navigate a novel environment after studying a visual map (Thorndyke & Hayes-Roth, 1982; Pick et al., 1995)
- People rely on visual landmarks to move through known environments even along new paths (Waller et al., 2000; Foo, Warren, Douchon & Tarr, 2005).

Hypotheses

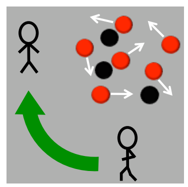
1. **Removal of visual information will lessen the cost of spatial updating**
   In an environment with no stable visual cues, people may not keep track of their own changing position, leaving more spatial resources available for object tracking.
2. **A moving guide will lessen the cost of spatial updating**
   A visual guide that moves with people will help them keep track of their own changing position, leaving more spatial resources available for object tracking.

Method

In a virtual environment, participants attempted to track 3 of 6 red balls moving linearly on the ground and bouncing off an invisible square enclosure. Tracking accuracy was measured with a target/distractor probe.

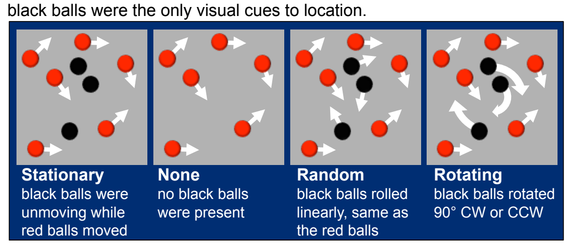
Self-Motion Conditions

In a gray ganzfeld, participants stepped in place (**stay**) or walked 90° CW or CCW around the tracking area (**move**).



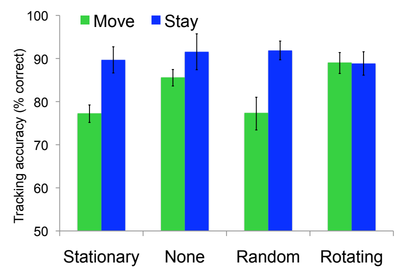
Context Conditions

Three **black balls** varied the context of the tracking task. The red and black balls were the only visual cues to location.



Experiment 1

Which visual cues affect the self-motion cost?



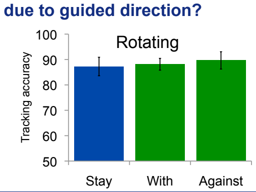
Self-motion impaired tracking, $F(1,11) = 25.0$, $p < .001$, replicating our previous work.
Context interacted with self-motion, $F(3,33) = 4.0$, $p < .02$
Self-motion impaired tracking performance only when the context balls were stationary or moved randomly (ts(11) > 3.7 and ps < .005).

Removing visual information did not decrease the cost of spatial updating.

A rotating guide decreased the cost of spatial updating.

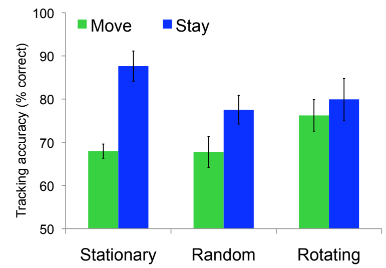
Was the improvement due to guided direction?

People moved in the same (with) or opposite (against) direction of the rotating balls. Direction congruency did not influence tracking accuracy, *F* < 1, *ns.*



Experiment 2

Can we replicate these results?



Self-motion impaired tracking, $F(1,12) = 35.6$, $p < 0.001$
Context interacted with self-motion, $F(2,24) = 6.1$, $p < .01$
Self-motion impaired tracking performance again only when the context balls were stationary or moved randomly (ts(12) > 3.7, ps < .005).

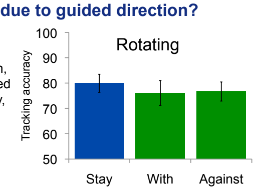
Results of Experiment 1 were replicated. Variations in visual crowding did not drive the results of Experiment 1.

Rotating context balls mitigated the cost of self-motion on object tracking.

Was the improvement due to guided direction?

An analysis of Rotating condition, when participants moved, showed no effect of direction congruency, *F* < 1, *ns.*

Replicated experiment 1.



Visual motion guides can reduce the cost of spatial updating.

Conclusions

People are impaired at tracking when they simultaneously move through the environment

- Object tracking and spatial updating rely on the same spatial process

A rotating, task-irrelevant guide within the tracking region can reduce the interference between object tracking and self-motion.

- Spatial processing may be used less by self-motion when visual motion shows how to move

It is unclear why both congruent and incongruent guides reduced the cost of spatial updating on object tracking.

Visual motion guides can support spatial updating during tracking.

Future Directions

Why does rotating visual information support tracking while moving? Because it was similar to self-motion, slow motion, predictable motion or rotating motion?

Does programming self-motion impair tracking only because of the cost to spatial updating, or do other movements similarly impair tracking accuracy?

- body rotation
- limb movements

Are there ways to move that facilitate tracking rather than impairing it? Body movements that are relevant to the tracking task may not produce a cost.

References

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This work was supported by NIH P30-EY008126