

# Self-motion influences multiple-object tracking in a virtual environment

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**Question: Is our ability to track moving objects affected by our own movements?**

## Introduction

Laboratory investigations of multiple-object tracking (MOT) have yet to manipulate observer motion.

- MOT in real-world situations often involves motion of the observer (e.g., playing team sports).

Previous research shows people use a scene-based frame of reference during MOT (Liu et al., 2005).

- But abrupt changes in observer viewpoint impair tracking performance (Huff et al., 2009).

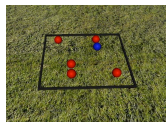
How could self-motion impair MOT?

- Changes in viewpoint associated with observer motion could impair MOT.
- The programming and execution of movements could also interfere with attentional systems tapped by MOT.

## Method

Participants tracked target balls while moving inside a virtual environment.

- A head-mounted display (nVisor SX) showed stereoscopic images.
- A three-axis orientation sensor (InertiaCube2) tracked head orientation while an optical tracking system (PPTX4) tracked head position.

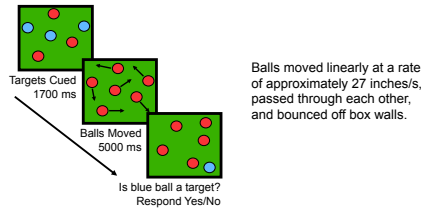


In the virtual environment, six 4.7 inch balls moved in linear paths within a 3 ft x 3 ft box.

## References

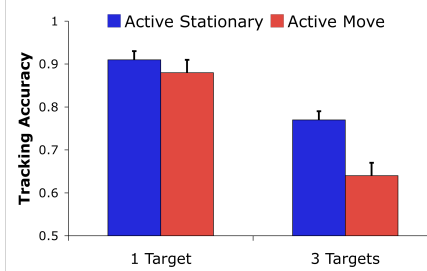
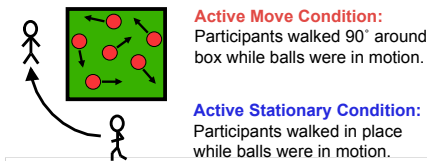
Huff, M., Jahn, G., & Schwan, S. (2009). Tracking multiple objects across abrupt viewpoint changes. *Visual Cognition*, 17, 297-306.  
Liu, G., Austen, E. L., Booth, K. S., Fisher, B. D., Argue, R., Rempel, M., I., & Enns, J. T. (2005). Multiple-object tracking is based on scene, not retinal coordinates. *Journal of Experimental Psychology: Human Perception & Performance*, 31, 235-247.

## General MOT Procedure



## Experiment 1: Does self-motion impair MOT?

Participants tracked 1 or 3 target balls in the virtual environment under two conditions:



- Participants are worse at tracking 3 targets than 1 ( $F(1,12)=120, p<0.001$ ).
- Participants are worse at tracking 3 targets when moving than when stationary ( $F(1,12)=8.3, p<0.05$ ).

Either MOT is not entirely scene-based, or movement programming and execution disrupt the same processes that underlie MOT.

**Self-motion impairs MOT.**

## Experiment 2: Does passive observer motion also impair MOT?

Participants tracked 1 or 3 target balls in the virtual environment under four conditions:



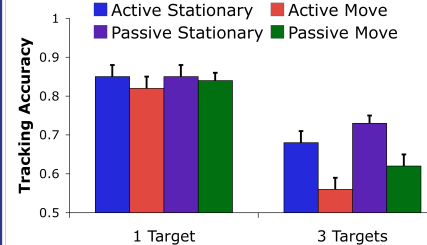
**Active Move Condition:** Participants walked 90° around box while balls were in motion.

**Active Stationary Condition:** Participants walked in place while balls were in motion.



**Passive Move Condition:** Participants wheeled 90° around box while balls were in motion.

**Passive Stationary Condition:** Participants sat still while balls were in motion.



- Participants are worse at tracking 3 targets when moving than when stationary ( $F(1,15)=22, p<0.001$ ), regardless of whether movement is active or passive ( $F<1$ ).

Movement programming and execution are not the source of impairment that self-motion causes in MOT.

**Passive and active observer motion both impair MOT.**

## Experiment 3: Which components of observer motion impair MOT?

Participants tracked 1 or 3 target balls in the virtual environment under four conditions:

**Active Move Condition**

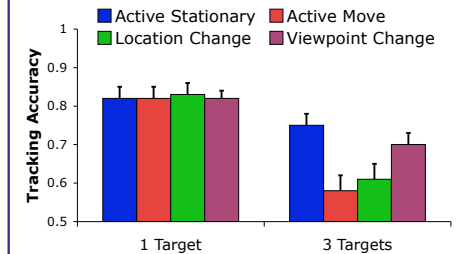
**Active Stationary Condition**

**Location Change Condition:**

Participants walked 90° around box while balls were in motion, but viewpoint remained stationary.

**Viewpoint Change Condition:**

Participants walked in place while balls were in motion, but viewpoint moved 90° around box.



- Participants are worse at tracking 3 targets when moving than when stationary ( $F(1,11)=5.1, p<0.01$ ).

•When tracking 3 targets, participants are worse in the **Location Change** condition than in the **Active Stationary** condition ( $t(11)=5.2, p<0.001$ ) and better in the **Viewpoint Change** condition than in the **Active Move** condition ( $t(11)=3.4, p<0.01$ ).

**Observer location changes are sufficient to impair MOT.**

## Conclusions

Observer motion (active or passive, with or without visual motion feedback) impairs the ability to track multiple moving objects.

Viewpoint changes are not the source of impairment that self-motion causes in MOT.

Vestibular movement signals may interfere with MOT.