How many objects are you worth?

Quantification of self-motion load on multiple object tracking

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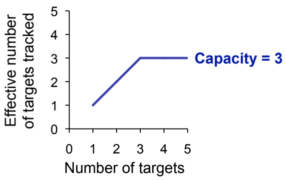
Purpose

To quantify the cost of self-motion on object tracking in terms of number of objects.

Introduction

People have a limited capacity to keep track of multiple moving objects (Pylyshyn & Storm, 1988; Alvarez & Franconeri, 2007; Drew & Vogel, 2008).

In a given set of conditions, tracking performance reaches an asymptote as the number of targets increases.



Tracking capacity varies across observers with a number of factors, such as working memory capacity (Oksama & Hyönä, 2004) and experience (Allen et al., 2004; Green & Bavelier, 2006; Barker, Allen & McGeorge, 2010).

Self-Motion

In many situations, people are moving while they attempt to track moving objects (e.g., driving in traffic, playing team sports).

However, keeping track of one's own location is obligatory and demanding (Farrell & Roberston, 1998; Wang et al., 2006).

This investigation is designed to determine how the ability to track objects and the ability to update one's own location in space relate to one another.

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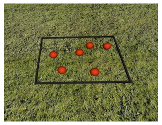
Previous Research

In a previous series of experiments, we have demonstrated that self-motion impaired performance at simultaneous multiple object tracking (Thomas & Seiffert, 2010).

Method

Participants tracked 3 target balls moving among 3 distractors while inside a virtual environment.

Six red balls moved linearly on the ground plane, bouncing off the boundaries of a black square box. At the same time, participants engaged in self-motion.

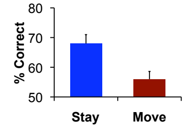


Results

We tested several self-motion conditions:

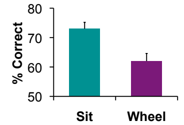
Stay Condition: Participants walked in place.

Move Condition: Participants walked 90˚ around the box.



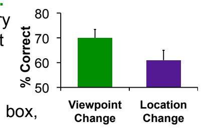
Sit Condition: Participants sat in a still wheelchair.

Wheel Condition: Participants were wheeled by experimenter 90˚ around the box.



Viewpoint Change Condition: Participants remained stationary (walked in place), but viewpoint moved 90˚ around the box.

Location Change Condition: Participants walked 90˚ around box, but viewpoint remained stationary.



Conclusion

Self-motion impaired object tracking, regardless of whether or not participants were responsible for their own movement, and regardless of participants' viewpoint.

Keeping track of your own location as you move seems to tap the same resources as keeping track of moving objects.

Current Experiment

We varied the number of targets to measure tracking capacity with and without self-motion.

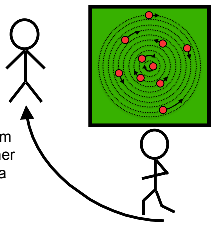
Method

As in our previous work, participants walked inside a virtual environment.

- A head-mounted display (nVisor SX) showed stereoscopic images while orientation and position sensors (InertiaCube2; PPTX4) tracked movements of the head.
- Participants held one end of a stick that was used to guide them in the self-motion task.

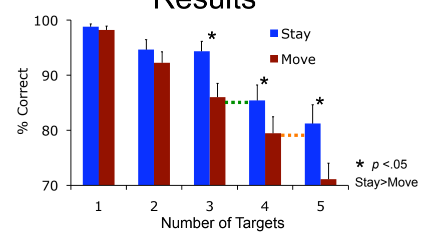
Visual Display:
Rendered in 3D were 10 red balls (.075 ft radius) rotating along concentric circular paths (0.2–1.3 ft rad) within a square black box.

Self-motion Task:
Participants remained 4 ft from the center of the box and either walked in place or walked in a 90° arc around the box.



Object Tracking task:
At the beginning of the trial, a subset of balls (1 – 5) turned blue to designate them as targets. During motion, all balls were red. After the balls stopped moving, participants indicated whether one probed ball was a target or distractor.

Results



Green dotted line: Performance at tracking 3 targets while moving was about the same as tracking 4 objects while stationary.

Orange dotted line: Performance at tracking 4 targets while moving was about the same as tracking 5 objects while stationary.

Self-motion impaired object tracking when there were 3 or more targets.

The cost of self-motion was about the same as adding one more target object.

Capacity Estimation

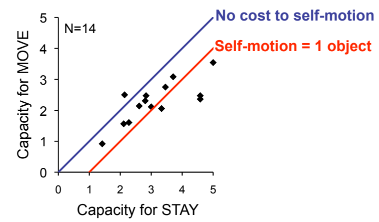
For each participant, we estimated tracking capacity as the effective number of balls tracked without correction for guessing[2].

First, we transposed hits (H) and correct rejections (CR) into effective number of balls tracked (C) out of the number of targets in that condition (N) using the formula:

$$C = (H+CR-1)*N$$

Second, we estimated capacity by finding the best fit elbow curve for each participants' data both with and without self-motion. The function assumed that when the number of targets was less than capacity, performance would be perfect and when the number of targets was greater than capacity, performance would be capped at capacity.

Lastly, we compared the capacity value for STAY and MOVE conditions for each participant. Note that capacity estimates are poor when close to the maximum number of targets that were tested.



For most participants, there was a cost of self-motion that was a little less than 1 object.

Conclusions

Self-motion impairs object tracking, most likely because of a common demand on spatial updating resources. Updating self position may be easier than updating objects.

How many objects are you worth? A little less than one.

Footnotes

1. This work was supported by NIH P30-EY008126 and a Vanderbilt Discovery Grant.

2. Our next experiment will employ a better method to assess capacity by using both a probe task and a target selection task, and the appropriate correction for guessing (Hulleman, 2005, *Vision Research*, *45,* 2298-2309).