



## 1. Abstract

In a previous study (Dennis & Pylyshyn, 2002), we found no differences in tracking performance during Multiple Object Tracking (MOT) trials when the objects changed colors "synchronously" (smoothly and in unison) and trials when the objects changed colors "asynchronously" (smoothly, so that no two objects were the same color at a given time). In the present study, we manipulated change in object size to test whether a more "spatial" property would produce different results. Because objects that change size are perceived as looming and retreating, theories that claim that spatial properties are monitored in MOT suggest that size changes may be more effective properties for discriminating between targets and nontargets and will improve tracking.

## 2. Background

The visual system can individuate and track up to about five objects effortlessly. One theory that attempts to describe this process is Visual Indexing theory (FINST), which proposes that object tracking occurs in parallel and independent of the encoding of object properties (Bahrami, 2003; Keane & Pylyshyn, 2006; Scholl, Pylyshyn, & Franconeri, 1999). As shown in previous Multiple Object Tracking (MOT) experiments, successful tracking does not utilize object properties such as color or shape (Keane & Pylyshyn, 2006; Scholl et al., 1999), but may use spatiotemporal cues (Franconeri, Pylyshyn, & Scholl, under review; Keane & Pylyshyn, 2006).

In this study, we dynamically varied the size of objects during tracking trials to see if the spatial properties of objects could be used to assist in individuating and tracking objects.

Specifically, we were interested in whether or not spatial features of an object increased tracking performance by indirectly helping discriminate between targets and nontargets.

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## 3. Method

We used a standard MOT paradigm (as described in Pylyshyn, 2004; Pylyshyn, 2006; Pylyshyn & Annan, 2006) and shown in Figure 1. Subjects were asked to track four independently-moving target circles among four identical distractors during five- and ten-second trials with the following object size change conditions:

- (A) all objects changed size smoothly and synchronously so that all objects remained the same size ("**synchronous**" condition);
- (B) all objects changed size asynchronously so that no two objects were ever the same size ("**asynchronous**" condition);
- (C) after one second of motion, targets expanded smoothly to 138% of nontarget size and then all objects returned to the same size one second before the end of the trial ("**segregated expanding**" condition); and
- (D) as in (C) except targets shrank smoothly to 62% of nontarget size ("**segregated shrinking**" condition).

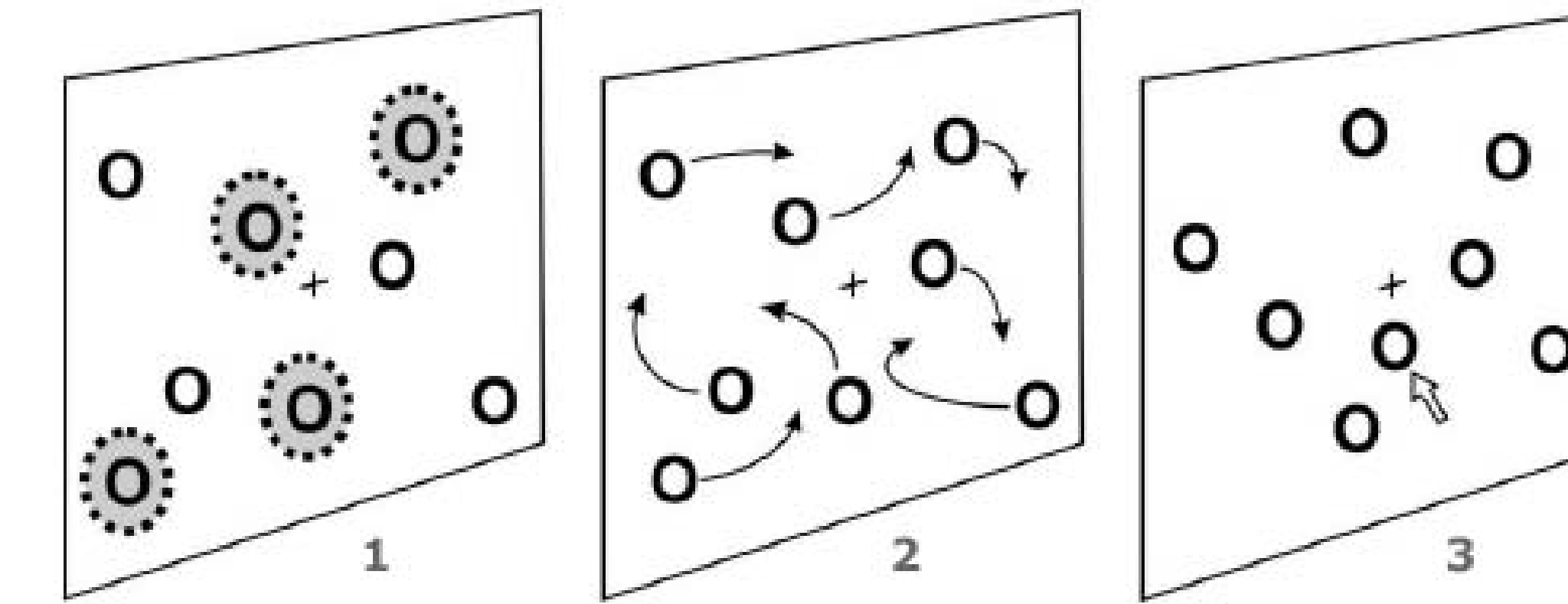
In conditions (C) and (D), targets and nontargets could easily be distinguished during the midpart of the trial by their different size but not at the beginning or end when they were the same size. Since conditions (C) and (D) each constituted only 16.5% of the trials and presented at random, we reasoned that subjects might not notice the correlation of object size with targethood.

- Thirty-one Rutgers University psychology undergraduates participated in this experiment and received research credits.
- Each subject received 240 randomized trials consisting of the following conditions:

Condition:	Number of Trials	
	5-sec trials	10-sec trials
(A) <b>synchronous</b>	40	40
(B) <b>asynchronous</b>	40	40
(C) <b>segregated expanding</b>	20	20
(D) <b>segregated shrinking</b>	20	20

- Each trial began with eight identical randomly-placed circles on a black computer screen.
- Four of the circles flashed for two seconds to identify them as the targets to be tracked.
- All circles began to move randomly on the screen and after one second they changed size according to condition.
- At the end of a trial, subjects selected the targets with a computer mouse. Tracking performance was then displayed on the screen.

## 3. Methods (Continued)



**Figure 1. Set-up of this MOT experiment.** Panel 1 shows the initial display of eight objects and a center fixation cross, with the flashing of the targets that are to be tracked. Panel 2 shows the objects moving randomly on the screen, which change size according to experimental condition. The subjects then select the targets in Panel 3.

## 4. Results

A within-subjects ANOVA revealed that the effect of Condition (4), Trial Duration (2), as well as the interaction between these two factors were all significant with  $p < .001$ . [ $F(3,90) = 100$ ;  $F(1,30) = 55$ ; and  $F(3,90) = 17$ , respectively]. The two segregated conditions (where targets were larger or smaller than nontargets) did not differ from one another.

If we replaced them with the mean of the two segregated conditions, the resulting ANOVA was unchanged from that given above, with Condition  $F(2,60) = 123$ ,  $p < .001$ ; Duration  $F(1,30) = 98$ ,  $p < .001$  and Condition x Duration  $F(2,60) = 20$ ,  $p < .001$ . This is what is shown in the figure below. (Error bars were computed using the within-subjects methods suggested by Loftus & Masson, 1994.)

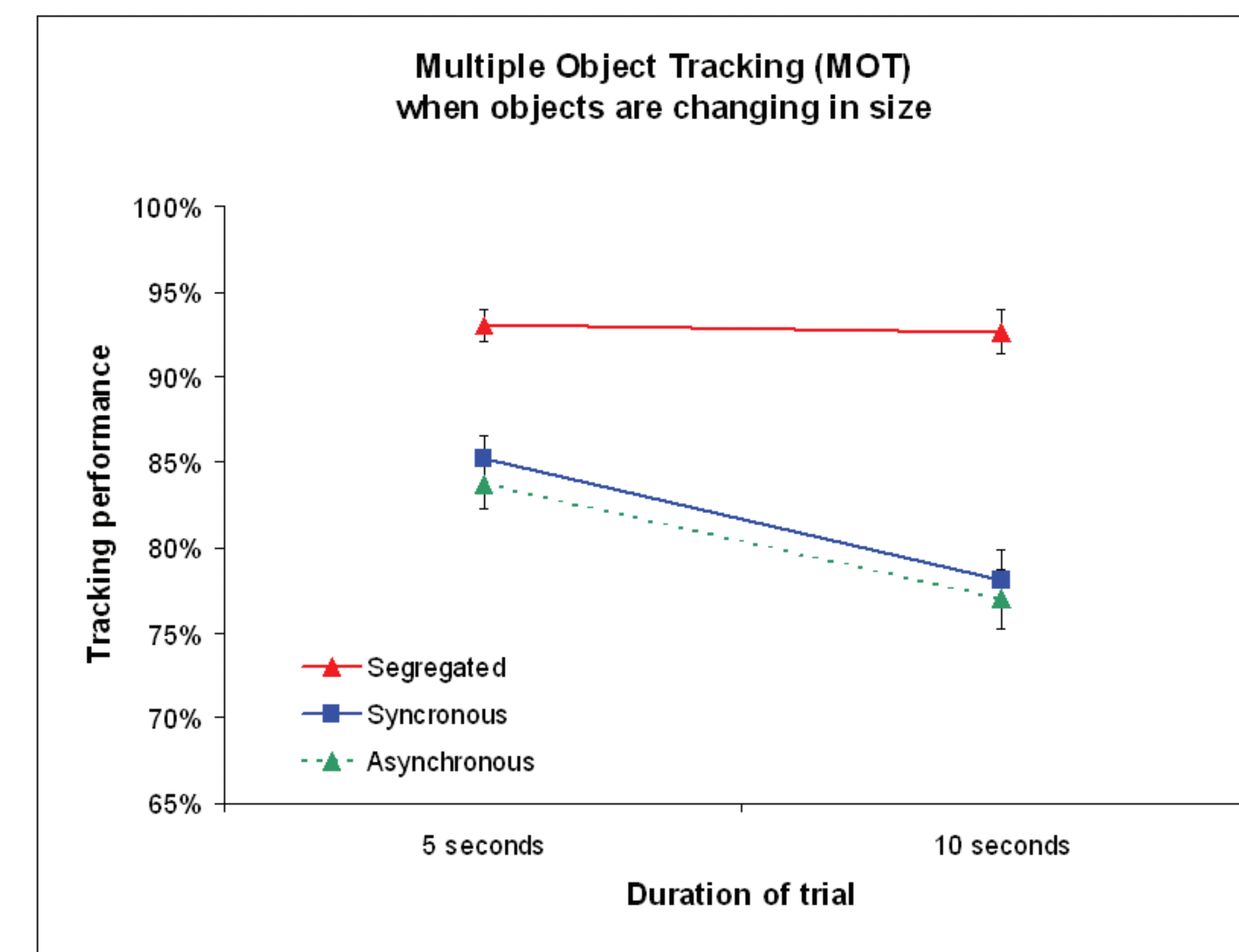


Figure 2. Shows tracking performance in all four conditions (segregated conditions are combined).

## 5. Discussion

As with our earlier color-change study, tracking performance in both synchronous and asynchronous conditions was the same for the five-second trials (84% correct) and for the ten-second trials (77% correct), with no interaction. In our previous study with color-change we also found these to be the same as the color remained fixed, though we did not include a fixed-size condition in the present study.

Somewhat surprisingly, we found that segregating targets and nontargets by size yielded consistently better tracking (93% correct), which was the same for both five- and ten-second trial durations. Klieger et al. in VSS 2004 found that color segregation led to dramatic differences in tracking performance whereas our differences are relatively small and show that performance in the segregated condition did not decrease with longer trials.

The fact that performance in the segregated condition did not diminish with the longer trials (as it always does in MOT studies) suggests that subjects may have been using the size information (perhaps unconsciously) since that information remained present for almost all of the trial and affected both duration conditions equally. Even though we showed previously that subjects do not routinely notice differences between objects and even though subjects did not report noticing that on some trials targets and nontargets were different sizes during the middle part of a trial in this experiment, they appeared to use this tell-tale difference to enhance tracking.

## 6. Conclusion

These results suggests that a distinctive target/nontarget size difference may be used in tracking objects even when this size difference occurs surreptitiously among randomly-changing sizes.

## 7. References

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