Segregating targets and nontargets in depth eliminates inhibition of nontargets in Multiple Object Tracking

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Abstract

In a typical Multiple Object Tracking (MOT) display of identical objects, inhibition occurs on task-irrelevant objects (nontargets). Using a probe-dot detection task during MOT, we tested inhibition of nontargets that are preattentively separable from target objects by being at different stereovision depth (Nakayama, 2002). The probe detection results from this current experiment support our hypothesis: nontargets on a depth plane different from targets are preattentively removed from the MOT task and are not inhibited. Superior probe detection was observed on front-plane targets and back-plane nontargets; probe detection on front-plane nontargets was significantly lower.

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Multiple Object Tracking (MOT) is a useful paradigm for studying properties of visual attention. In a typical MOT task, eight or more identical objects are presented on a computer screen. Several of these objects are distinguished as targets by flashing briefly at the beginning of a trial. These objects then move in a random and unpredictable manner, and the observer is asked to identify the targets at the conclusion of this movement (as described in (Pylyshyn, 2001; Pylyshyn & Storm, 1988)). Observers can easily track four or five objects among identical distractors in a varying range of conditions. Such results have been interpreted as the function of visual indexes (also called FINSTs), which are the preattentive individuation mechanisms proposed by Visual Indexing Theory (Pylyshyn, 2001).

In a recent MOT study, we showed that target-target pairs tend to be confused more often than target-nontarget pairs. We argued that this may be due to the inhibition of nontargets. This interpretation was supported by a study that used probe dots (as developed by (Watson & Humphreys, 1997)) and showed that nontargets were indeed inhibited (Pylyshyn, 2006). Inhibition of irrelevant objects is a general phenomenon and several varieties of attentional inhibition in vision have been reported (Theeuwes & Godljn, 2002; Tipper, 2001), including the Inhibition of Return (IOR). Such inhibition appears to be object-centered, with IOR having a significant object-centered component (Tipper et al., 1991). Yet, there is much that we do not know about visual inhibition. For example, there has been some discussion in the literature about whether inhibition is applied strategically in a top-down fashion when required by the task at hand (Watson & Humphreys, 1997) or whether objects are automatically marked for inhibition in a bottom-up manner (Theeuwes et al., 2001).

The inhibition of nontargets raises special problems for Visual Indexing Theory. In our studies, the nontargets themselves appear to be inhibited rather than everything in the display that is not a target, such as the empty space between the objects. Previous experiments demonstrated the object-based nature of nontarget inhibition by comparing probe detection performance when the probe appeared on targets, nontargets, and locations in the empty space between and near objects, and found that only the nontargets were inhibited (Pylyshyn, 2006). If inhibition can occur on multiple moving nontargets and not on the space through which they move, the question arises: by what mechanism can the inhibition be associated with the moving nontargets? The only mechanisms we have proposed for tracking objects are visual indexes, which hypothetically are already being fully used to track targets. This challenge was also noted in the context of visual search among moving items where nontargets showed inhibition (Ogawa et al., 2002).

In a recent study, we used probe detection during MOT to show that moving nontargets are inhibited while identical but stationary nontargets are not inhibited (Pylyshyn, 2006). We also measured inhibition on moving nontargets that were identical in appearance to the targets (nontarget circles) compared with those that were different from the targets (nontarget squares). We found that moving square nontargets and moving circle nontargets were inhibited equally (Pylyshyn, 2006). These data showed that static nontargets (which are easily distinguished from moving targets) are not inhibited as predicted by the top-down hypothesis, but moving nontargets that clearly differ in shape from targets (e.g., squares instead of circles) are still inhibited. This result indicates either that all unattended moving objects were inhibited or that the difference between square and circular nontargets was not sufficient to enable the segmentation of the differentshaped nontargets from potentially interfering with the tracking task. Perhaps if the featural difference was one that could be detected preattentively, nontargets could be segregated from targets and it would be unnecessary to inhibit them in order to keep them distinct from targets in the MOT task.

The present experiment further explores the inhibition process by examining the conditions under which observers are able to keep targets distinct from nontargets during a 3D-MOT task on a stereoscopic computer display. This display was designed to create the appearance of objects moving on two separate depth planes. Since there is evidence that depth can be used effectively to separate objects in a preattentive manner (Nakayama & Silverman, 1986), our experiment addresses whether identical moving nontargets on a different depth plane are sufficiently different or separable from targets so that inhibition of these nontargets is unnecessary. The pursuit of this question may elucidate the role of inhibition in keeping targets distinct from nontargets during MOT and whether inhibition applies only when nontargets are not preattentively separable from targets.

Subjects in this experiment were tested for the ability to perceive the two different depth planes through stereoscopic glasses (only these data were analyzed, n=15). The 80 trials consisted of 12 identical circles, eight appearing on the front plane and four appearing on the back plane. Four objects were identified as targets at the start of the trial by flashing briefly. These targets always appeared on the front plane so that there would be four targets and four nontargets on the front plane and four nontargets on the back plane. The subjects were asked to track the targets and look for a probe dot that might appear anywhere on the screen, including on target and nontarget items. We found that probe detection on front nontargets (52% correct) was significantly lower than probe detection on front targets (62%), back nontargets (60%), and empty space (70%). No other significant differences were found between these conditions. (See Figure 1.)

The results from this experiment indicate that nontargets on the same plane as targets are inhibited, while nontargets on a different depth plane are not inhibited. This suggests that nontargets appearing on a different depth plane from targets are preattentively separable and thus do not require inhibition, while nontargets on the same plane as targets do require inhibition. This study supports the hypothesis that inhibition functions in a bottom-up manner and is manifest only when nontargets could be confused with targets.

Summary word count: 998 (1000 max)

References

Nakayama, & Silverman. (1986). Serial and parallel processing of visual feature conjunctions. *Nature, 320*(6059), 264-265.

Ogawa, Takeda, & Yagi. (2002). Inhibitory tagging on randomly moving objects. *Psychological Science, 13*(2), 125-129.

Pylyshyn. (2001). Visual indexes, preconceptual objects, and situated vision. *Cognition, 80*(1-2), 127-158.

Pylyshyn. (2006). Some puzzling findings in multiple object tracking (MOT): II. Inhibition of moving nontargets. *Visual Cognition, 14*(2), 175-198.

Pylyshyn, & Storm. (1988). Tracking multiple independent targets: Evidence for a parallel tracking mechanism. *Spatial Vision, 3*(3), 179-197.

Theeuwes, & Godljn. (2002). Irrelevant singletons capture attention: Evidence from inhibition of return. *Perception & Psychophysics, 64*(5), 764-770.

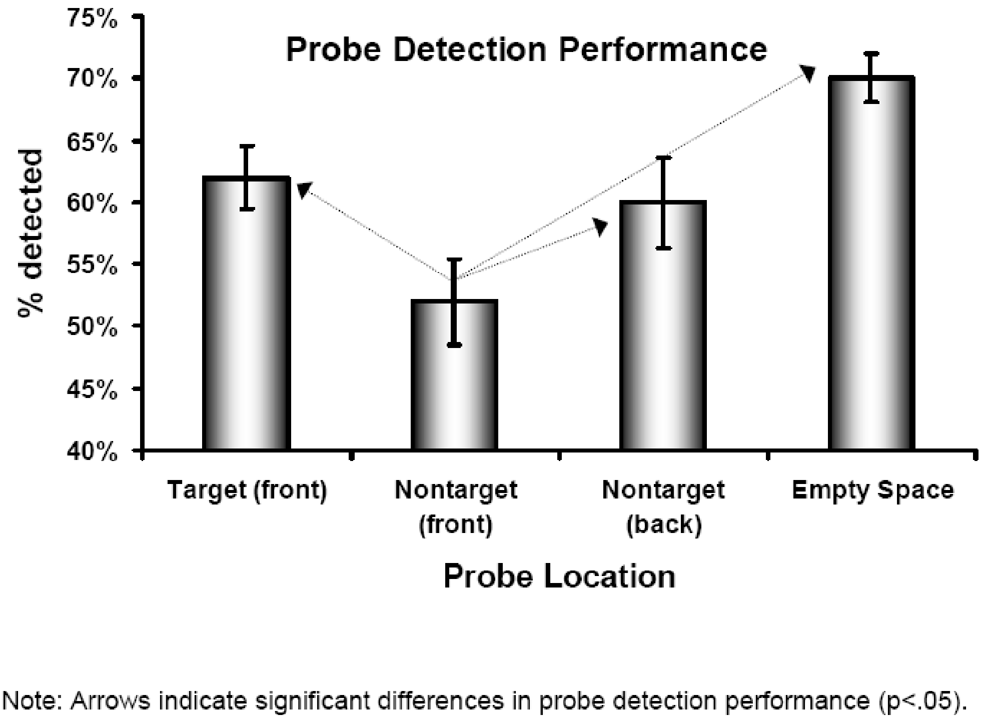
Theeuwes, Kramer, & Atchley. (2001). Spatial attention in early vision. *Acta Psychologica, 108*(1), 1-20.

Tipper. (2001). Does negative priming reflect inhibitory mechanisms? A review and integration of conflicting views. *Quarterly Journal of Experimental Psychology, 54A*(2), 321-343.

Tipper, Driver, & Weaver. (1991). Object-centred inhibition of return of visual attention. *Quarterly Journal of Experimental Psychology, 43A*(2), 289-298.

Watson, & Humphreys. (1997). Visual marking: Prioritizing selection for new objects by top-down attentional inhibition of old objects. *Psychological Review, 104*(1), 90-122.

Figure 1: Probe detection performance during MOT on two depth planes.



Note: Arrows indicate significant differences in probe detection performance (p<.05).