C 13

TRACKING INVISIBLE OBJECTS

VSS 2004

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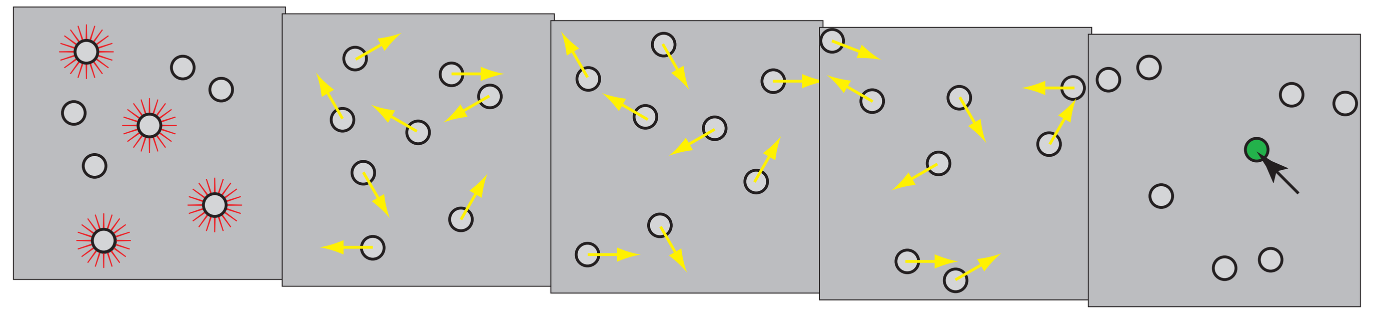
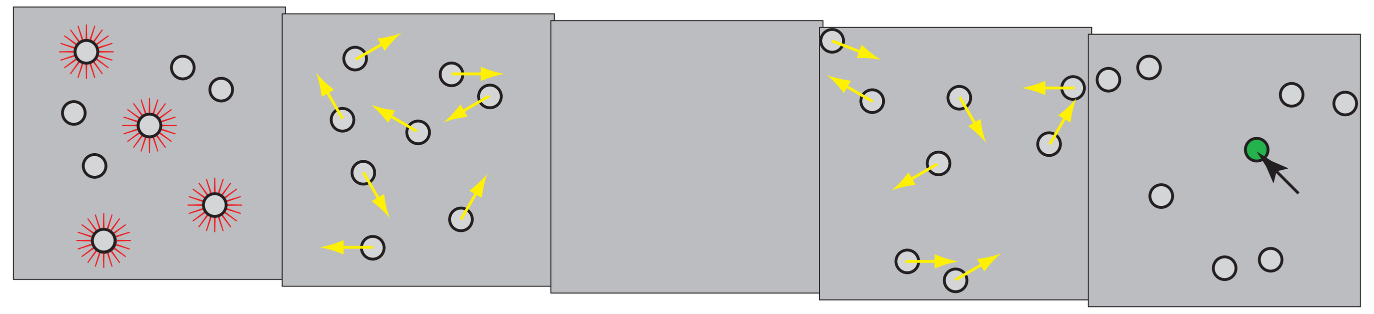
Multiple Object Tracking

Observers are shown a display of identical objects, and asked to track a subset of target items. All objects then move independently for some time; observers are then asked to indicate the target items. Observers' capacity in this task is typically 3-5 objects (Pylyshyn & Storm, 1988).



Tracking Across the Gap

We have previously demonstrated that observers can track moving objects which disappear for up to 400 ms (Alvarez et al. VSS 2001; see also Keane & Pylyshyn VSS 2003, Yin & Thornton, 1999).



How do we do this? Two alternatives

hypothesis 1: "impoverished occlusion"

We know that observers can successfully track objects which move behind occluders (Scholl & Pylyshyn, 1999). In these studies, objects disappeared asynchronously, and occlusion cues such as accretion and deletion at occluder boundaries are critical for performance. Perhaps the visual system treats the disappearance of objects as an impoverished form of occlusion. If so, performance in tracking across the gap should improve with the addition of occlusion cues. Performance might also improve if objects disappeared one by one, instead of all at once.

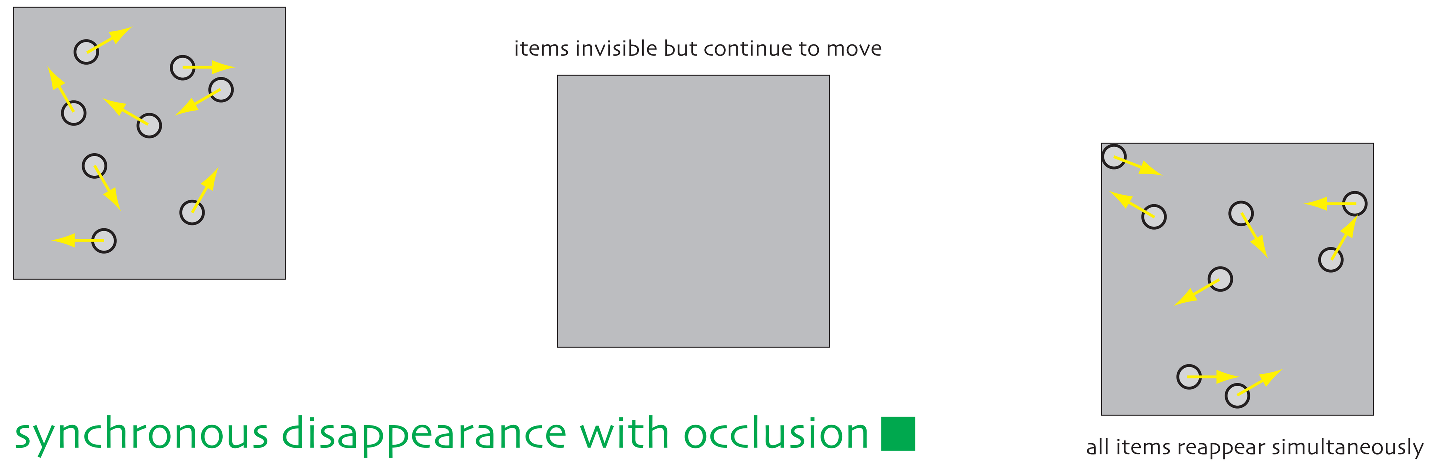
hypothesis 2: "out of mind, out of sight"

We have shown that observers can perform a demanding visual search task while tracking at little cost to either task (DiMase et al. VSS 2003). Performance is unchanged if the tracking stimuli disappear during the search task. The visual system must have a mechanism for putting tracking "on hold" while attention is diverted to another task. This mechanism might be invoked when objects disappear as well. If so, we predict that performance in tracking across the gap should be better when all objects disappear and reappear simultaneously than one by one. Occlusion cues should make little difference.

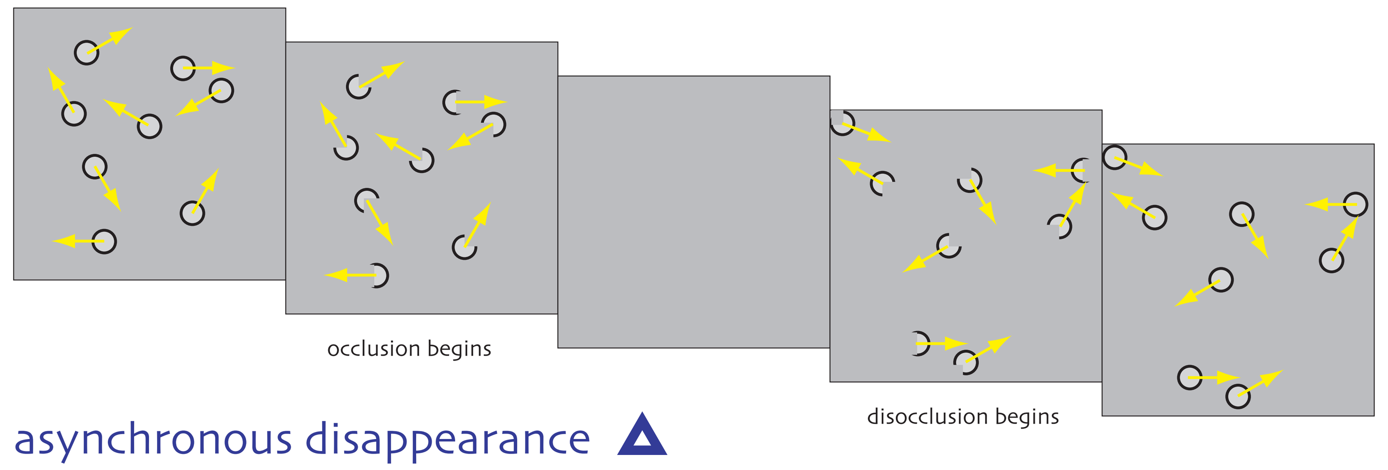
Methods

Targets flashed on the screen for four seconds. Objects then moved independently for five seconds. Objects were allowed to occlude one another (see poster C10). When motion ceased, observers were required to identify all targets with a mouse. The number of targets varied by experiment.

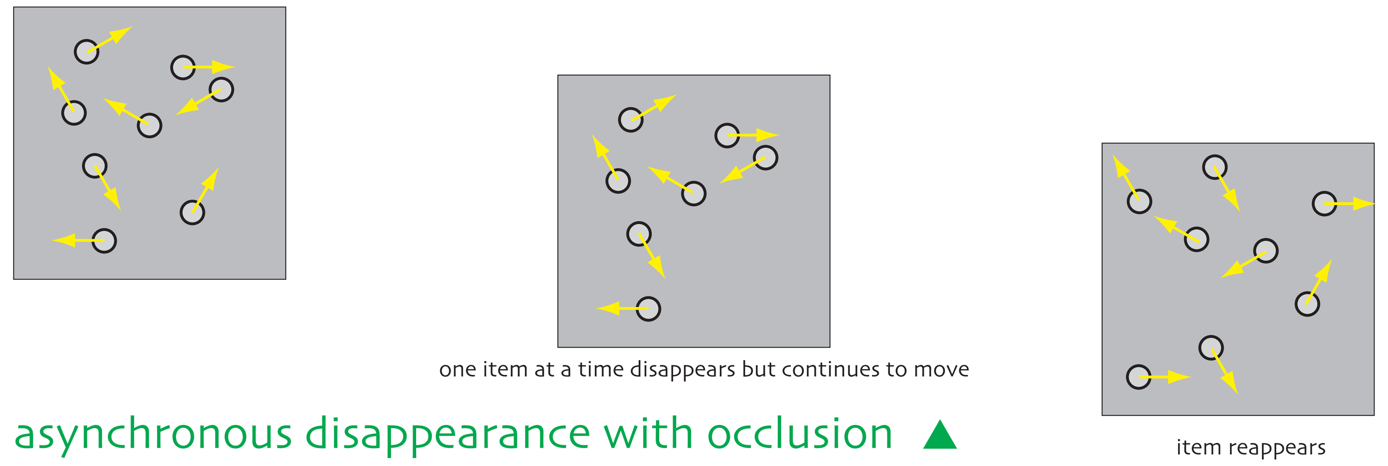
synchronous disappearance ■ colored symbols correspond to data points on figures



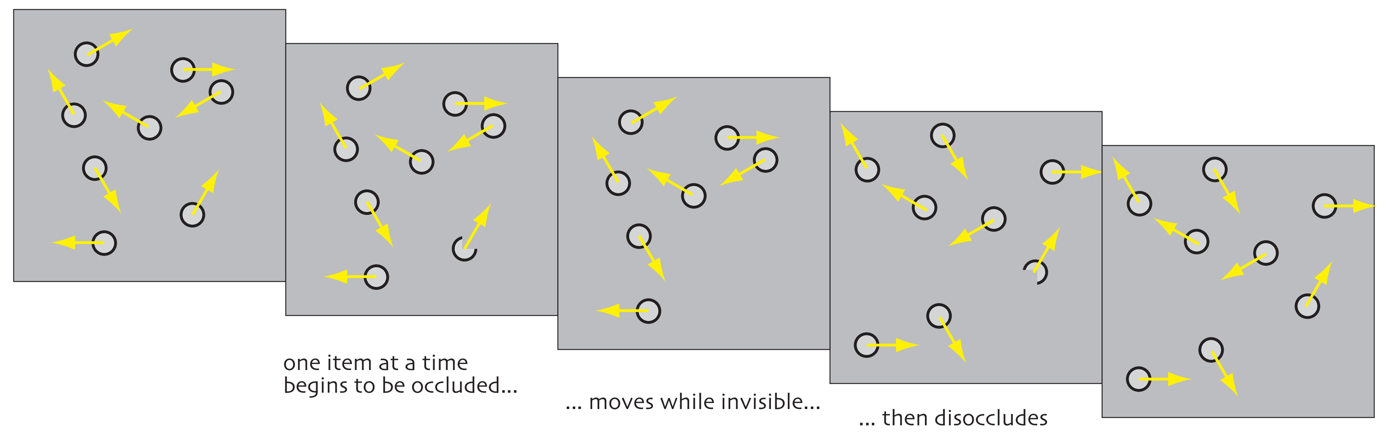
synchronous disappearance with occlusion ■



asynchronous disappearance ▲

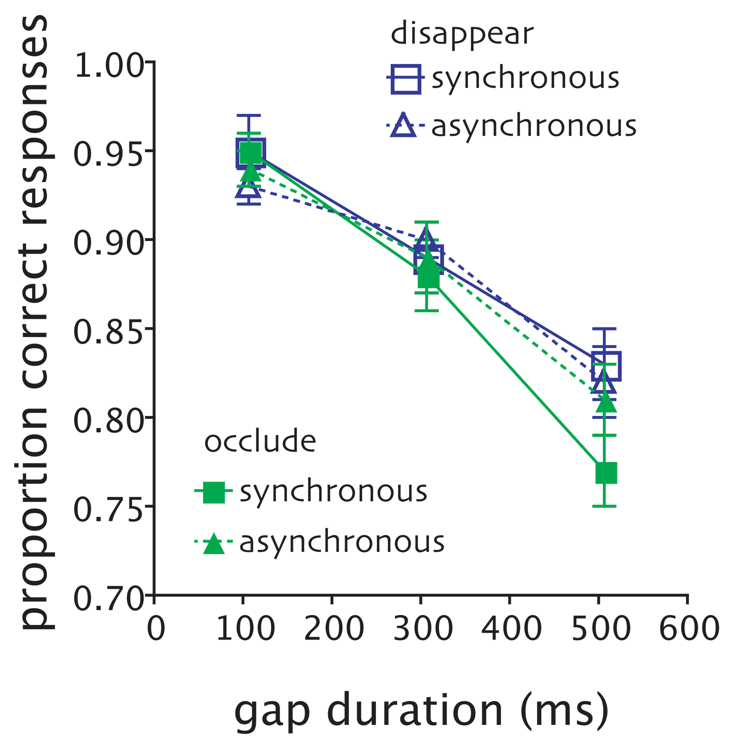


asynchronous disappearance with occlusion ▲



In all conditions, objects became invisible for 100, 300, or 500 ms, while continuing to move. Observers tracked for at least 2 s before objects disappeared. In synchronous conditions, all objects disappeared and reappeared simultaneously. In asynchronous conditions, objects disappeared and reappeared one at a time. In occlusion conditions, occluders were added for 170 ms before and after the gap.

1. Synchronous vs. asynchronous disappearance



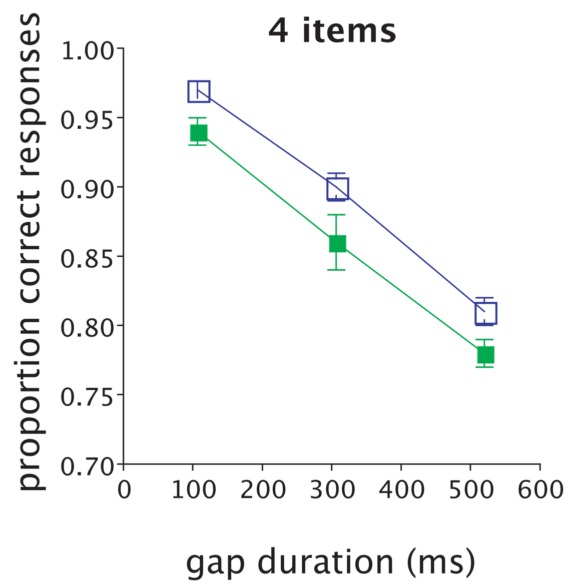
Observers were tested in all four stimulus conditions while tracking 5 disks.

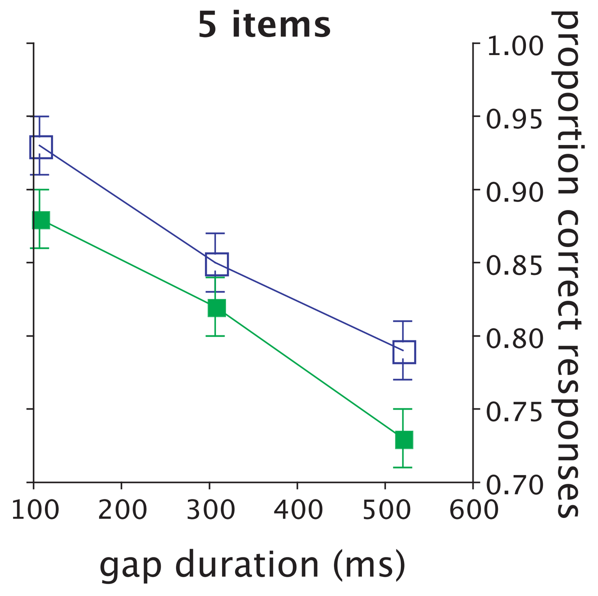
Overall, there was a slight advantage for the synchronous conditions; performance fell off more rapidly with gap duration for the asynchronous conditions. conditions. Occlusion cues provided no advantage.

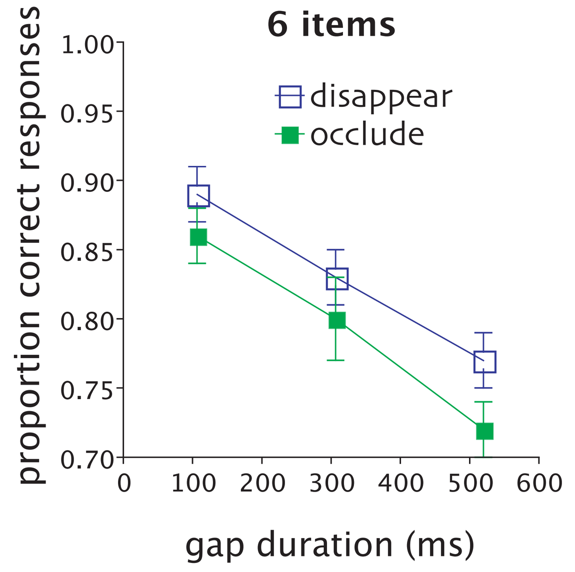
2. Varying tracking load

Do the results depend on how many objects are tracked?

Here we tested only the synchronous conditions.







Overall performance decreased with load, but in every case occlusion cues actually impaired performance. Perhaps the appearance of virtual occluders creates interference.

Conclusions

Tracking invisible objects is easier if they all disappear at the same time, and without occlusion/disocclusion cues. This is not consistent with the impoverished occlusion hypothesis.

Real world tracking tasks often occur in multi-tasking situations, such as driving, which require us to rapidly shift attention from tracking to other demanding tasks, and then recover tracked items (see Alvarez et al. VSS 2001). This implies that the visual system can store the locations or trajectories of tracked items for a brief time.

The simultaneous disappearance of all tracked objects mimics shifting attention to another task, and recruits this storage.

For details about what might be stored, see poster C17.

References

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This research was supported by NIH grant MH65576 to Todd Horowitz. Linda Tran was supported by Project Success. http://www.mfdp.med.harvard.edu/k12/project_success/.