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The Role of Memory in Visual Search

Arthur F. Kramer

Beckman Institute, University of Illinois

Until recently it was assumed that visual search performance benefited from accurate and robust representations of previously searched locations in the visual field. That is, visual search is guided, in part, by memory for areas of the visual field that had been previously inspected. However, Horowitz and Wolfe (1998, 2001) demonstrated that this may not be the case. In their earlier study they showed that visual search slopes were equivalent for conditions in which target and distractor positions were fixed and conditions in which distractors shifted positions every 100 ms. If visual search was memory-based one would expect that search performance would be superior in the fixed position condition, since in this condition, but not the random condition, memory could be used to prevent re-visiting previously searched locations.

The research by Horowitz and Wolfe generated a series of studies by researchers to further examine this surprising finding and to explore the nature of memory representations in search. In my presentation I will discuss some of the research that we have conducted in our laboratory on this topic. In one series of studies (Peterson et al, 2001) we used eye movement recording to examine the amnesiac search hypothesis offered by Horowitz and Wolfe. We found, counter to the amnesiac search hypothesis, that subjects rarely re-fixated objects that they had previously foveated. Indeed, the few refixations that we did observe tended to occur on an item that had just be examined. Furthermore, re-fixations occurred only when the previous fixation had been very brief. Such results suggest that subjects "looked" but did not "see" on these brief fixations – and therefore they needed to refixate an object to determine its identity. Of additional interest was the finding in the Peterson et al study that refixations did not even occur at lags of up to 11 items (i.e. subjects did not even refixate items that they had originally fixated 11 items ago!). Such data might suggest that a very large memory buffer underlies visual search. However, another possibility is that subjects augmented memory for the positions of previously fixated objects with mnemonic search strategies (e.g. start searching the upper left hand portion of the screen and search in a clockwise fashion).

A series of experiments conducted by McCarley et al (in press) in our laboratory addressed this issue by designing a paradigm that precluded the use of stereotypical search strategies. In this paradigm objects were presented in an eye movement contingent fashion. For example, subjects were presented with an object which they fixated. If it was the target the trial stopped and the subject responded (see Figure 1).

However, if the first object was not the target subjects would continue on to the second object, which had been presented during the saccade to the first object (so as to capitalize on saccade suppression and avoid onset capture). If this second object were the target subjects would respond and the trial would be concluded. However, if the second object was not the target two objects would be presented (during the saccade to the second object) with one object

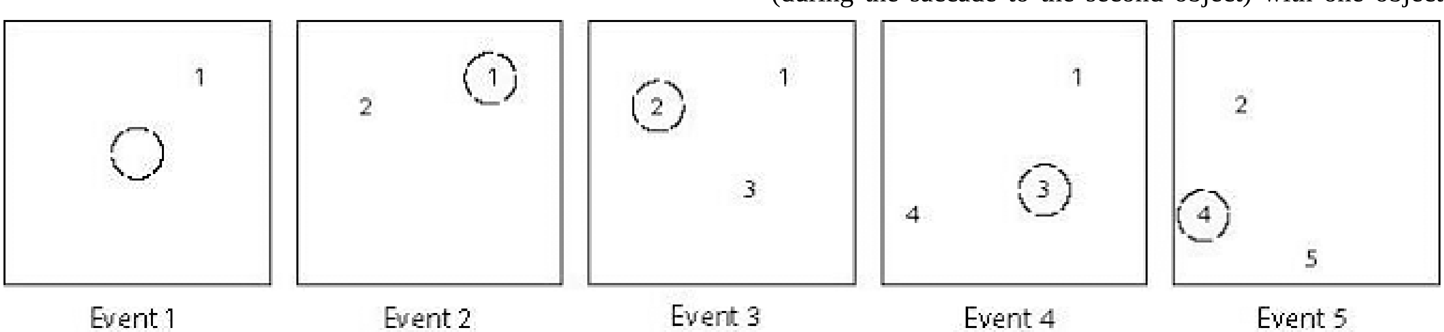

Figure 1. The sequence of events within a typical trial. Dashed circle indicates the observer's point of regard. Numbers are used to indicate different stimulus items. Stimuli in actual displays were T- and L-shaped characters too small to be discriminated without foveation. Note that from Event 3 onward, the observer is forced to choose between executing a saccade from the currently fixated item toward a new item, or toward a decoy item that has already been seen.

being an “old” (previously presented) object and the other object being new. This procedure would continue until the trial concluded without the presentation of a target (a target absent trial) or the subject found the target.

This procedure enabled us to examine the probability of fixating an old object (P(old object)) as a function of the lag between the initial presentation of the object and its re-presentation. The lag at which the P(fixate old) object approached 50% was used to define the size of the memory buffer that underlies visual search. The lag at which this occurred was 4-5, suggesting the subjects maintain a memory representation of at least 3-4 objects to ensure that they do not refixate old locations (see Figure 2).

Additional studies that use this eye movement contingent paradigm to examine the nature of the memory representation will be discussed as will the results of other research that has employed multiple targets paradigm to examine the role of memory in visual search. I will also discuss some very surprising aging results in which we used the visual search eye movement contingent paradigm to examine potential age-related changes in the role of memory in visual search.

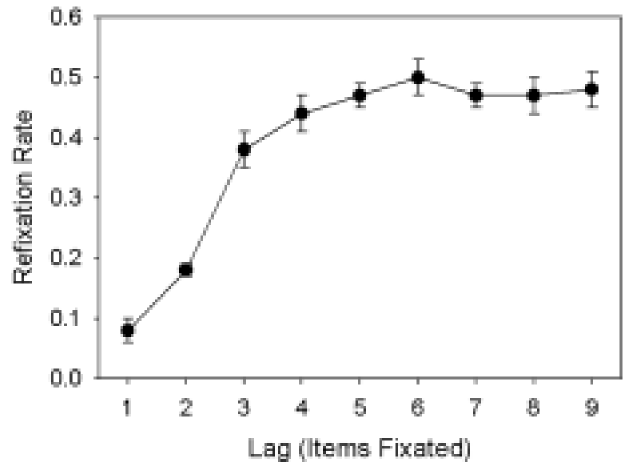

Figure 2. Refixation rates on decoy items, as a function of lag (in number of intervening items fixated) since the item was last fixated. Refixation rates remain below chance level (.50) until lags of 3-4, indicating memory-guided oculomotor target selection. Error bars indicate ± one standard error.