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Fixations are not all created equal: An objection to mindless visual search

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Abstract:	We welcome the call to revolution in theories of visual search, but do not think the authors go far enough. The treatment of fixation as uniform is an oversimplification which obscures the critical role of the mind. We remind readers that what happens during a fixation depends on mindset, as shown in studies of search strategy and of human's ability to rapidly resume search following an interruption.

Commentary Proposal on Hulleman & Olivers:

Fixations are not all created equal: An objection to mindless visual search

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Abstract

This call to revolution in theories of visual search does not go far enough. Treating fixations as uniform is an oversimplification which obscures the critical role of the mind. We remind readers that what happens during a fixation depends on mindset, as shown in studies of search strategy and of human's ability to rapidly resume search following an interruption.

We welcome Hulleman & Olivers' (2016) invitation to abandon the display item as the fundamental unit of visual search. There is now considerable evidence — some of which we have contributed (Enns & Kingstone, 1995; Fecteau, Enns & Kingstone, 2000; Roggeveen, Kingstone & Enns, 2004; van Zoest, Giesbrecht, Enns & Kingstone, 2006) — that display items cannot be considered in isolation from the items around them, nor from the limits of the observer's functional viewing field (FVF). However, Hulleman & Olivers' (2016) call to revolution does not go far enough. In short, they replace one operational unit (the experimenter-defined item in a search display) with another (the observer's FVF, as indexed by fixations). Both of these efforts to ground theories of search in easily observable third-person variables neglect the most important factor: the observer's *mind*. It is our view that what happens behind the observer's eyes is more important than what happens in front of them (the display items) or even in them (the FVF).

Fixations during visual search cannot be considered in isolation; they are always involved in a trading relationship with saccades. That is, at any given moment the observer is engaged in strategic decisions (albeit implicit ones) to keep their eyes still (allowing for *seeing*, the ability to distinguish targets from non-targets) or to move them (allowing for *looking*, the acquisition of new information from outside the current fixation). Similar to agents in classical reinforcement learning models (Sutton & Barto, 1998), who trade off between *exploiting* currently available resources and *exploring* for novel resources, visual searchers cycle between *seeing* the information in their current fixation, or *looking* to a new location. In typical search tasks, this cycle is repeated 3–4 times a second, which is consistent with Hulleman & Olivers (2016) decision to model fixations as lasting 250 milliseconds. Yet setting this average time as a constant conceals important variability.

We recently manipulated the mental strategies of participants by randomly assigning them to either search *passively*, by giving them instructions to "let the target pop into your mind," or to search *actively*, by telling them to "deliberately direct your attention." We found a passive response time advantage, as in previous studies (Smilek et al., 2006), and showed that this stemmed from the inherent tradeoff between seeing and looking (Watson et al, 2010). Passively-instructed participants made fewer fixations of longer duration, and once they fixated the target region for the first time, they made fewer subsequent fixations, responding more quickly. This suggests that they placed a greater emphasis on *seeing* rather than looking, and so were better able to process the target. These differences may not reflect differences in FVF: passively-instructed participants were no likelier to fixate closer to the center of the display, nor further away from individual items, either of which would have allowed them to take advantage of a larger FVF.

One of the most striking observations in Watson et al. (2010) is that there is more than one way to succeed in visual search. Even after trimming participants from each group to equate overall speed and accuracy, passively instructed participants made fewer fixations separated by larger saccades. This means it is possible to trade the higher information resolution of *seeing* with the greater information acquisition of *looking*, without affecting overall success.

Another demonstration of the critical importance of mind comes from studies of *rapid resumption* of visual search, in which participants are able to respond very rapidly (within 100-400 milliseconds) to a display that has been re-presented following a brief interruption (Lleras, Rensink & Enns, 2005). Ordinarily, these same responses made to the first look at a display take more than 500 milliseconds to be as accurate. Successful rapid resumption of an interrupted search depends on participant's forming a mental prediction of the target's response-relevant features and location based on a first look at the display. When these features or location change after the first look, but all other aspects of the display remain constant, rapid resumption is eliminated (Lleras, Rensink, & Enns, 2007). The prediction is more likely to be made when fixations are located close to the target, but it turns out that fixation location is not the determining factor either. When gaze-contingent displays are used, such that the target is always presented at fixation, rapid resumption is impossible (van Zoest et al., 2007). Once again, differences in the mind lead to differences in the processing that occurs during a fixation. If a correct prediction about the target has been made during the first glance, the second glance enables rapid responses; if this prediction has not been made, the search must be started over. This critical *predictive* aspect of visual search seems absent from Hulleman & Olivers' (2016) account.

The role of fixations depends on mindset, both between-subjects (as shown by our instructional study) and within-subjects (as shown by rapid resumption studies). Hulleman & Olivers (2016) account treats fixations as uniform, which is a serious oversimplification.

We conclude by reiterating three points Julian Hochberg (1968) made long ago, recently updated in a series of studies in Peterson, Gillam, & Sedgwick (2006). First, because every percept enters the mind through piecemeal views, a theory of perception must be about the mind's representation, not its trigger (the stimulus), nor its conduit (the eye). Second, as Hochberg liked to put it, "unlike objects themselves, our perception of objects is not everywhere dense" (Hochberg, 1982, p. 214). He contributed numerous demonstrations of the selectivity of perception, both in its overt actions (fixations) and in its covert processing (attention). Third, there is no perception in a glance that is divorced from prior mental representation. This recursive aspect to perception means that vision is as much influenced by what lies in the mind as what lies in the eye of the beholder.

References

Enns, J. T. & Kingstone, A. (1995). Access to global and local properties in visual search for compound stimuli. Psychological Science, 6, 283-291.

Fecteau, J.H., Enns, J. T. & Kingstone, A. (2000). Competition-induced visual field differences in search. Psychological Science, 11, 386-393.

Hochberg, J. (1968). In the mind's eye. Contemporary theory and research in visual perception, 309-331.

Hochberg, J. (1982). How big is a stimulus. In J. Beck (ed.), Contemporary theory and research in visual perception (pp. 191-217). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lleras, A., Rensink, R. A., & Enns, J. T. (2005). Rapid resumption of interrupted visual search new insights on the interaction between vision and memory. Psychological Science, 16(9), 684-688.

Lleras, A., Rensink, R. A., & Enns, J. T. (2007). Consequences of display changes during interrupted visual search: Rapid resumption is target specific. Perception & Psychophysics, 69(6), 980-993.

Peterson, M. A., Gillam, B., & Sedgwick, H. A. (Eds.). (2006). In the mind's eye: Julian Hochberg on the perception of pictures, films, and the world. Oxford University Press.

Roggeveen, A.B., Kingstone, A., & Enns, J.T. (2004). Influence of inter-item symmetry in visual search. Spatial Vision, 17, 443-464.

Smilek, D., Enns, J. T., Eastwood, J. D., & Merikle, P. M. (2006). Relax! Cognitive strategy influences visual search. Visual Cognition, 14(4-8), 543-564.

Sutton, R. S., & Barto, A. G. (1998). *Reinforcement Learning: An Introduction*. The MIT Press.

van Zoest, W., Giesbrecht, B., Enns, J. T. & Kingstone, A. F. (2006). Inter-item symmetry influences visual search. Psychological Science, 17, 535-542

van Zoest, W., Lleras, A., Kingstone, A. F., & Enns, J.T. (2007). In sight, out of mind: The role of eye movements in the rapid resumption of visual search. Perception & Psychophysics, 69, 1204-1217.

Watson, M. R., Brennan, A. A., Kingstone, A., & Enns, J. T. (2010). Looking versus seeing: Strategies alter eye movements during visual search. Psychonomic Bulletin & Review, 17(4), 543-549.