needs to be considered more explicitly both in experiments and models about visual search.

We applaud the authors for their effort to further promote gaze fixations and the FVF as first-class entities in models and theories of visual search. We believe that the development of computational cognitive architecture models provides a promising pathway to achieve the goals they have expressed. We encourage other researchers to embrace these positive developments but to also go further and (a) more explicitly consider the role of cognitive strategy in visual search and (b) as hinted by H&O, collect the empirical data needed to describe more completely and parametrically how visual properties are detected based on object eccentricity, size, and density (building on Anstis 1974; Bouma 1970; Engel 1977; Gordon & Abramov 1977; Virsu & Rovamo 1979). Both are needed for a comprehensive predictive model of visual search.

How functional are functional viewing fields?

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Árni Kristjánsson, Andrey Chetverikov, and Manje Brinkhuis
Faculty of Psychology, School of Health Sciences, University of Iceland, 101, Reykjavík, Iceland.
ak@hi.is andrey@hi.is manjebrinkhuis@gmail.com

Abstract: Hulleman & Olivers' (H&O's) proposal is a refreshing addition to the visual search literature. Although we like their proposal that fixations, not individual items should be considered a fundamental unit in visual search, we point out some unresolved problems that their account will have to solve. Additionally, we consider predictions that can be made from the account, in particular in relation to priming of visual search, finding that the account generates interesting testable predictions.

Hulleman & Olivers' (H&O's) target article is a refreshing addition to the visual search literature. We agree with them that there is need for a more flexible conception of visual search, and that eye movements should not be considered a nuisance factor. They are, however, not the first to point out problems with what they call the *item-based* approach, where slopes of set-size and response times take center stage. Concerns about traditional visual search approaches are raised in parallel models of visual search (Eckstein 1998; Kristjánsson 2015; Palmer et al. 1993) showed how slopes are ambiguous measures of search behavior; and Wang et al. (2005) have shown how even very difficult searches can yield flat slopes, calling for changed conceptions of search. But as H&O rightly highlight, satisfactory replacements to traditional approaches have not surfaced.

Functional viewing fields (FVF) play a central role in their account. Although we think this approach is useful, we still feel it comes up short on some important questions. Perhaps against the authors' intention, FVFs may conveniently describe a continuum between easy search involving the whole visual field ("parallel," broad, shallow processing within saliency maps) and item-based processing ("serial," narrow but deeper), similar to an "attentional window" (Belopolsky et al. 2007), whose size scales with attentional load (Lavie et al. 2004). The "parallel" versus "serial" dichotomy may no longer be useful for developing new ideas (Kristjánsson 2015; Nakayama & Martini 2011). FVFs are spatially constrained, and so the concept may encounter similar problems as spotlight metaphors. Attending to multiple moving items (Cavanagh & Alvarez 2005), perceptual grouping (Kerzel et al. 2012; Vatterott & Vecera 2015), or predictability (Jefferies et al. 2014) can shape or divide the attentional window, arguing against the idea of a single FVF. Additionally, whether items within spatially constrained FVFs are processed in parallel is not clear. For example, priming studies demonstrate that attention spreads unevenly between targets and distractors within FVFs (Kristjánsson & Driver 2008). A single FVF (even with a dynamically changing size) is therefore unlikely to explain nonuniform or spatially noncontiguous attention distribution.

Sometimes H&O seem to try and explain the *literature* on visual search rather than actual visual search and attention. One example is that FVFs may be difficult to define operationally, while they rather straightforwardly explain set-size effects. FVFs are supposedly small in difficult search tasks, but determining which tasks are hard seemingly requires set-size slopes, which FVF size is supposed to account for. This is circular. H&O discuss other factors influencing the size of FVF (e.g., distractor heterogeneity), but whether FVFs add to the explanatory power already provided by these factors is unclear. The proposal does, in other words, not contain a clear way of predicting FVF size except with already well-known tools.

According to H&O, set-size effects are explained with fixations, and they explicitly assume no covert attentional shifts within FVFs. Search where eye movements are *not* allowed should therefore not yield such effects when distractors are isoeccentric. But set-size effects persist when eccentricity is controlled for and eye movements are eliminated, (e.g. Carrasco et al. 2001; Foley & Schwarz 1998; Palmer et al. 1993). Rather, set-size effects might reflect the *discriminability* of target versus distractors, which relies on set-size, covert attention, and position within FVFs (Anton-Erxleben & Carrasco 2013; Carrasco et al. 2001; Carrasco & Yeshurun 1998). Importantly, if target location is pre-cued set size effects are reduced (Carrasco et al. 2001; Foley & Schwarz 1998), which neither item-based selection, nor FVF's can explain. We agree that target selection can rely on discriminability between items processed in parallel within FVFs, but the best approach to explaining how we attend in the visual scene will probably be multifaceted, involving covert and overt attentional shifts.

Despite these criticisms H&O's proposal is refreshing. We suggest several predictions that can be made from it. We consider priming of visual search (Maljkovic & Nakayama 1994; see Kristjánsson & Campana [2010] for review). Such priming occurs for searches of varying difficulty (Ásgeirsson & Kristjánsson 2011) and according to H&O, search difficulty determines FVF size. If stimuli are predominantly processed within FVFs, then for priming to manifest its effects, a primed target must fall within the FVF. Increased search difficulty contracts the FVF, lowering the probability that a target will fall within it. For difficult search tasks, priming effects should therefore decrease when set-size increases, while for easy tasks they should be constant (or decrease more slowly), as the FVF is larger and therefore likely to include the target. Here the proposal generates testable hypotheses, where the literature does not have clear answers (but see Becker & Ansorge 2013). Analogously, priming effects for targets should also last longer for easy search than for difficult search. With smaller FVFs more fixations are required to find the target. Hence, there will be more intervening fixations between the ones that include the target, most likely leading to faster decay. Temporal profiles of priming have been investigated (Kruijne et al. 2015; Martini 2010; Brascamp et al. 2011), but these studies do not provide a clear test of this prediction. Notably, it runs counter to a recent proposal that priming of conjunction search is longer lasting than feature priming (Kruijne & Meeter 2015).

Finally, we ask whether FVF size primes from previous trials, though as we discuss above, the measurement of the FVF size is problematic. While it is debatable that this is a prediction unique to FVFs, the approach clearly predicts priming for fixations rather than individual items. Fuggetta et al. (2009) found that search was faster when the physical size (and set-size) of a search array was constant than when it changed, but priming of items versus fixations has not directly been contrasted. We hope that these and other new predictions will help with assessing the usefulness of H&O's new approach.