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Commentary

Reevaluating the disengagement hypothesis

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1. Introduction

Despite extensive research, the question of the relative contributions of stimulus-driven and goal-directed factors to the allocation of attentional priority at the preattentive stage remains highly controversial. Theeuwes (2010) claims that within a spatially defined window of attention, the most salient object is always granted attentional priority mandatorily and irrespective of the observer's goals. At the other end the spectrum, Folk and colleagues' (e.g., Folk, Remington & Johnston, 1992; Anderson & Folk, 2010) increasingly popular account postulates that salient information in a visual scene can be ignored when it does not match the attentional set of the observer. In this commentary, I suggest that in line with the core assumption of most leading models of visual search, attention is guided by both stimulus-driven and goal-directed factors (e.g., Bundesen, 1990; Wolfe, 1994).

1.1. Another look at two fundamentally different experimental paradigms

As has been repeatedly pointed out, the two conflicting accounts rely on findings obtained using two fundamentally different experimental paradigms. The purely stimulus-driven view mainly relies on data collected using the additional singleton paradigm, while the contingent-capture account relies on data from the modified spatial cuing paradigm. As a consequence, the debate has focused on a reevaluation of the interpretation associated with each paradigm. A major but as yet largely overlooked difference between the studies supporting the purely stimulus-driven vs. contingent-capture views concerns the type of manipulation these have used. On the one hand, in studies relying on the additional singleton paradigm and supporting the purely stimulus-driven view, salience of the singleton distractor relative to that of the target is manipulated while the match between the irrelevant distractor and the observer's attentional state is kept constant. It follows that such findings can be informative with regard to the role of bottom-up guidance of attention but they can say nothing about the role of top-down factors. On the other hand, in studies relying on the modified spatial cueing paradigm and supporting the contingent-capture view, the match between the irrelevant singleton and the attentional set is manipulated while salience of the irrelevant singleton is not considered: such findings can shed light on the role of attentional set on attentional guidance but they can say nothing about the role of bottom-up factors.

Capture only indexes the net difference between the relative weights of bottom-up and top-down contributions to attentional priority within certain experimental conditions Thus, neither failure to observe capture despite the presence of a salient distractor nor findings of attentional capture despite adoption of a feature-based attentional set can unveil the mechanisms that affect attentional priority. To determine the relative contributions of bottom-up and top-down factors, both types of factors must be manipulated independently.

Although there has been no systematic investigation relying on this experimental rationale, several findings strongly support the idea that stimulus-driven and goal-directed factors jointly contribute to attentional priority. For instance, a comparison of the findings from Theeuwes (1991 vs. 1992) indicates that while an irrelevant color singleton interferes with visual search for a less salient shape singleton (demonstrating the role of bottom-up factors), such interference is dramatically reduced when the target's specific shape is known (demonstrating the role of top-down factors). This finding has been replicated in a within-subject design (e.g., Lamy, Carmel, Egeth, & Leber, 2006; Lamy & Yashar, 2008; Pinto, Olivers, & Theeuwes, 2005 — Theeuwes' alternative interpretation of this finding will be addressed in a later section). In addition, even using Folk's modified spatial cuing paradigm, an irrelevant singleton does elicit a shift of attention to its location when it is made salient enough (e.g., by increasing display density, Yeh & Liao, 2008 or the singleton's luminance, Lamy, 2005, Exp. 3).

1.2. Outline of the commentary

Within this theoretical framework, in the remainder of this article, I will focus – for lack of space – on just one of the main arguments put forward by Theeuwes against studies showing that attentional guidance is possible. Namely, I will reassess the evidence held to support the "disengagement-based" alternative account of the findings emanating from Folk et al.'s modified spatial cueing paradigm.

Theeuwes relied on the observation that in Folk et al.'s paradigm, there is typically a delay of 150 ms between the presentation of the cue display and that of the search display. He suggested that attention is captured by the irrelevant singleton cue early on, but disengagement of attention from the cue is relatively fast when the cue does not share the target defining property (Hypothesis 1), and relatively slow when the cue shares the target defining property (Hypothesis 2). In

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Theeuwes (2010); see also Pinto et al., 2005), this account has taken on additional features, related to the role of uncertainty on disengagement speed: the more uncertainty there is in a search task, the more processing of the irrelevant distractor is necessary to reject it as a non-target and disengage from it, and therefore, the larger the interference effect observed (Hypothesis 3).

The three central hypotheses that make up the disengagement alternative account serve to reject a host of findings that conflict with Theeuwes' salience-based account. Yet, as I will try to show, none of these hypotheses is supported by direct empirical evidence.

Hypothesis 1. Fast disengagement from irrelevant salient distractors.

The only direct evidence brought forward by Theeuwes to support the idea of fast disengagement from irrelevant singletons was reported by Theeuwes, Atchley and Kramer (2000). Subjects searched for a shape singleton and had to ignore a color singleton presented at different stimulus onset asynchronies (SOAs; from 50 to 400 ms) prior to the search display. While the distractor failed to summon attention at SOAs of 150–200 ms, thus extending Folk et al.'s findings (e.g., Folk & Remington, 1998) to cross-dimensional capture, it significantly disrupted search at earlier SOAs (50 and 100 ms). These findings nicely fit the predictions of the fast disengagement account. However, they have been challenged by later studies.

An important aspect of Theeuwes et al.'s (2000) findings which was not mentioned in Theeuwes' review (this issue) is that capture by the salient color singleton reappeared at the longest SOA (400 ms). This finding – which emerged in two separate experiments (Theeuwes et al., 2000, Exps 2 and 3) – cannot be explained by the fast disengagement account. Based on a review of the literature, Lamy (2005) suggested it may in fact reflect the role of temporal expectations in subjects' ability to overcome attentional capture rather than fast disengagement. Specifically, I proposed that it may be easier to override attentional capture when the interval of time during which an attentional shift toward the salient distractor must be withheld (distractor-to-target SOA) is predictable. In addition, I suggested that when the interval is unpredictable, capture can be overridden at the average expected interval. The results from three experiments confirmed these hypotheses. An irrelevant onset preceding a color singleton target by a given time interval failed to capture attention when the SOA (spanning from 50 ms to 425 ms across experiments) was predictable, thus replicating Folk et al.'s (1992) findings. This distractor did summon attention when SOAs varied unpredictably, but with moderately salient stimuli, capture was overridden at the expected average interval: capture was observed at early and at late SOAs, thus replicating Theeuwes et al.'s (2000) findings.

Consistent with Lamy (2005), Chen and Mordkoff (2007) showed that with a fixed 35-ms SOA, a color singleton pre-cue produces spatial congruency effects in search for color singleton, but an irrelevant onset fails to do so. Unless one makes the unfalsifiable claim that express disengagement of attention can be performed within as little time as 35 ms, this finding overrules Theeuwes' fast disengagement account.

Given the centrality of the fast disengagement hypothesis in Theeuwes' argumentation against the contingent-capture account, additional tests are clearly needed. There is, to date, no convincing evidence supporting the fast disengagement hypothesis.

Hypothesis 2. Slow disengagement from task-relevant salient distractors.

With the modified spatial cueing paradigm, a cue that possesses the target feature produces a spatial congruency effect, despite the fact that it typically appears 150 ms before the target. To account for the asymmetry between task-relevant and -irrelevant distractors, Theeuwes (2010) assumed that "finding a larger effect on RT does not mean that there is more capture; it means that it simply may take longer to disengage attention from the distractor location thereby increasing the effect on RT" (p. 89). Accordingly, he assumed that it takes time (more than 150 ms) to disengage attention from an object that shares the target defining property. Yet, to date, this hypothesis has not been tested.

Theeuwes (2010) suggested an interpretation of Anderson and Folk's (2010) recent findings that, in his view, supports the idea that increasing the match between the cue and target features slows disengagement speed after attention has been captured but does not speed the initial shift of attention to the cue. Relying on the graph depicting Anderson and Folk's results, he observed that the larger spatial effect when the cue looked like the target relative to when it did not resulted mainly from slower RTs on invalid-cue trials, with RTs on valid trials being about the same independent of cue-target similarity. He concluded that "attentional capture was not affected by cue-target resemblance but the speed of disengaging attention from the invalidly cued location was" (p. 93).

Beyond the facts that this interpretation rests solely on looking at the graph (with no supporting statistical analysis), and that across the experiments, the data looked just slightly more stable with regard to the modulation by similarity of different- relative to same-location RTs, it is important to realize that the rationale of the argument is flawed.

The study used a 150-ms SOA between the cue and target displays. At this time, according to the argument, attention is disengaged from the least similar cues and still dwells on the most similar cues. However, if attention still dwells at the cue location, then when the target appears at the same-location, no shift of attention is required and RTs should be fast. Conversely, when the target appears elsewhere, attention must be disengaged from the cue location and shifted to the target location, therefore RTs should be slow. Thus, Theeuwes' account in fact predicts that for the more similar cues same-location RTs should be faster and different-location RTs should be slower. In other words, with a 150-ms SOA, it is not the case that RTs on different-location trials are the marker of the disengagement speed and RTs on same-location trials are the marker of initial capture.

What kind of evidence, then, could provide empirical support for the notion that larger capture effects with task-relevant relative to irrelevant cues do not reflect increased capture but only slower disengagement of attention? One would have to show that at a short SOA (say, 50 ms) at which one can safely assume that disengagement has not taken place yet for either the more or the less similar cues, same-location RTs are unaffected by cue-target similarity, yet different-location RTs are longer for the more similar cues. Conversely however, finding faster same-location RTs for the more similar cues would unequivocally validate the claim that attentional settings do affect initial shifts of attention.

In the absence of such a test, the conclusion is that, to date, there is no empirical evidence supporting the slow disengagement hypothesis.

Hypothesis 3. Modulation of disengagement speed by target uncertainty.

The finding that a salient distractor interferes with visual search considerably more when its exact feature is unknown (Theeuwes, 1991) than when it is known (Theeuwes, 1992) poses a problem for the salience-based account. It indicates that in the latter case, attention is guided towards the known feature of the target which boosts the target's attentional priority (e.g., Bravo & Nakayama, 1992; Lamy, Carmel, et al., 2006), therefore reducing distractor interference. Theeuwes (2010) suggested two alternative accounts. On the one hand, he claimed that "when elements switch roles from trial to trial, once attention is captured by the singleton, substantial top-down processing is necessary to determine whether what is selected is the target or not. Consequently, in these types of experiments, interference effects are much larger (p. 89)". In other words, he proposed that disengaging attention from the distractor takes longer when the exact target feature is not known. On the other hand, however, he also suggested that the increased distractor singleton effect is entirely traced back to intertrial priming – which he defines as a bottom-up process – since the increased costs occur only on trials in which the target and the distractor singleton swap identity (p. 14). Thus, both post-perceptual decision processes and bottom-up intertrial priming are brought forward as the exclusive causes for the effects of target uncertainty on distractor interference, each on its own. Yet, the two accounts are incompatible. If disengagement is slowed by target uncertainty thereby increasing distractor interference, then even on trials in which the target repeats, such a disengagement cost should be observed. However, Pinto et al. (2005) showed that it is not the case: distractor interference was the same on repeated-target trials of the unknown-target condition as in the known-target condition.

On the empirical side, there is no strong evidence for either account. On the one hand, the data on which the disengagement-related account relies come from the additional singleton paradigm, which cannot disentangle attentional capture from attentional disengagement. Indeed, the critical measure using this paradigm, namely, the interference associated with the presence of a salient distractor, conflates the two processes. On the other hand, the finding that inter-trial priming modulates distractor interference has been contested. Lamy, Carmel, et al. (2006) showed that distractor interference does not interact with either target or distractor feature repetition (intertrial priming), in blunt contradiction with Pinto et al.'s findings. In a later study, Lamy and Yashar (2008) accounted for this inconsistency by showing that inter-trial priming reduces distractor interference only when conditions of distractor presence are blocked (as was the case in Pinto et al., 2005), and not when they are mixed (as was the case in Lamy, Carmel, et al., 2006). They concluded that when expectations related to distractor presence are equated in the distractor-present and distractor-absent conditions (see also Geyer, Muller, & Krummenacher, 2009) inter-trial priming does not modulate distractor interference and therefore cannot account for the increased vulnerability of unknown-target search relative to known-target search to such interference.

Taken together, the extant literature described by Theeuwes (2010) does not convincingly challenge the idea that the larger distractor interference in the unknown — relative to the known-target condition reflects top-down guidance of attention (e.g., Lamy, Bar-Anan, Egeth & Carmel, 2006).

2. Conclusion

Theeuwes (2010) presented considerable evidence that is compatible with the salience-based account, yet largely ignored evidence that is incompatible with it. In this commentary, I focused on Theeuwes' often ad hoc assumption that certain variables modulate disengagement speed but do not affect attentional capture per se. Although this conjecture may eventually turn out to be valid, I showed that there is currently no sound evidence supporting it.

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