Vision Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

Letter to the Editor

Target activation and distractor inhibition underlie priming of pop-out: A response to Dent (this issue)

ARTICLE INFO

Keywords:
Priming of pop out
Inter-trial priming
Target activation
Distractor inhibition
Visual attention
Visual search
Implicit memory

ABSTRACT

Visual search is faster when the target and distractors features repeat than when they switch on successive trials, a phenomenon known as priming of pop-out (PoP). In previous work, we suggested that two mechanisms, each indexed by a repetition benefit and a switch cost underlie PoP: target activation and distractor inhibition. Consistent with this account, we reported strong correlations between the benefit and cost indexing each mechanism and concluded that there are stable individual differences on target-activation and distractor-inhibition processes. In subsequent work, we noted flaws in our baseline for benefits and costs and suggested a different baseline. Yet, we did not explore the implications of these flaws for our previous conclusions - a gap that Dent (this issue) filled in a large-scale replication of our study. He found our reported correlations to entirely vanish when the corrected baselines are used, whereas repetition benefits were correlated and so were switching costs. He concluded that his findings invalidate the activation-inhibition account of PoP and proposed a hybrid account, according to which repetition effects reflect activation and inhibition, whereas switch costs index a conflict-resolution process. Here, we claim that failure to observe correlations between indices of the same components invalidates the claim that there are stable individual differences on these components but does not challenge the idea that target-activation and distractor inhibition underlie PoP. We reanalyzed the data from four published experiments. As Dent (this issue), we find no correlations between indices of the same component. However, we show that novel predictions of the activation-inhibition components account are supported, whereas the predictions of the conflict-resolution account are disconfirmed.

1. Introduction

In a seminal study, Maljkovic and Nakayama (1994) showed that what observers attend to at a given time affects how their attention is deployed in the few moments that follow. Observers searched for a target defined as the uniquely colored item among homogeneously colored distractors and made a discrimination response regarding its shape. The target and distractors' colors unpredictably either repeated or switched roles from trial to trial. Reaction times (RTs) were substantially faster when the target and distractor colors repeated than when they switched, an effect known as priming of pop out (PoP). This finding was replicated in numerous studies and for a variety of target properties, such as shape (e.g., Lamy, Carmel, Egeth, & Leber, 2006), orientation (Hillstrom, 2000), size (Wolfe, Butcher, Lee, & Hyle, 2003), location (e.g., Maljkovic & Nakayama, 1996) and facial expressions (e.g., Amunts, Yashar, & Lamy, 2014).

1.1. Initial evidence for the activation-inhibition components account of PoP

In a previous paper (Lamy, Antebi, Aviani, & Carmel, 2008) we suggested that two mechanisms underlie PoP: target activation and distractor inhibition. Using a variant of the PoP task in which the target and distractors colors could repeat, exchange roles, or be new, we suggested that the effects of each of these mechanisms could be quantified using two measures: a benefit and a cost. We showed that it is easier to select a target with the same color as the previous target than with a new color (target repetition benefit) and more difficult to reject distractors with the color of the previous target than with a new color (distractor switch cost). We took these two effects to reflect increased target activation, which results from selection of the target's color on the previous trial. Likewise, we showed that it is easier to reject distractors with the same color as the previous distractors than with a new color (distractor repetition benefit) and more difficult to select a target with the color of the previous distractor than with a new color (target switch cost). We took these two effects to reflect increased distractor inhibition, which results from rejection of the distractors' color on the previous trial.

Furthermore, we reported strong correlations between the benefit and cost indexing each mechanism within the same session and across sessions. By contrast, we found no correlation either between the two benefits or between the two costs, that is, between indices related to what we hold to be different mechanisms.

Our conclusion from these findings was two-fold: (1) Independent target-activation and distractor-inhibition mechanisms, each indexed by a repetition benefit and a switch cost, underlie PoP and (2) there are measurable and stable individual differences on each mechanism.

1.2. Dent's evidence against the activation-inhibition components account of PoP

In a later paper (Yashar & Lamy, 2010a), we noted flaws in the baseline used to calculate the benefits and costs in PoP, and suggested a

https://doi.org/10.1016/j.visres.2018.03.009
Received 20 December 2017; Received in revised form 24 February 2018; Accepted 2 March 2018

different baseline[1]. Yet, we did not explore the implications of these flaws for our earlier conclusions - a gap that Dent (this issue) filled in a large-scale replication of our experiment. He showed that while target repetition did not interact with distractor repetition, as reported by Lamy et al. (2008), target switch interacted with distractor switch, in contradiction with Lamy et al. (2008) findings. Moreover and most crucially, he found that the pattern of correlations reported by Lamy et al. (2008) were replicated when their flawed benefit and cost measures were used, yet entirely broke down when the corrected measures proposed by Yashar and Lamy (2010a) were used. Instead, significant correlations between the two repetition benefits and between the two switch costs were found, and none between the benefit and cost taken to index target activation nor between the benefit and cost taken to index distractor inhibition.

Dent (this issue) concluded that these results are "at odds with the suggestion of Lamy et al. (2008) that PoP is driven by two primary factors one related to distractor inhibition and one related to target activation, with each reflected in one switch and one repetition effect".

1.3. Objective of the present paper

The correlation data provided by Dent (this issue) are fully convincing and provide a crucial rectification of erroneous inferences drawn by Lamy et al., 2008. However, we disagree with his conclusion that his findings refute the activation-inhibition account of PoP. The primary objective of this paper is to put forward the arguments that lead us to such disagreement.

Dent's (this issue) conclusion relies on four claims. (1) The absence of a correlation between target repetition benefit and distractor switch cost, and between distractor repetition benefit and target switch cost, is incompatible with the claim that these index the same target-activation and distractor-inhibition mechanism, respectively. (2) The presence of an interaction between target and distractor switch costs is incompatible with the idea that the effects of target and distractor switching are independent measures of target activation and distractor inhibition. (3) Previous findings (Lamy et al., 2013), showing that both distractor inhibition indices are present in orientation singleton search and both target activation indices are absent, do not necessarily support the components account. (4) The correlations between repetition benefits and between switch costs, as well as the finding that the latter two interact with each other, suggest that repetition benefits index the same mechanism, which is different from the mechanism underlying switch costs.

We address each of these claims below and then present new evidence in favor of the components account. Before we do, however, it is important to clarify what the notions of target activation and distractor inhibition stand for in our account.

1.4. Clarification of the notions of target activation and distractor inhibition according to the components account

In our original paper, we suggested two possible interpretations of our findings (Lamy et al., 2008, p.39). Specifically, we proposed that increased target activation and distractor inhibition following target selection and distractor rejection on the previous trial may reflect either (a) the modulation of the preattentive representation of these features or (b) processes that occur at selection (i.e., attentional shifts or attentional engagement) after the target is detected. More recent findings from our lab allowed us to test these accounts against each other and clearly supported the latter.

We first demonstrated that PoP does not reflect only perceptual effects but also later, response-related effects (Lamy, Yashar, & Ruderman, 2010). We showed that the perceptual component of PoP (which we hold to consist of a target-activation and distractor-inhibition subcomponents), was apparent early in a search trial and was not affected by response factors. By contrast, the response-based component of PoP emerged later during search as an interaction between target-distractor repetition/switch and response repetition, which we showed to be driven by motor response repetition rather than by response repetition (Yashar & Lamy, 2011; Yashar, Makovski, & Lamy, 2013).

More critically for the present purposes, we further characterized the perceptual component of PoP in a series of studies showing that PoP does not affect the early, preattentive stage of perceptual processing that determines attentional salience, but a later stage, during which attention is engaged to the target and response-relevant features are extracted. Specifically, we showed that (a) selecting a given feature on a previous trial does not increase attentional capture by this feature on the current trial (Biderman, Biderman, Zivony, & Lamy, 2017; see also Yashar, White, Fang, & Carrasco, 2016; see Lamy & Kristjansson for a review); repeating the target and distractor features from one trial to the next (b) does not reduce search slopes (Amunts et al., 2014), (c) improves performance during temporal search in the absence of spatial uncertainty (Yashar & Lamy, 2010b) and (d) improves search accuracy under limited stimulus exposure conditions only when the task requires focal attention (i.e., in fine discrimination task but not in a coarse localization task).

Thus, target activation and distractor inhibition arise from the previous selection episode and come into play after stimulus-driven and goal-directed factors have determined attentional salience and a candidate target is detected: the larger the activation level of the current target feature relative to the activation level of the current distractor feature in a given search display, the faster attentional engagement to the target[2].

2. Responses to Dent (this issue) claims

2.1. Claim 1: absence of a correlation between indices of the same component

The absence of a correlation between indices of the same component convincingly demonstrates that there are no stable individual differences on target activation and distractor inhibition measures. It suggests that a given individual's visual search performance may rely on each of these processes to different extents from trial to trial.

However, it is important to underscore that target activation and distractor inhibition may nonetheless prove to be distinct, dissociable processes even if there are not stable individual differences on the benefits and costs that we take to index them. Finding manipulations that selectively affect the indices reflecting one mechanism, while leaving the indices reflecting the other mechanism intact would constitute solid evidence for a dissociation.

[1] The original analyses pertaining to conditions of target-color variation (repeated, new, switched) were conducted across distractor-color conditions, and the analyses pertaining to conditions of distractor-color variation (repeated, new, switched) were conducted across target-color conditions. Yashar and Lamy (2010a) noted that this procedure resulted in biased sampling of the orthogonal dimension: for instance, in the repeated- vs. new-target-color comparison used to measure the target-activation benefit, the repeated-target condition included only repeated- and new-distractor trials, whereas the new-target condition included also switched-distractor trials. Thus, activation effects were contaminated by inhibition effects, and vice versa. In order to address this problem, we suggested a different procedure for measuring repetition benefits and switch costs. Specifically, the baseline for repetition effects no longer included switched-feature trials and the baseline for switching effects no longer included repeated-feature trials. This procedure was used by the subsequent papers pertaining to target and distractor inter-trial variations published by our group (Lamy, Zivony, & Yashar, 2011; Lamy, Yashar, and Ruderman, 2013; Yashar & Lamy, 2010).

[2] Lleras and colleagues (e.g., Tseng, Glaser, Caddigan, & Lleras, 2014; Wan & Leeras, 2010) offered a similar account of the distractor previewing effect (DPE), which refers to slower identification of a color singleton when the distractor color vs. the target color was viewed in the preceding target-absent trial. They characterized the stage at which DPE operates as an "attentional-decision" stage.