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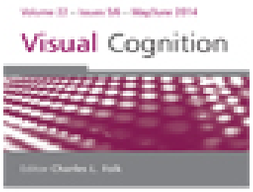

Visual Cognition

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/pvis20

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To cite this article: Martin Eimer (2021): Why signal suppression cannot resolve the attentional capture debate, Visual Cognition, DOI: 10.1080/13506285.2021.1904075

To link to this article: https://doi.org/10.1080/13506285.2021.1904075

VISUAL COGNITION
https://doi.org/10.1080/13506285.2021.1904075

Why signal suppression cannot resolve the attentional capture debate

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ABSTRACT

Luck et al. (2021, Progress toward resolving the attentional capture debate. *Visual Cognition*, *29*(1), 1–21. https://doi.org/10.1080/13506285.2020.1848949) propose that proactive suppression can help to resolve the long-standing attentional capture debate. They argue that salient but task-irrelevant stimuli automatically generate a priority signal, which leads to attentional capture if it is not suppressed. While this signal suppression framework provides a refreshing new perspective on attentional capture, it cannot fully resolve this debate. To do this, it would have to be demonstrated that task-contingent capture effects in spatial cueing tasks are linked to proactive feature-based suppression preventing attentional capture by salient but irrelevant objects. I argue that there is little evidence if any evidence for such a link. I consider possible reasons why suppression does not seem to play a major role in spatial cueing tasks, and also highlight important general limitations of proactive inhibitory control in visual search.

ARTICLE HISTORY
Received 22 February 2021
Accepted 11 March 2021

KEYWORDS
Attentional capture; visual search; spatial cueing

The attentional capture debate is very much a tale of two paradigms. Evidence for stimulus-driven capture is typically found with visual search displays that contain an additional singleton distractor, while support for task-set contingent capture is usually obtained in experiments that employ spatial cueing procedures. Luck et al. (2021) present good evidence for the feature-based proactive suppression of salient additional singletons in visual search displays under certain circumstances. This suppression is reflected by behavioural costs in probe trials, reduced oculomotor capture, and the presence of inhibition-related Pd components. As the attentional capture debate is fuelled by the fact that the additional singleton and spatial cueing paradigms produce apparently contradictory findings, resolving this debate would require equally strong evidence that contingent capture effects observed with spatial cueing result from the proactive feature-specific suppression of task-unrelated salient cue items. However, no such evidence is provided in this review article, which focuses exclusively on the suppression of distractor singletons in visual search displays.

The absence of such evidence is no coincidence – there appears to be little empirical support for links between feature-based signal suppression and task-set contingent attentional capture effects in the spatial cueing paradigm. It is true that several behavioural studies have found costs for targets that appear at a location previously occupied by a target-non-matching singleton cue (reviewed by Carmel & Lamy, 2014). At first sight, these same-location costs appear similar to the costs observed in the additional singleton paradigm on probe trials (Gaspelin et al., 2015), which makes it tempting to interpret them as evidence for feature-specific suppression. However, Carmel and Lamy (2014) have provided compelling evidence against this interpretation, by demonstrating that these costs occur not only when irrelevant singleton cues always have the same colour but also when their colour changes unpredictably across trials. Based on these findings, they proposed that same-location costs are unrelated to feature inhibition, and instead reflect costs associated with object updating. Further evidence against the involvement of feature-selective signal suppression in the spatial cueing paradigm comes from ERP studies of contingent capture conducted in our and other labs. These studies have consistently shown that while target-matching colour singleton cues trigger clear N2pc components associated with attentional capture, nontarget-colour singleton cues usually do

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not elicit any Pd components indicative of the distractor suppression, even when these cues produce reliable same-location costs (e.g., Eimer et al., 2009). While the absence of evidence is not necessarily evidence of absence, these observations contrast with the fact that reliable Pd components have been commonly observed in the additional singleton paradigm.

Perhaps the strongest evidence against the hypothesis that the proactive suppression of task-irrelevant singleton cues is responsible for the task-set contingent nature of spatial cueing effects was provided by Lien et al. (2010). These authors employed the spatial cueing paradigm in the context of a task switching design where two colour-defined targets alternated every second trial, and observed strong contingent capture effects under these conditions. Critically, when cue displays included a colour singleton that matched the target colour on the immediately preceding trial but was irrelevant for the current trial, there was no indication of any spatial cueing effects indicative of attentional capture. The inability of these colour singletons to attract attention cannot be due to feature-specific proactive signal suppression. It has been repeatedly shown that this type of inhibition cannot be set up on a trial-by-trial basis, but instead requires possibly hundreds of trials before it becomes effective (e.g., Berggren & Eimer, 2021; Cunningham & Egeth, 2016). Thus, the results of Lien et al. (2010) strongly suggest that activating a task set for a particular target feature is sufficient for salient but non-matching singleton cues to be ignored, without any involvement of feature-specific suppression. Overall, these findings strongly suggest that proactive inhibition as described by the signal suppression hypothesis is not responsible for task-set contingent nature of attentional capture effects observed in the spatial cueing paradigm. If the signal suppression cannot account for these effects, its chances for resolving the attentional capture debate appear slim.

This also raises the intriguing question why salient distractor features can be subject to proactive suppression in visual search displays, but are not suppressed when they appear in cue displays. It is possible that the point in time when the critical salient singleton items are presented – either prior to a search display (spatial cueing paradigm) or simultaneously with the target in the search display (additional singleton paradigm) – is a critical factor. We have recently shown that the activation of attentional task sets for target-defining features builds up gradually during the preparation for an upcoming search display (Grubert & Eimer, 2018). The start of feature-specific proactive suppression might be similarly sensitive to temporal expectations about search display onset, and is perhaps even more strongly tuned to search display onset than proactive facilitation. This would result in weak or absent suppression of task-irrelevant singletons in cue displays. Alternatively, distractor suppression could be the result of the pre-attentive detection of target-matching features in a search display, which signal the presence of a candidate target object at a specific location, and trigger the allocation of attention to this location. Such attention shifts might be accompanied by a concurrent suppression of potentially interfering salience signals from other locations – a type of target-driven reactive suppression that would be quite different from proactive inhibition, and also from reactive suppression that might follow any salience-triggered attentional capture. We have previously shown with ERP markers that distractor suppression in the additional singleton paradigm may be more strategic than is commonly assumed (Kiss et al., 2012). Additional distractor singletons captured attention (as reflected by N2pc components) under conditions where search displays remained visible until response execution, so that there was little risk that attentional capture would prevent target identification. In contrast, the same singletons were instead inhibited (as reflected by Pd components) when search display duration was very short (200 ms), and any attentional capture by singletons would have interfered strongly with the detection of search targets. These observations make it conceivable that target-induced singleton suppression might be triggered only under conditions where preventing distractor interference is essential for successful target processing. If this type of distractor suppression is sensitive to the temporal demands of a search selection task, it would suggest that it does not simply reflect local lateral inhibitory links between the target and the singleton distractor, as such links should be independent of any top-down strategic control.

Finally, while there is good evidence that proactive suppression can be activated under certain conditions by salient distractors in visual search displays, this type of inhibition appears to be much more effective when

it is location-based (e.g., when distractors are likely to be presented in one particular location; Wang & Theeuwes, 2018) than when it operates on non-spatial features. In fact, the scope and adaptive utility of feature-based proactive suppression appears remarkably limited. Apart from the possibility that it is only effective with relatively small display set sizes, it also requires repeated exposure to the same singleton distractor over a large number of trials (e.g., Cunningham & Egeth, 2016; Gaspelin & Luck, 2018). This is in sharp contrast with the activation of proactive task sets for target features, which can be regulated flexibly on a trial-by-trial basis. If feature-based signal suppression only becomes available after extended practice in a specific visual search task, it is unclear how useful such a mechanism will be in more ecologically valid real-world search contexts which rarely afford the possibility of extensive feature-specific learning. The slow build-up of feature-specific suppression effects also raises the possibility that instead of reflecting proactive inhibition, it might at least in part be the result of passive habitation (e.g., Berggren & Eimer, 2021; Turatto et al., 2018).

Overall, signal suppression is clearly an important factor that needs to be taken into account in models of stimulus-driven and task-set contingent attentional capture. However, proactive feature-based inhibitory control appears to operate only in a quite narrow range of circumstances, and does not seem to play a major role in experimental tasks that have obtained the strongest empirical evidence for contingent attentional capture. For these reasons, the signal suppression account is unlikely to provide a comprehensive resolution of the attentional capture debate.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Berggren, N., & Eimer, M. (2021). The guidance of attention by templates for rejection during visual search. *Attention, Perception, & Psychophysics*, *83*(1), 38–57. https://doi.org/10.3758/s13414-020-02191-z

Carmel, T., & Lamy, D. (2014). The same-location cost is unrelated to attentional settings: An object-updating account. *Journal of Experimental Psychology: Human Perception and Performance*, *40*(4), 1465–1478. https://doi.org/10.1037/a0036383

Cunningham, C. A., & Egeth, H. E. (2016). Taming the white bear: Initial costs and eventual benefits of distractor inhibition. *Psychological Science*, *27*(4), 476–485. https://doi.org/10.1177/0956797615626564

Eimer, M., Kiss, M., Press, C., & Sauter, D. (2009). The roles of feature-specific task set and bottom-up salience in attentional capture: An ERP study. *Journal of Experimental Psychology: Human Perception and Performance*, *35*(5), 1316–1328. https://doi.org/10.1037/a0015872

Gaspelin, N., Leonard, C. J., & Luck, S. J. (2015). Direct evidence for active suppression of salient-but-irrelevant sensory inputs. *Psychological Science*, *26*(11), 1740–1750. https://doi.org/10.1177/0956797615597913

Gaspelin, N., & Luck, S. J. (2018). Distinguishing among potential mechanisms of singleton suppression. *Journal of Experimental Psychology: Human Perception and Performance*, *44*(4), 626–644. https://doi.org/10.1037/xhp0000484

Grubert, A., & Eimer, M. (2018). The time course of target template activation processes during preparation for visual search. *The Journal of Neuroscience*, *38*(44), 9527–9538. https://doi.org/10.1523/JNEUROSCI.0409-18.2018

Kiss, M., Grubert, A., Petersen, A., & Eimer, M. (2012). Attentional capture by salient distractors during visual search is determined by temporal task demands. *Journal of Cognitive Neuroscience*, *24*(3), 749–759. https://doi.org/10.1162/jocn_a_00127

Lien, M. C., Ruthruff, E., & Johnston, J. C. (2010). Attentional capture with rapidly changing attentional control settings. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(1), 1–16. https://doi.org/10.1037/a0015875

Luck, S. J., Gaspelin, N., Folk, C. L., Remington, R. W., & Theeuwes, J. (2021). Progress toward resolving the attentional capture debate. *Visual Cognition*, *29*(1), 1–21. https://doi.org/10.1080/13506285.2020.1848949

Turatto, M., Bonetti, F., & Pascucci, D. (2018). Filtering visual onsets via habituation: A context-specific long-term memory of irrelevant stimuli. *Psychonomic Bulletin & Review*, *25*(3), 1028–1034. https://doi.org/10.3758/s13423-017-1320-x

Wang, B., & Theeuwes, J. (2018). Statistical regularities modulate attentional capture. *Journal of Experimental Psychology: Human Perception and Performance*, *44*(1), 13–17. https://doi.org/10.1037/xhp0000472