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Do we need attentional suppression?

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ABSTRACT
Gaspelin and Luck describe the signal suppression hypothesis, which proposes that attentional suppression prevents the capture of visual attention by salient distractors. We will discuss several problems with this proposal. On a theoretical level, we will argue that attentional suppression is a dispensable mechanism. Most effects of attentional suppression can be easily explained by reduced target expectancy at the distractor location. On an empirical level, we will argue that electrophysiological evidence for attentional suppression is spurious because, in key conditions, the P_D most likely reflects idiosyncratic scan paths.

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Commentary

Many articles on visual attention start with the sentence that the human visual system must select a few from a multitude of available stimuli. The most-cited reason for selection is the brain's limited capacity to process information. At a neuronal level, the corresponding reason may be that only a small fraction of cortical neurons can fire at the same time because the available energy to support neuronal activity is limited. Lennie (2003) estimated that less than 10% of the human cortex can be simultaneously active at a rate of 50 spikes per second. Therefore, the brain's energy consumption limits the number of tasks that the brain can accomplish at the same time. Because of this restriction, any theory of visual attention needs to carefully evaluate whether the proposed mechanisms are necessary to accomplish the selection of relevant information.

There seems a little doubt that visual processing needs to bias or guide attentional selection toward relevant stimuli. For instance, the biased competition theory by Desimone and Duncan (1995) supposes that a representation of the target stimulus in working memory (i.e., the attentional template) increases the chances that a matching stimulus wins the competition for representation against other stimuli in a cell's receptive field. In a similar vein, Wolfe's (1994) guided search theory or Müller et al.'s (1995) dimensional weighting theory assume that locations with stimuli matching the attentional template are enhanced.

Gaspelin and Luck propose to add the suppression of salient distractors to the list of mechanisms necessary for visual attention. Gaspelin and Luck stress that attentional suppression takes place in a "proactive" fashion. One would therefore expect that some neurons start firing in order to suppress the activity in neurons representing the distractor location or feature. In one electrophysiological study on this question, Cosman et al. (2018) show that the firing rate of prefrontal neurons increase once visual stimuli are shown in their receptive field. If a salient distractor is shown among those stimuli, the increase in firing rate is reduced. Some ∼50 ms later, the firing rates of neurons in the extrastriate cortex are also reduced. Thus, prefrontal and extrastriate neurons are "suppressed" relative to baseline firing rate with inconspicuous distractors. While these results are impressive, they do not provide direct evidence for the suppressive mechanism, which would become active at the time of distractor presentation. That is, it remains unclear where attentional suppression originates.

In addition, the reduced firing rates are subject to alternative interpretations. The salient distractor in Cosman et al. (2018) and in Gaspelin and Luck's work

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was never the target, consistent with the design of Theeuwes's additional singleton paradigm (see Figure 1(b) in Luck et al., 2021). Thus, a location containing the salient distractor had a zero probability of containing the target and could be excluded from the search. Distractor exclusion was promoted by the search task used in Cosman et al. (2018) and most of Gaspelin and Luck's work. In their feature search tasks, the target was not salient and a search for specific target features was required (see Figure 1(b) in Luck et al., 2021). However, attentional capture only occurs in search tasks where the target is salient and participants adopt a strategy of searching for any salient stimulus ("singleton search," Bacon & Egeth, 1994).

In Cosman et al. (2018), visually responsive neurons increased their firing rates when the target was shown inside their receptive fields. Because the search displays required feature search, it appears unlikely that a distractor shown in the receptive field captured attention. Rather, Cosman et al. (2018) observed reduced firing rates when a distractor was shown, which may reflect the zero probability of target presentation at the location of the salient distractor. In a similar vein, the reduced probability of first saccades going to the location of the salient distractor in Figure 3(a) of Luck et al. (2021) could simply reflect the zero probability that the distractor location contained the target.

Therefore, it may be that the reduction of target-related processes at the distractor location, which was induced by the design of the experiments, accounts for putative effects of attentional suppression in Cosman et al. (2018) and Luck et al. (2021, Figure 3(a)). Alternative explanations may also be found for electrophysiological evidence of attentional suppression coming from the P_D-component (Hickey et al., 2009). Gaspelin and Luck (2018) found a P_D to salient distractors in a condition where reaction times decreased in the presence of the distractor instead of the typical increase resulting from attentional capture. They proposed that attentional suppression of the salient distractor, as indexed by the P_D, allowed for the reduction of reaction times (see Figure 3(d) in Luck et al., 2021). However, the red solid line in Figure 3(d) shows a biphasic pattern where the P_D-component to the salient distractor was followed by a contralateral negativity to the salient distractor. The contralateral negativity, the N2pc, is considered an index of attentional selection (Eimer, 1996). While the biphasic response was already found to be reliable in Experiment 3 of Gaspelin and Luck (2018), it was more systematically explored by Kerzel and Burra (2020) who pointed out that the sequence of P_D and N2pc would indicate that attentional suppression was followed by attentional capture. However, Gaspelin and Luck proposed that attentional suppression prevents attentional capture. Therefore, Figure 3(d) of Luck et al. (2021) does not provide any evidence for the attentional suppression hypothesis. Rather, the results may reflect idiosyncratic scanning strategies. Possibly, participants scan the element opposite to the salient distractor before they return to the salient distractor (Kerzel & Burra, 2020). This idiosyncratic scanning strategy does not help participants to locate the target and it is unclear why it is consistently applied to small search displays. However, the more general point is that the P_D component provides only limited support for attentional suppression of salient distractors as a shift of visual attention to the opposite side would result in the same event-related potential. Furthermore, the temporal variability of the P_D is implausible for a process thought to counter bottom-up interference.

In sum, the results in favour of attentional suppression need more support as alternative accounts can be easily put forth. In light of the limited energy supply available to cortical neurons, it seems more reasonable to propose an alternative solution to the problem of salient distractors. It would cost the least amount of energy if visually selective neurons did just nothing. That is, ignoring salient distractors may be the cheapest solution. Given the limited supply of energy, passive ignoring seems preferable over active suppression. Recent studies with appropriate control conditions showed that attentional capture does not occur at ignored locations (Ruthruff & Gaspelin, 2018) and that behavioural evidence for attentional suppression was better explained by attentional capture through context elements (Schönhammer et al., 2020). In conclusion, the evidence for attentional suppression is mixed and importantly, convincing evidence for attentional suppression from single-cell recording or electrophysiology is missing.

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References

Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Perception & Psychophysics*, *55*(5), 485–496. https://doi.org/10.3758/BF03205306

Cosman, J. D., Lowe, K. A., Zinke, W., Woodman, G. F., & Schall, J. D. (2018). Prefrontal control of visual distraction. *Current Biology*, *28*(3), 414–420.e3. https://doi.org/10.1016/j.cub.2017.12.023

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience*, *18*(1), 193–222. https://doi.org/10.1146/annurev.ne.18.030195.001205

Eimer, M. (1996). The N2pc component as an indicator of attentional selectivity. *Electroencephalography and Clinical Neurophysiology*, *99*(3), 225–234. https://doi.org/10.1016/0013-4694(96)95711-9

Gaspelin, N., & Luck, S. J. (2018). Combined electrophysiological and behavioral evidence for the suppression of salient distractors. *Journal of Cognitive Neuroscience*, *30*(9), 1265–1280. https://doi.org/10.1162/jocn_a_01279

Hickey, C., Di Lollo, V., & McDonald, J. J. (2009). Electrophysiological indices of target and distractor processing in visual search. *Journal of Cognitive Neuroscience*, *21*(4), 760–775. https://doi.org/10.1162/jocn.2009.21039

Kerzel, D., & Burra, N. (2020). Capture by context elements, not attentional suppression of distractors, explains the P_D with small search displays. *Journal of Cognitive Neuroscience*, *32*(6), 1170–1183. https://doi.org/10.1162/jocn_a_01535

Lennie, P. (2003). The cost of cortical computation. *Current Biology*, *13*(6), 493–497. https://doi.org/10.1016/S0960-9822(03)00135-0

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

Müller, H. J., Heller, D., & Ziegler, J. (1995). Visual search for singleton feature targets within and across feature dimensions. *Perception & Psychophysics*, *57*(1), 1–17. https://doi.org/10.3758/BF03211845

Ruthruff, E., & Gaspelin, N. (2018). Immunity to attentional capture at ignored locations. *Attention, Perception, & Psychophysics*, *80*(2), 325–336. https://doi.org/10.3758/s13414-017-1440-4

Schönhammer, J. G., Becker, S. I., & Kerzel, D. (2020). Attentional capture by context cues, not inhibition of cue singletons, explains same location costs. *Journal of Experimental Psychology: Human Perception and Performance*, *46*(6), 610–628. https://doi.org/10.1037/xhp0000735

Wolfe, J. M. (1994). Guided search 2.0: A revised model of visual search. *Psychonomic Bulletin & Review*, *1*(2), 202–238. doi:10.3758/BF03200774