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VISUAL COGNITION
https://doi.org/10.1080/13506285.2021.1892894

Time to stop calling it attentional "capture" and embrace a mechanistic understanding of attentional priority

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ABSTRACT
In the target article, Luck et al. [2020. Progress toward resolving the attentional capture debate. *Visual Cognition*. doi:10.1080/13506285.2020.1848949] argue for progress that has been made in the attentional capture debate, offering points of agreement in addition to highlighting specific outstanding issues that could contribute to further resolution. This commentary questions the most fundamental assumption on which the debate rests: namely that the computation of attentional priority can culminate in a quantal event in which attention can be said to have been captured. The notion of attention-as-capturable leads to a forced dichotomy with respect to the occurrence of capture that undergirds the arguments forwarded by Luck et al. (2020), a dichotomy predicated on arbitrary lines of demarcation over a continuous and temporally-unfolding mental process distributed over multiple regions of the brain. These lines of demarcation serve to perpetuate claims that one type of stimulus either does or does not qualify as capturing attention under particular experiment conditions, on which this entire debate rests. I argue that it is more productive to conceptualize issues surrounding the control of attention in terms of the computation of attentional priority, which naturally links together goal-directed and stimulus-driven influences in a richer and more coherent way.

ARTICLE HISTORY
Received 14 January 2021
Accepted 16 February 2021

KEYWORDS
Attentional capture; selective attention; visual search; signal suppression; salience

Attentional capture is a concept in the scientific literature used to refer to instances in which observers fail to ignore a task-irrelevant stimulus. A seemingly straightforward question that can be posed in research on attentional control is whether a certain kind of stimulus can capture attention. Researchers of attentional control have long debated whether physically salient stimuli automatically capture attention independently of the cognitive state of the observer or whether such stimuli can be ignored on the basis of this control state (e.g., Folk & Remington, 2010; Theeuwes, 2010).

The concept of signal suppression, pioneered by Luck and Gaspelin (Gaspelin & Luck, 2018; Sawaki & Luck, 2010) offers an intermediate position in this debate by postulating that the ability to overcome distraction by a physically salient stimulus can in some instances be considered an active cognitive process subsumed by a dedicated mechanism of information processing. They argue that physically salient stimuli generally have high attentional priority and compete for selection (generate an "attend-to-me" signal), and the failure of a physically salient stimulus to capture attention can in some instances be accounted for by this suppression mechanism preventing capture. Their position allows for physically salient stimuli to have a privileged status in the computation of attentional priority—one that is independent of the cognitive state of the observer—without such stimuli necessarily capturing attention, thereby offering a framework with which previously conflicting findings concern when attentional capture does and does not occur can be reconciled. Using this framework as a foundation in the target article, Luck et al. (2020) offer some key assertions that are presented as consensus ground truth in the debate surrounding the control of attention.

First of all, I think the central tenant of this paper is commendable. On the surface, I am sure the agreed-upon points appear as small concessions to someone from outside of the field of attentional control. To see this combination of authors formally agree to

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assertions that affirm both the influence of physical salience and the modulatory role of goal-directed influences on the control of attention, however, reflects a signal service to the field that should not be taken lightly. It is a formal proclamation that historical "hard line" positions on the debate should no longer be considered tenable, which was not the case until more recently.

Although I could weigh in on the points of disagreement that remain among the three overarching perspectives on attentional capture offered in Luck et al. (2020), I think it would be more productive for me to devote the remainder of this commentary to what I find to be a fundamental issue with the terms of the debate itself. Specifically, I will offer a critical view of the very concept of attention as capturable, upon which this entire debate rests. To me, this is the key question we need to be thinking about when we read Luck et al. (2020) or more broadly consider the attentional capture debate: At what point can the capture of attention be said to have occurred, as though attention somehow decided to grab hold of something then and there?

The distinction between attentional capture and an "attend-to-me" signal that is subject to suppression (Sawaki & Luck, 2010) has always seemed forced to me. Although a formal definition of the concept remains elusive, the putative "attend-to-me" signal often reads as tantamount to priority in the attention system—a physically salient stimulus evokes a stronger sensory response which feeds forward into a priority map of some sort where competition with at least one other source of priority (e.g., modulation by task goals) occurs. From the evidence presented by Luck et al. (2020), it is certainly reasonable to assert that, under certain circumstances, stimulus-driven influences (i.e., the effects of physical salience) can be suppressed at different stages of the computation of attentional priority. However, postulating a suppressive mechanism by which attentional capture can be averted still demands a formal definition of the very thing that is purportedly averted—a criterion for determining when priority "crosses the line" and becomes or produces capture. As will be argued in this commentary, the field of attentional control has no such criterion that can withstand scrutiny.

Priority in the attention system unfolds dynamically via stimulus-driven input and feedback loops, probably at multiple levels throughout the brain (e.g., Anderson, 2019; Corbetta & Shulman, 2002). Such priority clearly guides eye movements or *overt attention* (Thompson et al., 2005), which when directed to a task-irrelevant distractor is one frequently relied-upon indicator of attentional capture (e.g., Anderson & Kim, 2019; Ludwig & Gilchrist, 2002; Theeuwes et al., 2003). The act of initiating a saccade to a stimulus seems like an insufficient criterion for defining attentional capture, though, given that this act is subject to decision thresholding and appears to simply follow from the state of the priority map at the time of saccade initiation (Thompson et al., 2005; van Zoest et al., 2004). It also reduces the concept of attention to a motor action, which offers an incomplete understanding of selective information processing (Posner, 1980). In this context, it is perhaps unsurprising that the timing of stimulus presentation in attention tasks (Theeuwes, 2010) and the difficulty of resolving (and thus time required to resolve) target–non-target competition (Gaspelin et al., 2016) have served as bones of contention in the attentional capture debate.

This same core issue crops up when distinguishing between attentional capture and a filtering cost (e.g., Becker, 2007), which reflects another historical bone of contention in the attentional capture debate. If priority unfolds dynamically, whether a slowing in target report is accompanied by a spatially-localized effect of a salient distractor on behaviour may simply boil down to the stage of information processing at which priority became sufficiently differentiated between the distractor and target, along with the speed with which participants are required to make a perceptual judgment. Reducing attentional capture to the presence of such a behavioural effect is arbitrary and too simplistic.

Another candidate for defining capture might be the act of shifting attention, which can be measured from brain activation and reflects a transient, time-locked neural event that could be argued to be quantal in nature (Corbetta & Shulman, 2002; Yantis et al., 2002). However, such attention shifts can be recruited in the absence of stimulus-driven input (Gmeindl et al., 2016) and may better reflect changes in the nature of the biasing signals applied to the priority map or its constituent inputs. Likewise, electroencephalographic (EEG) correlates of attentional "capture" (discussed in Luck et al., 2020) could simply reflect the readout of a priority map at some stage of computation or the engagement of a shifting mechanism. As someone who has studied attentional capture my entire career, I am myself hard-pressed to identify a specific set of criteria for defining whether and when the phenomenon of "capture" occurs that does not devolve into a behavioural consequence of attentional priority or its neural correlates.

While Luck et al. (2020) highlight legitimate progress that has been made in the attentional capture debate, my read of their discussion leads me to wonder whether the very terms of the debate are predicated on a theoretically questionable assumption about the nature of attentional priority as culminating in a quantal event called "capture," an idea borne out of historical terminology and thinking rooted in behavioural paradigms. If the capture of attention is in fact a quantal event that can be readily defined in an agreed upon way, a productive conversation about what does and does not capture attention under different contexts and situations would make sense. I think the more the debate on attentional capture has progressed, however, the clearer it has become that such a conception of attention as "capturable" is indefensible; it at best reflects an impoverish definition of attention that forces a dichotomy onto a continuous, dynamic, and distributed representation. In scientific practice, this dichotomy engenders arbitrary lines of demarcation by which the field has attempted to judge whether a particular stimulus has met some bar for having "captured" attention, which is then interpreted as favouring either a stimulus-driven or goal-contingent account. As I read Luck et al. (2020), I wonder what the literature on attentional control would have looked like had our scientific pursuits been framed along the lines of developing a mechanistic understanding of the computation of attentional priority, and whether the battle lines would have ever been as sharp as they were or whether the word "debate" would even come to mind today.

What we really need to do as a field is move towards a mechanistic understanding of the nature of attentional priority computations. What are the specific feedback loops within which attentional priority is modulated by goals, and how are such goals represented in the brain (e.g., Woodman et al., 2013)? At what stage of the computation of attentional priority do suppressive mechanisms reduce the priority of physically salient stimuli (e.g., Gaspelin & Luck, 2018), and what are the specific control mechanisms by which such suppression is implemented? Salience with respect to local feature contrast can emerge at varying stages in the visual hierarchy (brightness, colour contrast, shape contrast, emergent features from global configuration); do suppressive mechanisms operate on priority only at a later (common) stage of information processing (e.g., Awh et al., 2012) or multiple stages depending on the nature of the salience? What are the different mechanisms by which the computation of attentional priority is shaped by learning, and how is their influence distributed across the brain (e.g., Anderson, 2019)? How is the computation of attentional priority modulated by contextual factors (e.g., Anderson, 2015; Gregoire et al., in press)? How do different mechanisms of computing attentional priority relate to (e.g., Kim & Anderson, 2019) and interact with each other (e.g., Kim & Anderson, 2021)? Addressing questions like these will provide a much richer understanding of the nature of attentional control that will obviate any debate over whether a particular type of stimulus qualifies as capturing attention and will instead provide the grounds for more precise prediction of the nature of the attentional processing given a particular array of stimuli and task conditions.

You read the word "priority" multiple times in Luck et al. (2020). This reflects a broader historical shift in the terminology used by scientists in the attentional capture debate, myself included. In my opinion, Luck et al. (2020) serves as a case-in-point that the term "attentional capture" has outlived its theoretical utility. It illustrates why we need to embrace a conversation about the nature of attentional priority that leaves not only the attentional capture debate but the very conception of attention-as-capturable in the historical past.

Disclosure statement

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

Funding

This work was supported by National Institute on Drug Abuse [grant number R01-DA046410].

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