Author Preprint

Current Opinion in Psychology

Attention and Perception: 40 reviews, 40 views

Joy J. Geng
Department of Psychology, Center for Mind and Brain at University of California Davis

Andrew B. Leber
Department of Psychology and Center for Cognitive & Brain Sciences, The Ohio State University

Sarah Shomstein
Department of Psychological and Brain Sciences, George Washington University

We are pleased to present this special issue on Attention and Perception, which covers some of the newest and most exciting developments in the field. Although studies of attention were amongst the earliest experimental investigations focused on uncovering psychological mechanisms ((Helmholtz, 1896) cited in (Carrasco, 2011; Nakayama & Mackeben, 1989)), the field has expanded considerably over the decades. This expansion reflects the many ways in which the mechanisms of attention are central to perception and cognition. However, it has been a mixed blessing. On the one hand, it speaks to the rich contribution of attentional mechanisms in information processing. On the other hand, it has led to a state in which the word "attention" has come to mean different things to different subfields. In this special issue, we present 40 articles that illustrate the breadth of research in which attention is thought to play a critical role.

We approached this issue with two major purposes. First, for those who are new to the study of attention, this issue will introduce recent approaches to studying this central cognitive function that showcase the sophisticated convergent methodologies that can be used for this line of inquiry. Second, for those who are expert in this field, the breadth of articles in this issue will offer new, interesting, and provocative ideas for future research. Below we describe clusters of these reviews and highlight the original bedrock topics in attention from which they developed. We believe that these reviews reflect the extent of methodological practices and current state of the art for various attentional mechanisms and as such serves as a catalogue for the scope of attentional processing.

Traditional cognitive models of attention have focused on the dichotomy between "top-down" attentional signals that originate from volitional, endogenous signals within the observer and "bottom-up" signals based on sensory salience present in the environment (Egeth & Yantis, 1997). However, recent theories posit multiple sources of information that are neither purely volitional nor entirely based on sensory salience. Several current reviews discuss how these other sources of information contribute to determine attentional priority, including priming (Kristjansson & Asgeirsson, 2018), selection history (Theeuwes, 2019), reward associations (Anderson, 2018), learned habits (Jiang & Sisk, 2018), self-related information (Sui & Rotshtein, 2019), and interactions between prior knowledge of real-world objects (Shomstein, Malcolm, & Nah, 2019), scenes (Vo, Boettcher, & Draschkow, 2019), and distractor context (Geng & Witkowski, 2019). Two articles address strategic factors that impact individual attentional abilities (Esterman & Rothlein, 2019; Leber & Irons,

2019), and one summarizes methodological tools to probe strategy use in attention-related tasks (Leber & Irons, 2019). Many of these reviews underscore that a major future challenge will be to understand how different internal and task-related sources of information are integrated during complex behaviors in real world environments.

The study of the brain mechanisms underlying attention has historically been divided between those that modulate sensory "site" regions, and those that set attentional priority in higher order network of "source" regions (Reynolds & Chelazzi, 2004). Foundational work on "site" regions has shown that attention operates by modulating sensory processing to enhance goal-related information. Several reviews describe the evidence for these early modulations in response to space and feature-based attention triggered by information from one or multiple modalities (Carrasco & Barbot, 2018; Foster & Awh, 2018; Jonikaitis & Moore, 2019; Liu, 2019; Stormer, 2019; Van Diepen, Foxe, & Mazaheri, 2019; Yeshurun, 2018), while also describing potential limitations of sensory modulation to fully describe our behavioral and subjective experiences (Knotts, Odegaard, Lau, & Rosenthal, 2018; Liu, 2019). Several reviews address current controversies surrounding the mechanisms of sensory modulation. Van Diepen et al. and Foster and Awh present differing views on the computational significance of alpha oscillations measured from scalp EEG (Foster & Awh, 2018; Van Diepen et al., 2019). Parr and Friston, and Rungratsameetaweemana and Serences present different perspectives on the theoretical and computational relationship between expectations and attention in sensory processing (Parr & Friston, 2018; Rungratsameetaweemana & Serences, 2019). Wolfe additionally revisits the concept of preattentive features and argues for a distinction between basic visual information used by selective attention and early visual features, which points towards novel ways to consider the relationship between cognitive and neural models of attention (Wolfe & Utochkin, 2018). Overall, these reviews illustrate the depth of knowledge gained and the open questions that remain to be answered regarding how mechanisms of attention operate within the early visual system.

With regard to the "source" regions of attentional control, it has long been appreciated that frontoparietal networks that are involved in oculomotor control play a crucial role in attentional control (Rizzolatti, Lucia, Dascoloa, & Umlita, 1987). However, the specific functional divisions between regions and the complete network are still unknown. Several reviews in this issue provide new theories for the specific functional role of cortical, subcortical, and cerebellar brain regions, and their interactions in attentional control (Bisley & Mirpour, 2019; Brissenden & Somers, 2019; Helfrich, Breska, & Knight, 2019; Jonikaitis & Moore, 2019), as well as differences between the two hemispheres (Bartolomeo & Malkinson, 2019). One review discusses the many ways in which attention and performance follow different periodic tempos that operate over milliseconds to days (Shalev, Bauer, & Nobre, 2019). Several reviews also deal directly with elucidating the intricate relationship between eye-movements and attention (Golomb, 2019; Parr & Friston, 2018; Verghese, McKee, & Levi, 2019) and their relationship to other cognitive functions such as working memory, decision making, and motor actions (Jonikaitis & Moore, 2019; Krajbich, 2018; Song, 2019). These reviews provide evidence for a direct link between oculomotor control and attentional functions, but also suggest that the transformations in information processing between the two are more complex than previously appreciated and may integrate computations for working memory and decisions.

The fact that attention is an essential component in a large range of cognitive functions is evident in the many neurological and psychiatric disorders that include deficits in attentional processing. However, the causes of the attentional deficits are still largely unknown. Several reviews address how attentional dysfunctions might be predicted during development (Kim & Kastner, 2019; Verghese et al., 2019) and arise from neuromodulatory systems controlling acetylcholine and norepinephrine (Esterman & Rothlein, 2019; Malhotra, 2018; Parr & Friston, 2018; Sarter & Lustig, 2019). Several others focus on the flip-side of dysfunctions and consider how novel interventions, including training and neurofeedback, can be used to treat and improve attention (Chopin, Bediou, & Bavelier, 2019; Fisher, 2019; Kim & Kastner, 2019; Kramer, Porfido,

& Mitroff, 2019; Verghese et al., 2019) or counteract attentional biases toward negative stimuli that may contribute to depression (Mennen, Norman, & Turk-Browne, 2019).

Work on attention has been overwhelmingly focused on questions of how goal-related information is represented and enhanced. More recently, there has been a renewed interest in probing attentional mechanisms involved in down-regulating, or suppressing, distractor processing. Several reviews tackle this issue, suggesting that there are attentional mechanisms unique to distractor suppression that may differ qualitatively from those of target selection (Chelazzi, Marini, Pascucci, & Turatto, 2019; Gaspelin & Luck, 2018; Liesefeld & Muller, 2019; Van Diepen et al., 2019). These studies suggest avenues for further research that promise to illuminate the complementary functions of target selection and distractor suppression.

To summarize, in addition to the two primary goals we set out for this issue (serving as a gateway to the topic, as well as introducing reconceptualization of attentional mechanisms involved in selection), we hope that the breadth represented here will serve as a reminder of the importance of being cautious in defining exactly which attentional mechanisms are investigated within specific studies and of developing testable theories that may guide research within multiple subfields. Ultimately, we hope that this collection offers new and provocative ideas that will help shape research on attention in coming years.

References

Anderson, B. A. (2018). Neurobiology of value-driven attention. *Curr Opin Psychol, 29*, 27-33. doi:10.1016/j.copsyc.2018.11.004

Bartolomeo, P., & Malkinson, T. S. (2019). Hemispheric lateralization of attention processes in the human brain. *Current Opinion in Psychology, 29*, 90-96.

Bisley, J. W., & Mirpour, K. (2019). The neural instantiation of a priority map. *Curr Opin Psychol, 29*, 108-112. doi:10.1016/j.copsyc.2019.01.002

Brissenden, J. A., & Somers, D. C. (2019). Cortico-cerebellar networks for visual attention and working memory. *Curr Opin Psychol, 29*, 239-247. doi:10.1016/j.copsyc.2019.05.003

Carrasco, M. (2011). Visual attention: the past 25 years. *Vision Res, 51*(13), 1484-1525. doi:10.1016/j.visres.2011.04.012

Carrasco, M., & Barbot, A. (2018). Spatial attention alters visual appearance. *Curr Opin Psychol, 29*, 56-64. doi:10.1016/j.copsyc.2018.10.010

Chelazzi, L., Marini, F., Pascucci, D., & Turatto, M. (2019). Getting rid of visual distractors: the why, when, how, and where. *Curr Opin Psychol, 29*, 135-147. doi:10.1016/j.copsyc.2019.02.004

Chopin, A., Bediou, B., & Bavelier, D. (2019). Altering perception: the case of action video gaming. *Curr Opin Psychol, 29*, 168-173. doi:10.1016/j.copsyc.2019.03.004

Egeth, H. E., & Yantis, S. (1997). Visual attention: control, representation, and time course. *Annu Rev Psychol, 48*, 269-297. doi:10.1146/annurev.psych.48.1.269

Esterman, M., & Rothlein, D. (2019). Models of sustained attention. *Curr Opin Psychol, 29*, 174-180. doi:10.1016/j.copsyc.2019.03.005

Fisher, A. V. (2019). Selective sustained attention: a developmental foundation for cognition. *Curr Opin Psychol, 29*, 248-253. doi:10.1016/j.copsyc.2019.06.002

Foster, J. J., & Awh, E. (2018). The role of alpha oscillations in spatial attention: limited evidence for a suppression account. *Curr Opin Psychol, 29*, 34-40. doi:10.1016/j.copsyc.2018.11.001

Gaspelin, N., & Luck, S. J. (2018). Inhibition as a potential resolution to the attentional capture debate. *Curr Opin Psychol, 29*, 12-18. doi:10.1016/j.copsyc.2018.10.013

Geng, J. J., & Witkowski, P. (2019). Template-to-distractor distinctiveness regulates visual search efficiency. *Curr Opin Psychol, 29*, 119-125. doi:10.1016/j.copsyc.2019.01.003

Golomb, J. D. (2019). Remapping locations and features across saccades: a dual-spotlight theory of attentional updating. *Curr Opin Psychol, 29*, 211-218. doi:10.1016/j.copsyc.2019.03.018

Helfrich, R. F., Breska, A., & Knight, R. T. (2019). Neural entrainment and network resonance in support of top-down guided attention. *Curr Opin Psychol, 29*, 82-89. doi:10.1016/j.copsyc.2018.12.016

Helmholtz, H. (1896). Handbuch der Physiologischen Optik, Dritter Abschnitt. In (Auflage, Zweite ed.). Hamburg: Voss.

Jiang, Y. V., & Sisk, C. A. (2018). Habit-like attention. *Curr Opin Psychol, 29*, 65-70. doi:10.1016/j.copsyc.2018.11.014

Jonikaitis, D., & Moore, T. (2019). The interdependence of attention, working memory and gaze control: behavior and neural circuitry. *Curr Opin Psychol, 29*, 126-134. doi:10.1016/j.copsyc.2019.01.012

Kim, N. Y., & Kastner, S. (2019). A biased competition theory for the developmental cognitive neuroscience of visuo-spatial attention. *Curr Opin Psychol, 29*, 219-228. doi:10.1016/j.copsyc.2019.03.017

Knotts, J. D., Odegaard, B., Lau, H., & Rosenthal, D. (2018). Subjective inflation: phenomenology's get-rich-quick scheme. *Curr Opin Psychol, 29*, 49-55. doi:10.1016/j.copsyc.2018.11.006

Krajbich, I. (2018). Accounting for attention in sequential sampling models of decision making. *Curr Opin Psychol, 29*, 6-11. doi:10.1016/j.copsyc.2018.10.008

Kramer, M. R., Porfido, C. L., & Mitroff, S. R. (2019). Evaluation of strategies to train visual search performance in professional populations. *Curr Opin Psychol, 29*, 113-118. doi:10.1016/j.copsyc.2019.01.001

Kristjansson, A., & Asgeirsson, A. G. (2018). Attentional priming: recent insights and current controversies. *Curr Opin Psychol, 29*, 71-75. doi:10.1016/j.copsyc.2018.11.013

Leber, A. B., & Irons, J. L. (2019). A methodological toolbox for investigating attentional strategy. *Current Opinion in Psychology*. doi:10.1016/j.copsyc.2019.08.008

Liesefeld, H. R., & Muller, H. J. (2019). Distractor handling via dimension weighting. *Curr Opin Psychol, 29*, 160-167. doi:10.1016/j.copsyc.2019.03.003

Liu, T. (2019). Feature-based attention: effects and control. *Curr Opin Psychol, 29*, 187-192. doi:10.1016/j.copsyc.2019.03.013

Malhotra, P. A. (2018). Impairments of attention in Alzheimer's disease. *Curr Opin Psychol, 29*, 41-48. doi:10.1016/j.copsyc.2018.11.002

Mennen, A. C., Norman, K. A., & Turk-Browne, N. B. (2019). Attentional bias in depression: understanding mechanisms to improve training and treatment. *Current Opinion in Psychology*. doi:10.1016/j.copsyc.2019.07.036

Nakayama, K., & Mackeben, M. (1989). Sustained and transient components of focal visual attention. *Vision Research, 29*(11), 1631–1647.

Parr, T., & Friston, K. J. (2018). Attention or salience? *Curr Opin Psychol, 29*, 1-5. doi:10.1016/j.copsyc.2018.10.006

Reynolds, J. H., & Chelazzi, L. (2004). Attentional modulation of visual processing. *Annu Rev Neurosci, 27*, 611-647. doi:10.1146/annurev.neuro.26.041002.131039

Rizzolatti, G., Lucia, R., Dascoloa, I., & Umlita, C. (1987). Reorienting attention across the horizontal and vertical meridians: evidence in favor of a premotor theory of attention. *Neuropsychologia, 25*(1), 31-40.

Rungratsameetaweemana, N., & Serences, J. T. (2019). Dissociating the impact of attention and expectation on early sensory processing. *Curr Opin Psychol, 29*, 181-186. doi:10.1016/j.copsyc.2019.03.014

Sarter, M., & Lustig, C. (2019). Cholinergic double duty: cue detection and attentional control. *Curr Opin Psychol, 29*, 102-107. doi:10.1016/j.copsyc.2018.12.026

Shalev, N., Bauer, A. R., & Nobre, A. C. (2019). The tempos of performance. *Curr Opin Psychol, 29*, 254-260. doi:10.1016/j.copsyc.2019.06.003

Shomstein, S., Malcolm, G. L., & Nah, J. C. (2019). Intrusive effects of task-irrelevant information on visual selective attention: semantics and size. *Curr Opin Psychol, 29*, 153-159. doi:10.1016/j.copsyc.2019.02.008

Song, J.-H. (2019). The role of attention in motor control and learning. *Current Opinion in Psychology*. doi:10.1016/j.copsyc.2019.08.002

Stormer, V. S. (2019). Orienting spatial attention to sounds enhances visual processing. *Curr Opin Psychol, 29*, 193-198. doi:10.1016/j.copsyc.2019.03.010

Sui, J., & Rotshtein, P. (2019). Self-prioritization and the attentional systems. *Curr Opin Psychol, 29*, 148-152. doi:10.1016/j.copsyc.2019.02.010

Theeuwes, J. (2019). Goal-driven, stimulus-driven, and history-driven selection. *Curr Opin Psychol, 29*, 97-101. doi:10.1016/j.copsyc.2018.12.024

Van Diepen, R. M., Foxe, J. J., & Mazaheri, A. (2019). The functional role of alpha-band activity in attentional processing: the current zeitgeist and future outlook. *Curr Opin Psychol, 29*, 229-238. doi:10.1016/j.copsyc.2019.03.015

Verghese, P., McKee, S. P., & Levi, D. M. (2019). Attention deficits in Amblyopia. *Curr Opin Psychol, 29*, 199-204. doi:10.1016/j.copsyc.2019.03.011

Vo, M. L., Boettcher, S. E., & Draschkow, D. (2019). Reading scenes: how scene grammar guides attention and aids perception in real-world environments. *Curr Opin Psychol, 29*, 205-210. doi:10.1016/j.copsyc.2019.03.009

Wolfe, J. M., & Utochkin, I. S. (2018). What is a preattentive feature? *Curr Opin Psychol, 29*, 19-26. doi:10.1016/j.copsyc.2018.11.005

Yeshurun, Y. (2018). The spatial distribution of attention. *Curr Opin Psychol, 29*, 76-81. doi:10.1016/j.copsyc.2018.12.008