

Control of gaze, visual attention, and working memory in natural environments

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A central feature of human cognition is the strict limitation on the ability to acquire visual information from the environment, set by limitations in attention. Related to this are the limits in retaining this information, set by the capacity of working memory. We have little understanding of how these limitations influence the way that visual perception operates in the natural world, in the service of everyday visually guided behavior. Consideration of how the limited processing capacity of cognition influences acquisition of visual information leads us to the problem of how such acquisition is controlled. It is not really possible to address the question of precisely what information is selected from the image, and when it is selected, in the context of traditional experimental paradigms, where the trial structure is designed to measure a particular visual operation over repeated instances, each of short duration. In natural behavior, on the other hand, sequences of operations are performed over time periods of several seconds, and the timing of these operations is under the observer's control. The last decade has seen tremendous advances in our knowledge of the way gaze is used to select information from scenes in the context of everyday behavior. Perhaps the most important insight is that gaze patterns reflect extensive learning at several levels. At the most general level, observers must learn the sequence of operations required to perform tasks. They must learn where to look in a scene to get the information they need for component sub-tasks. They must learn the structure and dynamic properties of the world in order to fixate critical regions at the right time. They must learn how to allocate attention and gaze to satisfy competing demands in an optimal fashion and be sensitive to changes in those demands. A growing understanding of the importance of reward in modulating the underlying neural mechanisms, and theoretical developments using reinforcement learning models of complex behavior provide us with the tools to understand the control of fixations, attention, and working memory in the context of natural behavior.