Filling in the Retinal Image

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The optics of the eye form an image on a surface at the back of the eyeball called the retina. The retina contains the photoreceptors that sample the image and convert it into a neural signal. The spacing of the photoreceptors in the retina is not uniform and varies with retinal locus. The central retinal field, called the macula, is densely packed with photoreceptors. The packing density falls off rapidly as a function of retinal eccentricity with respect to the macular region and there are regions in which there are no photoreceptors at all. The retinal regions without photoreceptors are called blind spots or scotomas.

The neural transformations which convert retinal image signals into percepts fills in the gaps and regularizes the inhomogeneities of the retinal photoreceptor sampling mosaic. The filling in mechanism is so powerful that we are generally not aware of our physiological blind spot, where the nerve head exits the eyeball, or other naturally occurring scotomas such as the central field loss that occurs during night vision. Individuals with pathological scotomas are also generally unaware of the field losses that result from the pathology.

The filling-in mechanism plays an important role in understanding visual performance. For example, a person with a peripheral field loss is usually unaware of the loss and subjectively believes that his or her vision is as good as ever, yet his or her performance in a task such as driving can be severely impaired.

The filling-in mechanism is not well understood. A systematic collaborative research program at the Ames Research Center and SRI in Menlo Park, California, has been designed to explore this mechanism. It has been known for some time that when an image boundary is stabilized on the retina the boundary is not perceived. Using image-stabilization techniques, we have been able to show that retinally local adaptation (the control of sensitivity) can be separated from more central neural effects which control the appearance of fields. In particular, we have shown that the perceived fields which are in fact different from the image on the retina due to filling-in control some aspects of performance and not others. We have linked these mechanisms to putative mechanisms of color coding and color constancy.