Scotomas and perceptual filling-in.

Hold your right hand out at arms length, spread your fingers, and fixate your thumb. Close your left eye and notice that your little finger of the right hand has vanished. What has taken its place?

A scotoma is a region of the visual field that is locally blind. The word is from the Greek “skōtos” meaning darkness, and has the same root as scotopic. The plural is either scotomas or scotomata. The term scotoma is usually applied when there is vision loss surrounded by intact vision, as opposed to a field loss that occurs at the edge of the visual field.

A scotoma may be monocular or binocular, physiological or pathological, absolute or relative, positive or negative.

A physiological scotoma is due to natural structures in the eye. A pathological scotoma is due to disease processes that cause blindness in a local area.

Examples of physiological scotomas: The optic disc in each eye produces a monocular scotoma, the “physiological blind spot” of the eye. Blood vessels blocking the photoreceptors throughout the visual field produce “angioscotomas”.

Fluorescein angiography image of blood vessels. Larger vessels produce absolute scotomas, smaller ones produce relative scotomas.

The optic disk is an absolute scotoma, because there are no photoreceptors there.
The lack of rods in the central fovea produces a **foveal scotopic scotoma** in dim light. This figure from Crossland et al. 2011 shows results from microperimetry testing of dark adapted subjects. The tested region was centered on the fovea, and the red area in the fundus image shows the scotoma in the rod free area of the central fovea. The MP-1 is an instrument by Nidek that tracks the eye, allowing for precise microperimetry.

An **absolute scotoma** refers to a complete loss of vision in a particular region. A **relative scotoma** refers to a loss of vision with some sensitivity remaining. A relative scotoma is usually described as so many log units (or db) of sensitivity loss.

A **positive scotoma** is one that is perceived as a (usually) dark region that obscures vision. A **negative scotoma** is not perceived directly, because of “filling-in”. Patients are only aware of negative scotomas when they notice objects disappearing into them.

An example of a negative scotoma is the physiological blind spot. People are not aware of blindness in the region of the optic disc until it is specifically pointed out to them. Pathological scotomas are usually negative scotomas.

An example of a (temporary) positive scotoma is a very strong afterimage. People are aware of the loss of vision because it appears as a floating blob that covers objects. Positive scotomas may occur right after laser photo-coagulation surgery, but the perception of the scotoma will usually fade. Another example of a positive scotoma is the **scintillation scotoma** that comes with migraine auras. The patient is aware of the blindness because the area is filled with a dynamic pattern of twinkling lines.

The term scotoma is used more generally sometimes. For example, “**Ring scotoma**” has two different meanings:

1) it describes a pair of arcuate scotomas that are on either side of the fovea, also called an **annular scotoma** or

2) it describes the blocked area produced by a strong convex lens, for example as in a hyperopic spectacle correction. There is a region of the visual world that is not seen at the rim of the lens due to the prismatic effects of the lens.

A **mental scotoma** is a figurative blindspot in your psyche, used to describe cases when someone lacks insight.
**Filling-in** is a term that describes the perception of pattern and color in a region that is actually blind. Filling-in prevents us from noticing that we have a scotoma, which is a benefit because we are not distracted or confused by the appearance of blind spots. It has a cost clinically, because patients do not notice that they are losing vision until it is quite advanced.

The phenomenon of filling-in is more general than just scotomas. Perception fills in information in many ways, in order to give us the best estimate of the true structure of the world.

The Kanizsa triangle is an example of the brain filling in details that are not in the picture. The solid white triangle appears to have edges all the way around, because the brain extends the edges where the disc is covered. Areas of solid color are filled in from the visible edges. Otherwise, adaptation would make them look gray.

Filling in of color is illustrated in this figure, similar to one made by John Krauskopf of Bell Labs. Fixate the black dot steadily. The green ring will vanish and be replaced by red. The fading of the green is due to adaptation. The replacement with red is due to filling in. The red does not fade because tiny eye movements cause the sharp edges to shift on the retina. Filling in occurs from the edges in.

The **Amsler Grid** is used for patients to self-screen for AMD. Patients looks for areas of distorsion or missing lines.

Filling-in of patterns can make the Amsler Grid look complete, even if there is a scotoma blocking part of it.

The Amsler grid fills in for ~75% of patients with retinal scotomas < 6° diameter (Schuchard, 1993).