The eyes have it

Most humans detect objects and changes in light intensity with their eyes. The cells that respond to light are photoreceptors called rods and cones (see Figure 1), situated in the retina at the back of the eye. Each cone cell is connected to a single nerve cell, so cones confer greater acuity (ability to detect detail) than rods, which share connections to nerve cells with other rod cells. Cone and rod cells also differ in sensitivity (the intensity of light required to produce a sufficiently large potential to trigger a nerve impulse — see pp. 2–5, this issue).

The distribution of these photoreceptor cells is not uniform, especially in the center of the retina where there are thousands of cones packed into a tiny region called the fovea (see Figure 2) whereas rods are more numerous toward the periphery. Rods are most sensitive in low light intensity, so if you look directly at a constellation of stars, such as Figure 3, on a clear night you will make out just a few bright stars. If you look to one side of the constellation, however, you will be able to make out more stars.

This is because the intensity of light from the dimmer stars is too low to be detected by your cones when you are looking straight at them. When you look to one side, the light rays are focused on the part of the retina that has a high concentration of rods. The detection of the less bright stars is down to the process of summation. This is where individual cell action potentials fall short of the threshold level to stimulate a nerve cell but because each rod cell is combined with others, the combined action potential exceeds the threshold and the nerve cell fires.

When we look at patterns such as Figure 4, a pulsing sensation arises. This is because, however hard we try to maintain steady fixation, small movements of our eyes constantly sample the image, thus activating a different mix of rod cells and cone cells every fraction of a second. The brain interprets this as movement. You can modify the mix of photoreceptors if you look at Figure 4 from a greater distance, or make the image blurred (e.g. view without reading glasses). You will find a reduction in the pulsing effect. Similarly, if you flick your eyes across different parts of the image, this will increase the apparent movement.