Lighting Res. Technol. 2014; Vol. **46**: 368

Opinion: CFF is a seductive but misleading concept

The Society of Light and Lighting

When a light varies rapidly in its output it appears to flicker. The sensation of flicker depends upon the amplitude of oscillation and the frequency with which it occurs. As the frequency increases or the amplitude decreases the light can appear continuous, and this appearance has given rise to the concept of flicker fusion. But flicker does not fuse at frequencies above the 'critical flicker fusion' (CFF) frequency. The eyes are continually in motion, moving the retinal image in a succession of drifts and rapid saccades, some small, some large. Because of this movement and its occasional extreme rapidity, no successive flashes of an intermittent source stimulate the same retinal neurons, and as a result the flicker can, in principle, be resolved spatially.

When the eyes make a large saccade we are usually unaware of what we see even though the eyes are open and the retinal cells are functional. This lack of awareness, called saccadic suppression, arises partly because the movement of the retinal image is relatively rapid and continuous during a saccade, partly because the brain anticipates and allows for the movement, and partly because what we see before and after the rapid eye movement are relatively stable images that mask the rapidly moving image. When the visual scene is illuminated intermittently by flickering light, the image during the saccade is not a moving image, but a succession of discrete images. The normal mechanisms of saccadic suppression are compromised; the intrasaccadic images can be perceived and can get confused with the images before and after the saccade. For example, when you are driving at night behind a vehicle with LED tail lights, each saccade is accompanied by a disconcerting trail of images of the tail lights. At night there is little to see before and after the saccade to mask the intrasaccadic image. The frequency of flicker at which such intrasaccadic images are visible can be as high as 2 kHz.

The neural processes in the brain that subserve vision evolved to process images from nature and they function with optimal efficiency with images that have a natural spatial structure. When images have an unnatural spatial structure, for example when they are large high contrast patterns varying in luminance or colour, they are uncomfortable to view. They evoke a large haemodynamic response in the brain, suggestive of inefficient neural computation. Similar considerations may apply to the temporal as well as the spatial aspects of an image. When the intra-saccadic image on the retina is unnatural and discontinuous as a result of flicker the neural computation involved in vision may be compromised. This may be why eye movement control is disturbed by flicker at frequencies well above the CFF, and why such rapid and imperceptible flicker causes headaches: headaches are known to be associated with an abnormal haemodynamic response to visual stimulation.

Ever since its introduction, electric lighting has had subtle, pervasive and deleterious effects on health because of its temporal variation. There is no such thing as flicker fusion.

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10.1177/1477153514541613