## Some Observations on the Rotating Pendulum

WHEN a simple harmonic pendulum is viewed binocularly with a neutral-tint filter in front of one eye, the pendulum, instead of swinging to and fro in a plane, appears to swing in an ellipse, first advancing towards and then receding from the observer[1]. The simplified but not quite true explanation of the illusion is that the 'latent period' of vision in the unobscured eye is shorter than that in the other eye, the brighter retinal image being followed by the shorter latent period. If with a pendulum swinging from right to left, both eyes fixate the true position in space of the pendulum, then the right eye will project the pendulum along a line to the right of the line of fixation whilst the left eye if obscured will project it along a line still more to the right of its line of fixation. The lines of projection will intersect at a point on the observer's side of the pendulum and this is the position in space which the pendulum will appear to occupy. Similarly it can be shown that the pendulum will appear to recede from the observer when passing from left to right and that its point will trace out an ellipse. Using a movable pointer beneath the pendulum, an observer can measure the apparent forward displacements with filters of varying densities in front of one eye and it is possible to calculate the difference in time (sec.) between the latent periods of the two eyes ( $\Delta LP$) for any given ratio between the retinal illuminations of the two eyes ($I_u/I_o$). I find that the relation is $0{\cdot}02 \log_{10} I_u/I_o = \Delta LP + c$, where $c$ is a small constant depending on the difference between the latent periods of the unobscured eyes. The relation holds accurately for any one illumination of the pendulum, but with any given filter $\Delta LP$ becomes smaller if the illumination is considerably increased.

With the filter in front of the right eye the pendulum will seem to swing anti-clockwise, and provided the eyes are treated alike in other ways, we are probably justified in saying that because the right retinal image is less bright, the latent period is longer. It might be thought that a source of light shining into the right eye would lower the apparent brightness of the pendulum by simultaneous contrast. This in its turn might lengthen the latent period and the apparent motion of the pendulum would be anti-clockwise. This, however, is not so, and with an illumination of 15 ft.c. on the pendulum, a small electric torch shining into the right eye from a distance will produce a considerable clockwise rotation. Contrary to expectation, the extraneous source of light shining into the right eye has decreased and not increased its latent period. This result is probably due to nervous interaction between various parts of the retina since the illusion decreases progressively when the angle between the pendulum and the light source is increased, finally disappearing at about 30°. In addition, the illusion is not obtained when the image of the light source falls on the blindspot.

The illusion also appears when one eye looks through a sheet of glass in which is reflected the light from the open sky, and it does not matter whether the reflection of the sky covers the pendulum completely or merely covers the field of vision to one side of it. The latent period always appears to be shorter in the eye with the additional illumination. It might be thought that these experiments could be explained by saying that scattered light within the eye adds itself to the retinal brightness of the pendulum's image and so shortens the latent period of perception. That this is not the true view can be shown by the following experiment. When the electric torch is held close to one eye for a few seconds, that eye still has the shorter latent period even after the torch is removed. To the dazzled eye the pendulum appears much darker than to the normal eye, showing that the latent period can be varied independently of brightness and that there is no rigid connexion between them. The dazzled eye has apparently gained in quickness of perception but has lost in other ways. Frank Allen[2], working on the critical frequency of flicker, argued that because the fusion frequency of a test patch was higher when other parts of the retina were illuminated, that, therefore, the apparent brightness was higher. A given visual brightness is not followed by an unvariable latent period, and it is doubtful whether Allen was justified in assuming that, because the fusion frequency was raised, the apparent brightness was also higher.

It is rather surprising that the pendulum appears to swing almost straight after one eye has been dark adapted for five minutes or so, and we must conclude that the retinal interaction is largely confined to the mechanism of photopic vision.

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[1] Pulfrich, C., *Naturwiss.*, **10**, 553 (1922).
[2] Allen, F., *J. Opt. Soc. Amer.*, **13**, 383 (1926).