In actuality the relation between the play of water and the time between eruptions is just opposite to that which Geis suggests. A short time of play heralds a long interval, whereas a long play heralds a short interval. The National Park Service personnel depend on this relationship in informing visitors when the next eruption will occur.

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Perception by Locusts of Rotated Patterns

In 1962, using as visual stimulus a symmetrical pattern of black and white stripes moved across a fixed window in an opaque screen (*1*), we concluded that threshold responses could be detected in the nerve cord of the locust when the angle subtended by adjacent stripes was as low as 0.3 deg. This finding has since been confirmed by Palka (*2*), who has, however, offered an alternative explanation of the result, in which what is relevant is not the angular separation of adjacent stripes of the pattern but certain effects occurring at the edges of the window. Palka claims that inclination of the edges of the window to the stripes greatly reduces the response. He further suggests that a resolution of 0.3 deg transgresses the Rayleigh limit, taking into account the geometry and dimensions of the single ommatidium. With this we agree, but, according to the diffraction theory we propose, the images found deep in the eye are related to a much larger entrance pupil than that of a single ommatidium; it is these images that we suggest give rise to the high degree of resolution we observe.

A similar criticism of our interpretation is offered by Barlow (*3*), who has further shown that anomalous values (two to four times the normal) can be obtained for resolution of the human eye when a striped pattern is moved behind a fixed window. The movement of such a pattern was detected by the human eye in Barlow's experiments as a flickering at the edges where the pattern met the window, even when the central part of the pattern was not resolved.

It was clearly important that we should repeat our experiments with a stimulus system in which edge effects were as far as possible eliminated, to see whether our original result could then be reproduced. A large wheel pattern consisting of radial black stripes on a white ground was made, with a careful attempt to maintain evenness of stripe width and separation. This was photographically reduced by a factor of about four, and the print so obtained was mounted on a rotating carrier behind a circular aperture 7 cm in diameter in a large black screen. The central area of the pattern was eclipsed by a plain disc alternatively white or black, leaving about 1.5 cm of each stripe visible at the periphery. Care was taken to see that the pattern rotated concentrically with the aperture and that the illumination was uniform. Stimuli, presented at 10-second intervals to avoid fatigue, consisted of rapid rotations through an angle of about 45 deg, alternately clockwise and anticlockwise as viewed by the insect. Movements were executed manually, and velocity was not precisely controlled. Adopting the 50-percent response level as threshold criterion (spike responses of the nerve cord), we repeatedly obtained resolutions down to 0.3 deg, using radial patterns with stripe separation 3.6 mm at the edge. The diameter of the whole wheel pattern then subtended an angle of about 6 deg at the eye.

An interesting feature of the experiments was that all insects examined were able to distinguish clockwise from anticlockwise rotations. Of 11 eyes tested, where the responses to 20 stimuli, alternately clockwise and anticlockwise, were recorded, 7 showed lower threshold for clockwise and 4 for anticlockwise rotation. The two eyes of any one insect behaved similarly, rotational preference being a feature of the individual insect. The difference in scores for clockwise and anticlockwise movements only became apparent when the pattern was at a distance from the eye approaching the resolution limit, and was often very marked in this condition. There could be complete failure to respond to one direction of rotation while a high score was still obtained with the opposite rotation.

A further observation of some importance was that, when the central black area was replaced by white, there was a marked inhibition of the responses, in such a way that low figures for resolution were obtained, not better than 1 deg. On the other hand, when the black screen surrounding the pattern aperture was covered with white paper, the response was not only not inhibited but was slightly increased.

It seems clear that, with a wheel pattern, resolutions of the same order as those reported earlier for linear patterns enclosed by a window can be obtained, and that edge effects appear to contribute little to the responses recorded. As an additional check on this point we have intentionally introduced a window by obscuring one half of the wheel-pattern aperture—upper, lower, left, or right—and have tested the responses before and after this maneuver. We have found no significant change in score.

Tests have been made using the same rotated pattern on human eyes. Five volunteers were asked to detect the movement of the pattern at increasing distances. The limiting values so found ranged from 1.1 to 1.6 minutes. Thus so far there has been no suggestion of the anomalously high resolution which Barlow found using the horizontal window.

We cannot readily explain the effects of inclining the pattern within the window which are reported by Palka. We would, however, draw attention to our earlier work (*1*), in which linear patterns were moved at various angles with respect to the horizontal meridian of the eye, though still at normal alignment within the window. We found that threshold varied widely with angle of presentation, but no regular axes of maximum and minimum could be established. Such axes, spaced at 60-deg intervals, are predicted by the diffraction theory (*1*) for a hexagonal array of facets, and can readily be seen in eye slices examined under the microscope when the object pattern is rotated. Again the wheel pattern has the advantage of eliminating the possibility of inadvertently presenting linear stimulus movements along axes of differing resolution.

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