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COMMENT ON INFERRED POSITIVE PHOTOTROPIC ACTIVITY IN HUMAN PHOTORECEPTORS

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A new interpretation of results from a previous paper (J. M. Enoch & D. G. Birch, *Phil. Trans. R. Soc. Lond.* B **291**, 323–351 (1981)) is presented.

A paper entitled 'Inferred positive phototropic activity in human photoreceptors' was presented by Enoch & Birch (1981). That paper contained two different experiments. In one experiment, the observer was patched and showed a markedly flattened Stiles–Crawford (S.–C.) function of the first type. (The S.–C. function is a psychophysical measure of the directional sensitivity of the retina which normally shows a peak of sensitivity for light passing through a point near the centre of the entrance pupil of the eye.) In another experiment a unilateral displaced pupil aperture contact lens was worn over the dilated pupil by an observer. The S.–C. peak shifted into the aperture. On the basis of these two separate experiments Enoch & Birch suggested that there was a phototropic effect present in retinal receptors. Here, the authors call attention to the fact that the interpretation of the first of the two experiments, the patching study, was apparently in error. However, the overall conclusion that a phototropic effect is present in human retinal photoreceptors is not altered.

In subsequent studies in Enoch's laboratory, conducted with A. Eisner, mixed results were obtained when the patching experiment was repeated. One related study was published (Enoch *et al.* 1982). Applegate (1983, 1984) repeated the patching experiment (independently) and could not duplicate the results of Enoch & Birch (1981) when testing normal subjects, but did replicate the induced movement of receptor alignment toward a new pupillary aperture (Applegate & Bonds 1981). Recently, Enoch, working with T. Yasuma, R. Hamer, V. Lakshminarayanan and R. Nygaard, repeated the patching study on four individuals. This research group found that the original findings in the patching experiment could not be duplicated.

Enoch suggested that D. Birch, who was one of the original subjects and experimenter, and R. Hamer, who is one of the recent group of four subjects and an experimenter, mutually patch and test each other with assistance from Enoch and others in the laboratory. S. Yamade, a corneal specialist (ophthalmologist) and physicist, would also serve as an experimenter. These experiments have now been completed, and it is evident that the results do not duplicate the findings of the original study. Birch's data showed some flattening. Hamer's data showed no appreciable changes in the S.–C. function.

Several discussions were held on the issue. Some comments made by Birch provide a basis for further testing and clarification. Enoch purchased large hard plastic black patches with a

raised polystyrene foam edge (about $\frac{3}{8}$ inch (1 cm) thick, manufactured by Bernell Inc.) to be worn to provide an oxygen reserve. However, Birch made the patches he used into a pressure bandage during the experiment by adding padding in the air chamber just anterior to the cornea, and by taping the patch tightly for extended periods of time. Such an occlusion technique can, in the short term, lead to corneal oedema and corneal clouding, as well as intraocular pressure changes in the eye and altered temperature in the plane of the cornea.

There was a failure of communication between Enoch and Birch. Enoch had entered research as a test subject and researcher in studies of corneal oedema, clouding and physiology (Finkelstein 1952). The maintenance of normal corneal physiology in these experiments was discussed in the original paper by Enoch *et al.* (1979). Birch, in his effort to exclude light from the eye, eliminated the available oxygen reserve and bound the patch down tightly as possible. The experiment called for maintenance of total darkness and minimal exposure to light even during testing. Initially, the time course and magnitude of measured effects were not known, and Enoch had thought care had been taken to provide a reasonable air (oxygen) reserve, and some air leak was assumed. The clarity of the cornea was not considered in detail because of the desire to maintain darkened conditions. A second experiment, where a translucent but otherwise similar patch was used (but without additional gauze or tape), resulted in no measurable change in the S.–C. function (Enoch & Birch 1981).

Two studies presented at the recent (December 1984) meeting of the American Academy of Optometry may be relevant. Schoessler & Osborn (1984) reported on changes in the physiology of the cornea in an individual who had unilateral lid droop (ptosis). This patient showed an increase in corneal thickness and endothelial cell changes in the cornea on the side of the lid droop. Applegate & Massof (1984) reported on the flattening of the Stiles–Crawford function in the presence of cataract; that is, scattering of light caused by changes in the eye lens.

During the summer of 1984, after testing the Stiles–Crawford functions (which took about 4 h for a complete series), Yamade and Enoch observed that a modest amount of corneal oedema was present in the eyes of both observers who had been patched for several days. Obviously, the hypothesis that corneal oedema, clouding and scatter were the cause of the reported flattening of the Stiles–Crawford function will have to be clarified further. Actually, the more interesting question now becomes, how is photoreceptor alignment maintained in the dark?

A. Bradley (University of California, Berkeley) has suggested a second hypothesis for the apparently artefactual S.–C. function flattening. The possibility exists that flattening in the original experiments could have been the result of active realignment of receptors to light leaking around the edge of the patch and the associated tape occlusion system. It remains to be determined whether such light leakage could sufficiently alter energy distribution in the pupillary aperture to induce phototropism. However, if light entered around the edge of the patch air might have entered as well, making this hypothesis somewhat counter to that provided above.

Data from recent studies will be presented at a meeting of the Optical Society of America and additional studies will be conducted in an attempt to clarify this issue. At the present time, however, Enoch and Birch wish to withdraw the suggested interpretation of flattened Stiles–Crawford effects of the first kind (Enoch & Birch 1981) following extended unilateral eye patching. This does not alter the substance of the larger conclusion relative to photoreceptor phototropism.

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