THE EFFECT OF DARKNESS ON THE MIOSIS ASSOCIATED WITH THE NEAR REFLEX

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Abstract
Research was undertaken to investigate the pupillary constriction associated with the near reflex and to demonstrate the effect of darkness upon this reflex.

It was found that there exists a linear relationship between convergence and pupillary constriction and that this same relationship is present even in total darkness. It is suggested that it must be either proximal or voluntary convergence which is utilised in total darkness to initiate the miosis occurring on near fixation. The available evidence in literature supports this conclusion.

Key words
Miosis, near reflex, infra red photography, proximal convergence, voluntary convergence

As a result of recent research [1] into the effects of proximal convergence upon near fixation it has become apparent that there is scope for investigation into the related near reflex, in particular the miosis occurring on near fixation.

Thus the aim of the paper is to investigate the pupillary constriction associated with accommodation and convergence, and to demonstrate its effect in the dark.

Normally, when an individual alters fixation from a distant object to a near object, the eyes converge, accommodation takes place, and the pupils undergo an equal amount of constriction. This relationship that exists between accommodation, convergence and miosis is known as the near reflex, although many authors (including Adler[2], Newell[3] and Walsh and Hoyt[4]) agree that the relationship is not a true reflex but a synkinesis, as it is possible to demonstrate miosis when either convergence or accommodation is abolished. Convergence may be selectively eliminated by the interposition of base-in prisms before each eye so that on fixation of a near target accommodation and miosis occur alone. Accommodation may be selectively eliminated by placing appropriate convex lenses before each eye so that, as one converges to a near target, miosis occurs but accommodation is inhibited.

Knoll[5] states that "when the eyes are made to converge with accommodation kept fixed there is some pupillary constriction but very small by comparison with that which would occur were accommodation permitted to match the convergence". Knoll expresses the view that it is primarily accommodative convergence which initiates miosis. According to Alpern, Ellen and Goldsmith[6] the pupil continues to constrict even when the amplitude of accommodation has been exceeded. They feel that the effort to accommodate is sufficient to cause pupillary constriction.

Marg and Morgan[7] in 1950 investigated the proximal pupillary factor in relation to the near reflex. Under conditions of normal illumination they found no evidence to support the existence of such a factor. Morgan's later research[8] studied the pupil size in the 'dark' in relation to the near reflex. However, throughout the experiment the fixation target was illuminated, with the result that other factors were present to initiate the miosis, (i.e. accommodation or convergence).

According to Newell[9], the near reflex is related to vergence movements involving the visual response to the awareness of the nearness of an object. He states that it may occur without visual response when an individual converges for the distance he believes the object to be, basing his

judgement on sound or touch.

Pupillary constriction associated with near fixation can be observed on presbyopic subjects and also on uncorrected myopes. Because these individuals do not utilise accommodation on near fixation the miosis which results is not associated with accommodative convergence or even the effort to accommodate, as in an uncorrected myope. Thus, when the influence of accommodation and accommodative convergence are absent on near fixation one must consider other factors which may cause the associated miosis.

It is important to understand that for the normal non-presbyopic individual all three components of the near reflex must be considered as being associated in a common function, and it is only under certain conditions that one may be seen to be dissociated from the other two.

Parkes [10] has defined four stimuli which will produce the synkinetic near response:

1. a blurred retinal image
2. a stimulation of bitemporal retinal elements causing diplopia of the near object
3. an awareness of near
4. voluntary convergence

Because the pupils dilate in the dark, it was of interest to determine the effect of total darkness on this response. Alder[11] states that "this contraction (of the pupils) is independant of any change in illumination."

Method

Nine subjects for study were selected. One could argue that accommodation or convergence anomalies may invalidate the results obtained and thus nullify any conclusions which may be drawn. However, to eliminate this possibility as far as possible, each subject chosen had normal convergence and accommodation. On this basis I have then assumed that the pupils of each subject gave a normal response on near fixation.

Procedure

The subject was seated at a table and requested to place his chin on a chin rest with his forehead against a bar, in an attempt to keep the subject as still as possible, in order to obtain the greatest consistency in the measurements recorded throughout the experiment.

A fixation target, the letter O, was then placed at distances varying between 50 and 10 centimetres from the subjects' eyes (50, 33, 25, 20, 16.5, 12.5, 10 cms). Initially, in normal illumination the subject was instructed to fixate the target at each fixation distance and a photographic record was obtained following the method described by Cornell[1]. The procedure was then repeated utilising infra-red photography after the subject had been dark adapted for several minutes. In total darkness the fixation target was invisible to the subject who lacked any form of visual stimulus to aid the location of the target. The subject was instructed to reach out and to grasp the target and then to imagine he was looking at it. With the absence of visual clues the subject was reliant upon proprioceptive information to locate the target in space relative to the body.

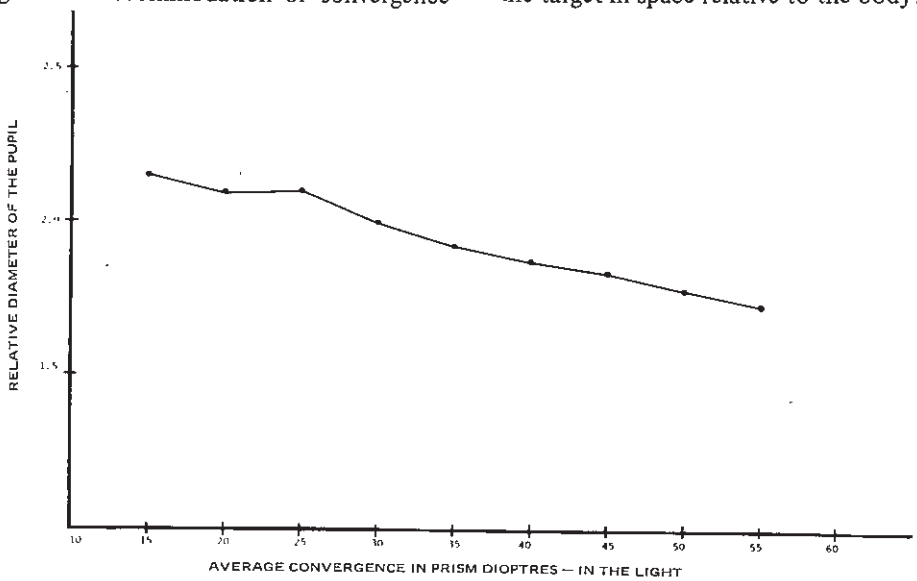

Figure 1. "Pupillary diameter vs convergence in the light"

By taking into account each subjects' inter-pupillary distance it was possible to calculate the amount of convergence which each subject utilised at each fixation distance in the light. By projecting the slides it was possible to obtain a measurement of the pupil diameter at each distance. The basic trend revealed by Figure 1 corresponds with our current knowledge of the miosis associated with near fixation. Overall as the eyes become more convergent the pupillary constriction increases.

A linear relationship was found to exist between the two variables studied. The gradient of the line was found to be -0.011. ($y = mx + b$). Knowing the equation and gradient of the line it was possible to compute points to give a line of best fit, and when compared to the mean values, they proved to be correct to at least one decimal place.

The readings obtained in the dark for each subject were plotted on their individual graphs in the light, and it was possible to calculate the amount of convergence induced.

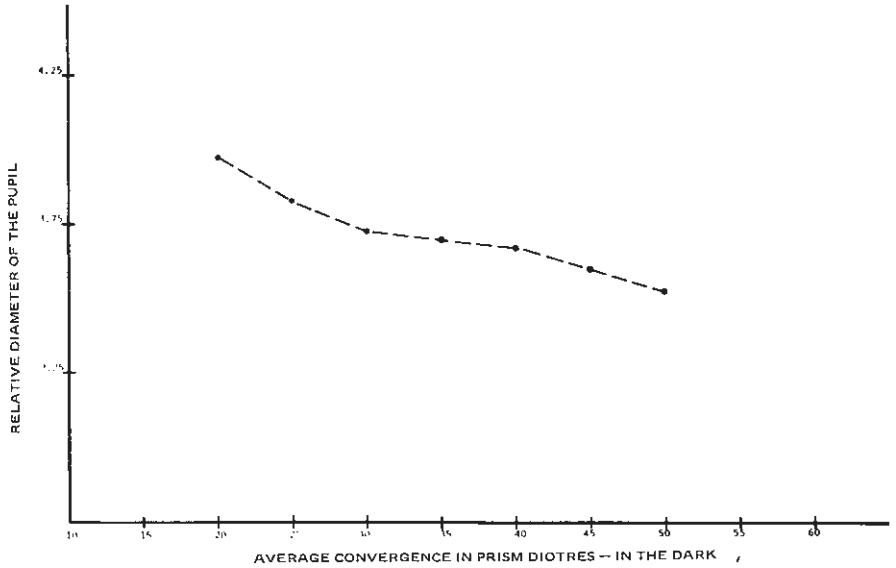

Figure 2. "Pupillary diameter vs convergence in the dark"

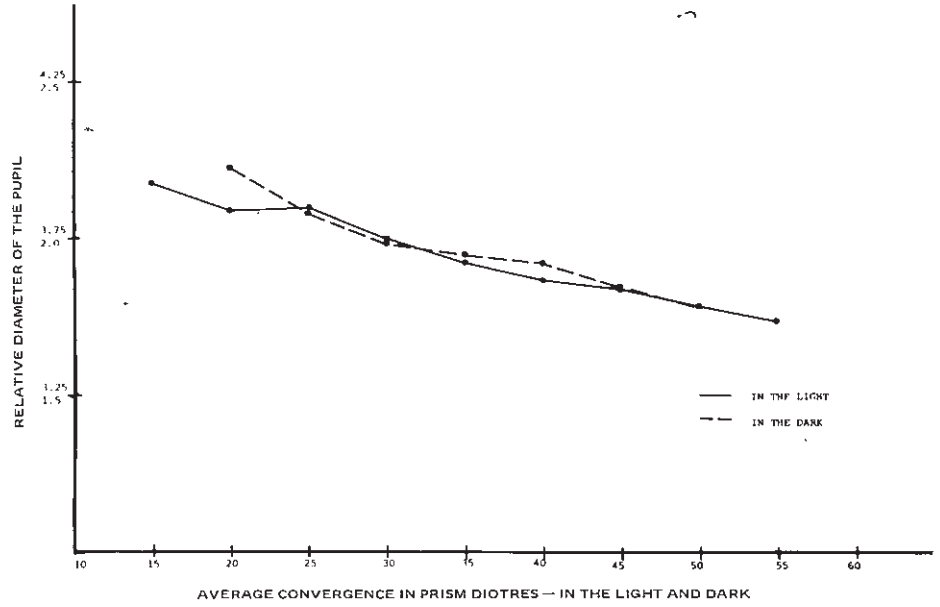

Figure 3. "Pupillary diameter vs. average curves in the light and dark"

This graph shows the mean values for the nine subjects in the dark. Although the pupillary diameters are seen to be proportionately larger in the dark, if one superimposes the two graphs representing the average values in the light and dark, it can be clearly seen that there is a high correlation between the two (Figure 3).

The results in the dark revealed a linear relationship between the two variables. The gradient of the line was found to –0.013. Comparing the two gradients –0.011 (light) and –0.013 (dark) shows that they are the same to two decimal places.

Thus evidence exists to support the supposition that the near reflex operates even in total darkness, which also confirms Adler's statement that the near reflex is not dependant upon constant illumination. However, what remains to be discovered is the mechanism which stimulates miosis in the dark. It is possible that one can exclude accommodation and its associated convergence on the basis that in the dark the subject was not visually stimulated, and therefore, could not perceive blur. Finally, fusional convergence may also be excluded on the basis that in the dark fusion was not stimulated. Hence voluntary and proximal convergence factors remain as the only factors which we can utilise to initiate miosis on near fixation in total darkness.

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