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**Is Increased Accommodation  
A Necessary Condition for Instrument Myopia?  
(Reprint)**

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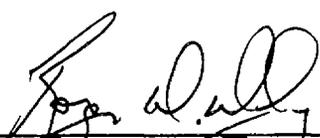
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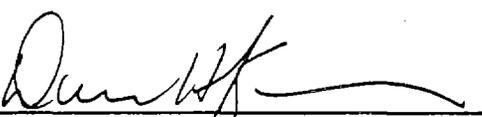
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**IS INCREASED ACCOMMODATION A NECESSARY CONDITION  
FOR INSTRUMENT MYOPIA?**

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**INTRODUCTION**

The cornerstone of our understanding of instrument myopia is that observers, who are not myopic under ordinary circumstances, tend to focus instruments as though they were myopic.<sup>1</sup> It is presumed that this occurs because the level of accommodation is greater during instrument viewing than under other conditions.<sup>1</sup> Our hypothesis was that this presumption is not always correct.

We based our hypothesis on the dark focus bias theory of accommodation, which holds that accommodation generally tends to seek its resting position or dark focus, and that the dark focus lies intermediate between the far and near points of accommodation.<sup>2</sup> The tendency for accommodation to regress to its dark focus is facilitated by viewing through a small artificial pupil, which opens the accommodative feedback loop (by increasing the depth of focus of the eye) under either instrument<sup>1-3</sup> or no-instrument conditions.<sup>4</sup> An example of such an artificial pupil is the exit pupil of optical instruments, which can increase dark focus bias if it is smaller than the entrance pupil of the eye.<sup>2,3</sup> We reasoned that, if the exit pupil of an optical instrument could be matched in size with the entrance pupil of the eye, and that similar targets could be presented for instrument and no-instrument viewing, then the levels of instrument and no-instrument accommodation should approach equality.

To test this hypothesis, we selected an instrument whose eyepiece functioned as a simple magnifier, and which, therefore, did not form an exit pupil.<sup>5</sup> Under such circumstances, the entrance pupil of the eye serves as the instrument's exit pupil, which ensures the equality of these two apertures.<sup>6</sup> We then measured accommodation during instrument viewing, and during a no-instrument control in which the stimulus conditions were similar to those found during instrument viewing, but in which the instrument was not used. Instrument accommodation was measured with the eyepiece focus fixed at infinity so that we could isolate the effects of user focus settings from the effects of instrument viewing per se.

In a second experiment, we allowed the observers, who were emmetropes, to focus the instrument for best vision. We wished to learn whether emmetropic subjects, for whom the limiting aperture for depth of focus of the eye was the same during

instrument and no-instrument viewing, would exhibit the myopic focusing behavior that is found with instruments that have exit pupils smaller than the eye's entrance pupil.

**METHODS**

Accommodation was measured in one eye with a dynamic infrared optometer under binocular, steady-state viewing conditions. A beamsplitter was used so that we could measure accommodation while the subjects viewed the visual stimuli either through the instrument or without the instrument. The stimuli were high and low contrast Bailey-Lovie visual acuity charts. The optical instrument was a pair of night vision goggles, which are unity magnification binoculars which electronically amplify ambient light and thus provide photopic vision under night sky conditions. Stimulus contrast, luminance, spatial frequency, and optical vergence were matched closely under instrument and no-instrument conditions. Although contrast was less when the

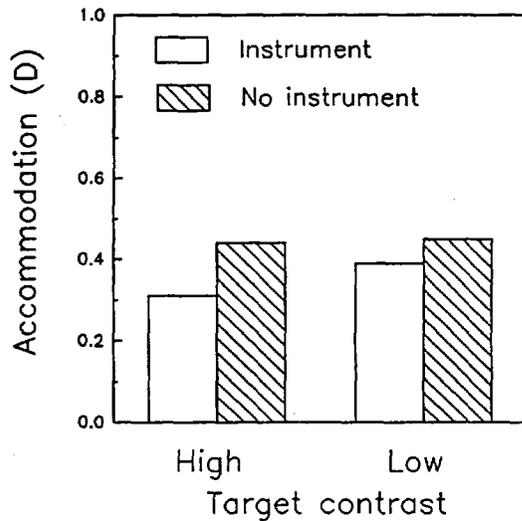
**Table 1. Target Parameters**

Parameter	Instrument		No Instrument	
	High	Low	High	Low
Contrast (percent)	62	12	98	21
Luminance (cd/m <sup>2</sup> )	6.5		6.5	

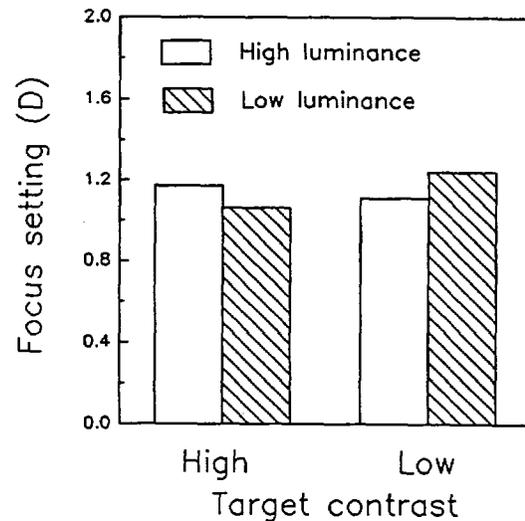
target was viewed with the instrument than without, previous research has shown that such differences are unlikely to influence steady-state accommodation.<sup>7</sup> The night vision goggle display is spatially lowpass filtered; however, it is generally accepted that the middle spatial frequencies, which are well represented in the night vision goggle display, are sufficient to stimulate an optimal accommodative response.<sup>7</sup> The instrument eyepieces were set to 0.0 D for the fixed focus condition, and the objective lenses were focused for the object distance (5.8 m). The subject's task during the measurement of accommodation was to view through the instrument and keep threshold sized letters clear. Prior to making focus adjustments, the subjects were trained to use the least amount of minus dioptric power necessary to achieve best vision. Thirteen young adult volunteer subjects were recruited, who had uncorrected distance visual acuities of at least 20/20 in each eye, and were free from eye disease and other ocular anomalies.

**RESULTS**

Figure 1 shows that accommodation during instrument viewing was no greater than accommodation during the no-instrument control, regardless of target contrast. The instrument and no-instrument



**Figure 1.** Accommodation under instrument and no-instrument conditions at two levels of target contrast.



**Figure 2.** Focus setting as a function of target luminance and contrast.

accommodation means were 0.35 and 0.45 D, respectively, when averaged across contrast. Figure 2 shows that the subjects, although they were emmetropic, exhibited a strong tendency to focus the instrument as though they were myopic. This tendency was robust with respect to target contrast and luminance (12 and 1  $\text{cd}/\text{m}^2$  for high and low luminance, respectively). The mean focus adjustment across all conditions was -1.1 D. By comparing the magnitude of the focus settings (Fig. 2) to the level of instrument accommodation for the fixed infinity focus condition (Fig. 1), it can be seen that focus adjustment magnitude exceeded that of accommodation by greater than a factor of two. Thus, the focus settings were not merely a compensation for the amount of accommodation present during the fixed infinity focus condition.

## DISCUSSION

Our main conclusion is that accommodation during viewing through optical instruments is not necessarily greater than accommodation during ordinary viewing conditions without instruments. We also conclude that emmetropic observers do focus instruments as though they were myopic, even when the level of accommodation is no greater with instrument viewing than without. What then could be the etiology of the myopic focus adjustments?

In a previous report,<sup>8</sup> we showed that emmetropes obtain better visual acuity after the myopic focus adjustment than during a fixed infinity focus control, when the experimental conditions were the same as those described in the current paper. We also demonstrated that observers who focus their instruments

close to their individual dark focuses show a greater improvement in visual acuity with focus adjustment than those who do not.<sup>8</sup> The presumed benefit of placing the stimulus at the dark focus, where accommodation is most accurate, would be optimization of retinal image contrast through reduced focusing error. Another possibility for the myopic focusing behavior is that the observers may be improving visual performance by driving accommodation to a level which minimizes the aberrations of the eye.<sup>9</sup>

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