

# REDUCTION OF VISUAL DISCOMFORT (ASTHENOPIA) & PHORIA FOLLOWING MODULATION OF VDT NEARWORK-INDUCED ACCOMMODATIVE HYSTERESIS

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## Abstract

Nine young emmetropes were exposed to either 10 or 20 minutes of visual display terminal (VDT) work at 20 cm (5.0 D). In the first phase of the study, individual measures of the accommodative nearpoint, degree of phoria at near, and visual discomfort/asthenopia were obtained and contrasted to a baseline condition of no VDT work. The group average binocular and monocular accommodative nearpoint values did not differ from baseline following 10 or 20 minutes of nearwork. A systematic increase in exophoria was observed. Eyestrain ratings generally increased in a positively accelerating manner and approached noticeably high magnitudes after 10 minutes.

In the second phase of the study binocular accommodative rock was carried out at the end of each trial, aimed at modulating the exophoria and eyestrain ratings. Thus, the subjects were instructed to alternately view targets in a plane from near (2 D) to infinity (0 D), and back again every consecutive 5 seconds. This training lasted 2 minutes longer than the respective trials of the first phase. The main results were: (A) Inward shifts of the binocular measures of accommodative nearpoints resulted after the accommodation/vergence training. (B) The binocular training effects did not transfer to the monocular accommodative nearpoint measures. (C) All subjects showed a decrease in their phorias. (D) The eyestrain ratings were significantly reduced by the training. These results indicated that binocular accommodative rock training of a short duration was able to

modulate some aspects of VDT nearwork-induced hysteresis in the visual system.

## Key Words

accommodative nearpoint, asthenopia, binocular accommodative rock training, computer vision, convergence nearpoint nearwork, phoria.

## INTRODUCTION

In this age of high technology, office work is coming to mean work at a video display terminal (VDT). Both the international trade union<sup>1</sup> and the World Health Organization (WHO)<sup>2</sup> have made appreciable vision problems connected with nearwork in general, and display work in particular, the subject of official documents. The disorders and subjective discomfort involved may comprise eye fatigue, pain in the eyes and surrounding muscles, overexertion and transient nearsightedness.<sup>3-6</sup>

Work tasks that require intense visual effort cause eye fatigue and discomfort (asthenopia) with an intensity and frequency which is rarely found in other non-occupational activities. Prolonged and continuous VDT-work is known to induce a broad spectrum of asthenopic symptoms.<sup>7-9</sup>

## PURPOSE

The purpose of this study was to investigate whether repetitive binocular accommodative rock training, alternating from near (2 D) to far (0 D) point images (delivered in 5 sec intervals) could modulate nearwork-induced accommodative hysteresis in the visual system. The following two independent variables were

used: (1) A demanding nearwork task for different exposure periods and (2) binocular accommodative rock training. The monocular and binocular accommodative nearpoint, the degree of phoria at 40 cm, as well as the subjective intensity of asthenopia assessed by means of sensory verbal descriptors were employed as dependent variables.

## METHOD

### Subjects

Nine young healthy emmetropes (five males, four females) with a mean age of 25 years (range: 18 - 34) were selected for the study. We defined emmetropia as a spherical equivalent of < 0.50 D of myopia or hyperopia. Persons with oculomotor dysfunctions were excluded after a screening carried out by a clinical orthoptist. Measurements included assessments of visual acuity, refractive status, ocular motility, and fusion. All subjects had an unaided acuity of 20/20 or better, no strabismus or oculo-motor restrictions at distance and near, and no history of ocular disorders or disease. None of the subjects were on any medication. Informed consent was obtained from each subject after the nature and possible consequences of the study had been explained. Each participant received a monetary reward at the completion of the study.

### Apparatus

#### Initial phase

A document (font size 12) appeared on a monochromatic VDT screen placed along the subject's midline at a viewing distance of 20 cm (5 D) in an evenly illuminated room. The overall size of the doc-

ument on the screen was 17 cm wide and 20 cm tall.

### Training phase

The device housing the optical/holographic training technology (I-Relax<sup>a</sup>) measures 4.5" x 6" x 3.5". It was placed on the desk next to the computer VDT. The dual image generating apparatus presented a hologram at near (2 D) and a colorized 35 mm slide close to the plane of optical infinity (0 D). The near and far images were viewed in consecutive repetitions. The distant image, when appropriately focused, positions the accommodative response at the plane of optical infinity (0 D). The near image requires an accommodative response of 2.0 D. The illumination of these images lasted for 1 minute during which each image appeared for 5 seconds in consecutive repetition. By manually resetting the built-in timer the illumination could also last for, 2 or 3 minutes. We were aware that the subjects were initially required to perform a strenuous and visually-demanding VDT-related near work at 20 cm that required sustained focus and attention. Consequently the results of a pretrial session indicated that the accommodative rock activity of 2 min duration was the best under the present experimental conditions, and this duration was employed in the main study.

### Baseline findings

All oculomotility and accommodative measurements were normal and age appropriate. None of the subjects had a history of asthenopia. No subject had a near phoria greater than 3 PD of esophoria or 6 PD of exophoria.

#### Oculomotor and accommodative measures

*Phorias:* A prism cover-test was performed at 40 cm to assess the direction and magnitude of existing phorias. An occluder was placed in front of one eye and the patient was instructed to look at the target (a penlight). The occluder was switched to the other eye and prism was used to neutralize any movement of the initially occluded eye. The procedure was repeated as required to estimate the deviation expressed in prism diopters.<sup>10</sup>

The nearpoints of both accommodation and convergence functions were measured using standardized orthoptic procedures and a Royal Airforce Ruler (RAF).<sup>b</sup>

*Monocular accommodative nearpoints:* the subject was seated in front of the RAF with the non-tested eye fully occluded. The subject was instructed to read a sentence from the beginning to the end, over and over again, and to exert full and maximum effort to maintain target clarity. This target was initially positioned at approximately 3 D. The target was then positioned inward successively in 0.5 D steps. The subject was asked to state when he/she could no longer see the print clearly because of blur. The first stimulus level yielding the maximum accommodative response (i.e., response saturation) was considered to represent the accommodative nearpoint. Each measurement of this nearpoint was repeated until at least two subsequent measures of similar magnitude were obtained.

*Binocular accommodative/convergence nearpoints:* The same procedure as for the monocular nearpoint was adopted, but now under binocular conditions. The subject was asked to state when the print first blurred and/or doubled.

#### Asthenopia/Visual discomfort

Eyestrain was subjectively determined by means of sensory verbal descriptors. This category scale consisted of the following descriptors: *No (eye-strain), very very weak, very weak, weak, neither weak nor strong, slightly strong, strong, very strong, very very strong, maximal.* For the statistical analysis a numerical value was arbitrarily assigned to each verbal descriptor.

The identical oculomotor and asthenopia measures were taken post task.

### Procedures

#### Adaptation task

Subjects were instructed to type and edit the document on the VDT and to keep the text in focus at all times. This kind of nearwork requires constant attention and cognitive effort.<sup>11</sup> The subjects were told to work (read and type) continuously for the duration of the task. The baseline nearwork trials lasted 10 or 20 minutes, respectively. Trials involving the binocular accommodative rock training lasted two minutes longer (i.e., 12 and 22 minutes, respectively).

Subjects performed in five trials scheduled on two or three separate occasions scheduled days apart to avoid carry-over-effects and/or problems as to compliance with instructions. Appropri-

ate 30-minute breaks were inserted between trials performed during the same day. The order of the trials was randomized.

#### Statistical design

The performance in near work trials of varying duration were contrasted with the baseline (no near work) by explorative *t*-tests for paired differences (corrected for multiple comparisons) in order to investigate effects of the accommodative training. To test if visuomotor adaptation had an impact on the performance, linear regression analysis was also performed on the data.

#### Post-task measurements

Immediately after task completion (approximately 2-5 seconds) the subjects' phoria, nearpoint of accommodation (monocular right, monocular left, and binocular) and visual discomfort/asthenopia were assessed as described above. These measurements were always collected within less than 4 minutes.

## RESULTS

**1. Phoria.** The reliability of the individual measures of phoria was computed by comparing all measures collected after 10 minutes of nearwork with those collected after 20 minutes. The product moment correlation coefficient,  $r_{xy}$ , between these values ( $x = 10$  minutes,  $y = 20$  minutes) yielded a very high value of  $r = 0.96$  ( $P < 0.0001$ ). The nine subjects showed systematic changes in their physiological phoria after both 10 and 20 minutes of nearwork (two-tailed, paired *t*-tests, 10 minutes:  $p < 0.05$ ; 20 minutes:  $p < 0.0001$ ). All subjects manifested increases in their exophoria except for one subject who showed an increase in his esophoria. A fatigued accommodative system (see below) could play a role in contributing a less synergistic afference (postural influence) to the vergence response, with an increase in exophoria at near as a direct consequence. Accommodative rock training reduced the magnitude of these values (Figure 1). The phoria measures collected after training differed significantly from the phoria after nearwork per se (one-tailed, paired *t*-tests, 10 minutes:  $p < 0.00001$ ; 20 minutes:  $p < 0.01$ ). Analogous to the reasoning applied above, this may be attributed to a restored accommodative afference to the vergence system following accommodative exercises.

**2. Accommodative and convergence nearpoint.** Both the binocular and the monocular nearpoint values measured at baseline were, as expected, correlated with age (binocular:  $r = 0.75$ ,  $p < 0.05$ ; right eye:  $r = 0.84$ ,  $p < 0.01$ ; left eye:  $r = 0.71$ ,  $p < 0.05$ ). The reliability of these measures was computed by comparing all nearpoints collected after 10 minutes of nearwork with those collected after 20 minutes. The correlation coefficient,  $r_{xy}$ , between these values ( $x = 10$  min.,  $y = 20$  min.) yielded in general very satisfactory values (binocular:  $r = 0.97$ ,  $p < 0.0001$ ; right eye:  $r = 0.94$ ,  $p < 0.0001$ ; left eye:  $r = 0.79$ ,  $p < 0.01$ ).

The monocular nearpoint values were not at all affected by the nearwork. The binocular values collected after both 10 and 20 minutes unexpectedly did not differ from baseline, although magnitudes of outward shifts were observed to range between 1 - 2 D in several observers (Figure 2). Since eyestrain in these trials reached rather high levels (see below), it is possible that subjects unwittingly came to tolerate more blur (but not diplopia) due to general fatigue and/or attentional factors. Hence, they may not have been fully focused on the computer screen. The consequence of these circumstances would together have an impact on the RAF measurements and cause nearpoints to be overestimated and/or to render the accommodative system less adaptable.

The binocular measures collected after 10 minutes of nearwork were however influenced by training (one-tailed, paired  $t$ -test,  $p = 0.01$ ). However, binocular accommodative rock brought the binocular nearpoint values back to baseline in four subjects (Figure 2B; subject 1, 3, 7, and 9). The magnitude of these reversible shifts ranged between 1 - 4 D (Mean:  $2.25 \pm 1.26$  S.D.). Moreover, in two of these cases the binocular nearpoints were brought inward by an amount exceeding that of the baseline (Figure 2B; subject 7 and 9). Finally, two subjects who did not show any nearwork-induced shifts of their binocular nearpoints, nevertheless manifested effects of training (Figure 2B; subject 5 and 8). The binocular values collected after 20 minutes of nearwork and 2 minutes of training did not differ from baseline.

The monocular nearpoints were also not affected by the training.

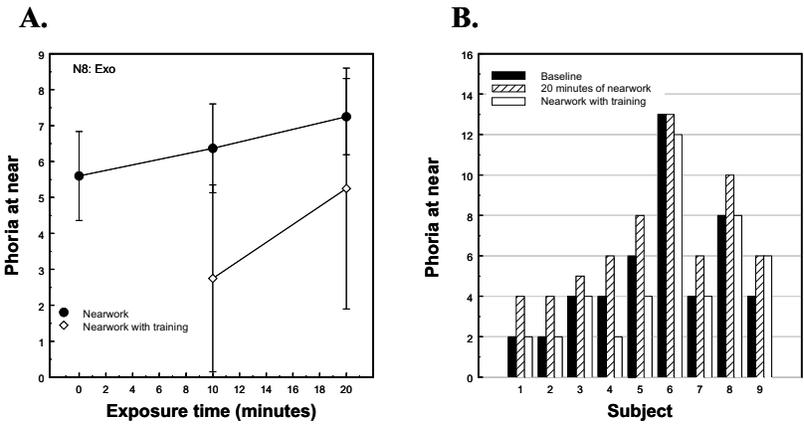


Figure 1 (A). Degree of phoria as a function of nearwork and binocular accommodative rock. Data are represented as means + S.D. (B). Individual degrees of phoria. Both the esophoria (subject #1) and the exophoria were systematically reduced by the binocular accommodative rock.

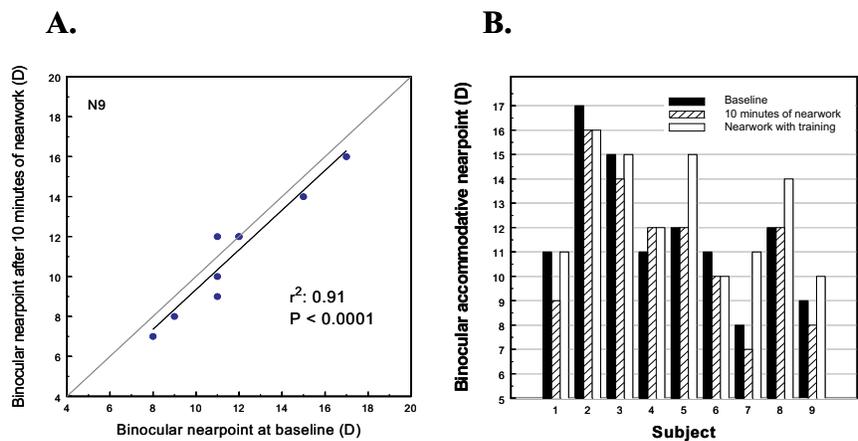


Figure 2(A). Binocular nearpoints at baseline versus after 10 minutes of nearwork. The linear regression between these values yielded a slope of 1.0 ( $Y$ -intercept =  $-0.6$ ). (B). Individual binocular accommodative/vergence nearpoint measures.

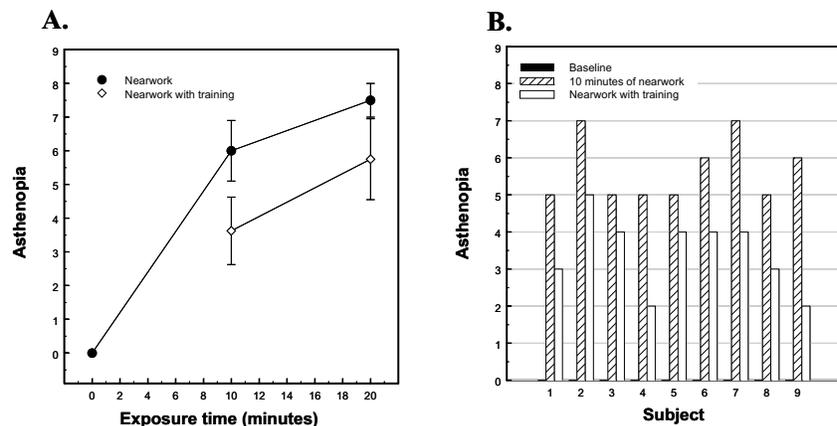


Figure 3(A). The subjective magnitude of asthenopia as a function of nearwork and accommodative/vergence exercises. Data are represented as  $\pm$  S.D. (B). Individual psychophysical ratings of asthenopia/visual discomfort. Asthenopia was significantly reduced by the accommodative/vergence exercises.

The lack of statistical significant effects of nearwork or training on the monocular values designates convergence as a

key mediating function in the present protocol. The monocular values were otherwise quite comparable to the binocular

values. The linear regression between the right eye measures versus the binocular measures yielded a correlation  $r = 0.75$  ( $P < 0.05$ ) and between the left eye measures versus the binocular measures a correlation of  $r = 0.71$  ( $P < 0.05$ ).

**3. Asthenopia/Visual discomfort.** The reliability of the asthenopia measures was computed by comparing all asthenopia estimates collected after 10 minutes with those collected after 20 minutes. The correlation coefficient,  $r_{xy}$ , between these values ( $x = 10$  minutes,  $y = 20$  minutes) gave a value of  $r = 0.87$  ( $P < 0.01$ ). A significant effect of 10 and 20 minutes of nearwork (two-tailed, paired  $t$ -tests,  $p < 0.001$ ) and that of training on asthenopia (two-tailed, paired  $t$ -test,  $p < 0.005$ ) came forth into notice. Eyestrain ratings generally increased in a positively accelerating manner and approached noticeably high magnitudes already after 10 minutes (Figure 3). This eyestrain was systematically alleviated by the accommodative exercises. No obvious relationship was found between changes in asthenopia/visual discomfort and shifts in accommodative/vergence nearpoints or with increases in phoria.

## DISCUSSION

Numerous studies have shown that, immediately after an extended and continuous near vision task, the final phase of the accommodative movement time in response to a far target is prolonged. This lenticular or neuromuscular hysteresis presents itself as a post task myopic shift in the measured far point refraction.<sup>8</sup> This transient shift in accommodation has an exponential decay time of 30 - 40 seconds for short duration tasks at moderate accommodative stimulus levels and has a mean magnitude ranging from 0.15 D to 0.4 D. Because of the small change, the target image can often be within the eye's depth of focus and may not be perceived as blur. The post task accommodative shift is also related to the target distance from the resting state of accommodation.<sup>12</sup> Moreover, following a sustained nearwork task, a decreased ability to posture the focal point at near with a reduced amplitude of accommodation is often a consequence. This is what we have observed in the present study.

In the same way as the accommodative/vergence function can be degraded by prolonged nearwork as shown here, it is equally apt to return to normal function

again given an opportunity through appropriate training.<sup>13-16</sup> The capability of quickly changing focus from far to near and back to far is a necessary qualification for the proper functioning of the visual system.

The intent of the present binocular accommodative rock training was to improve the ability to change focus from one distance to another more rapidly and to counteract the experimentally nearwork-induced post task shifts in visual discomfort and phoria. This training brought about an increase in binocular accommodative nearpoint values, a lower degree of physiological phoria and a reduction in asthenopia (visual discomfort).

## CONCLUSIONS

The training seemed to be beneficial for the visual system. An improved accommodative/vergence ability might also prevent or reduce the tendency to develop visual discomfort, eye and/or muscle strain,<sup>17</sup> especially in those individuals who perform considerable nearwork, have abnormal near accommodation, and/or are at risk to develop functional myopia, inasmuch as even transient retinal blur may have the potential to cause myopigenesis.

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## Sources

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