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Pursuit Tracking Performance With and Without a Fixed Aiming Point in the Presence of Laser Ocular Filters

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ABSTRACT

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PREFACE

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Pursuit Tracking Performance With and Without a Fixed Aiming Point in the Presence of Laser Ocular Filters.

Lasers have become increasingly more important on the battlefield. Laser developments in anti-armor warfare have included the neodymium laser rangefinder, ruby rangefinder and designators whose reflected light guide projectiles to their designated targets. Belkin (1) stated that the presence of these and other laser battlefield weapon systems would make the probability of ocular injury high.

The problem of ocular injury is greatly increased for soldiers who use magnifying optics (e.g. tank gunners, TOW missile operators). Because of the focusing properties of the magnifying optics and of the eye itself, the energy deposited will increase by a factor equal to the square of the magnifying optics. The consequences of the exposure to a laser source can range from a brief loss of visual scene to a vitreous hemorrhage. To reduce the probability of such an event, this problem is being evaluated from several points of view including tactics, doctrine, and laser ocular protection.

One of the approaches currently being considered is the use of laser ocular filters. While such filters might offer the protection necessary, they also may degrade vision. In an earlier report, Stamper et al (2) evaluated the effect of laser protective filters on simulated pursuit tracking performance. While this report did provide useful information concerning the effects of these filters on tracking performance some readers expressed concern because of the high contrast aiming patch affixed to the target vehicle. This study addresses that issue. Specifically, we investigated the effects of a high contrast aiming patch on pursuit tracking performance in the presence of the laser ocular protective materials used in the earlier Stamper et al study (2). The null hypothesis is that the presence or absence of the aiming patch will have no effect on pursuit tracking performance.

METHODS

Volunteers. Nine male volunteers ranging in age from 18 to 30 years, from the Letterman Army Institute of Research, Presidio of San Francisco, CA served as participants. Only volunteers with a 20/20 visual acuity, corrected or uncorrected, and normal dark adaptation function were accepted for this study. Each volunteer was given a Volunteer Agreement/Privacy Act Statement to read and sign.

Apparatus. Pursuit tracking performance was evaluated with the BLASER tracking simulator. This simulator consisted of a scale model T-62 Russian tank target on a terrain board and a full-sized sandbag bunker which housed a viscous-damped optical tracking device. The track-mounted tank was driven across the terrain in either one of two directions (left-to-right or right-to-left) and traversed an arc located approximately 5 m from the operator. The target traveled across the terrain for 15 sec at a constant angular velocity of [illegible] mrad/sec. The unity power optics located in the tracking device simulated a distance of 1 km. Affixed to one side of the tank at the center of mass was a 2.6 cm (1 in) square aiming patch which subtended a visual angle of 5 mrad at the eye. The aiming patch contained an infrared light-emitting diode (IR LED) in the center that was imaged by a television camera mounted coaxially with the optics of the tracking device. Its signal provided a reference source for the microprocessor and associated software to monitor performance electronically, but it was invisible to the operator.

Tracking performance data were collected under two ambient light conditions: bright and dawn/dusk. The dawn/dusk condition was created by inserting a 2.7 OD neutral density filter in the optical pathway of the tracking device. The terrain luminance was measured with a Spectra Minispot Photometer. The average luminance at the objective of the lens was 261 nits with the filter removed and was calculated to be 0.8 nits with the filter in place. No light from the terrain entered the bunker except through the tracking device optics. During the bright ambient light condition the luminance inside the bunker was 5.0 nits; the bunker light was turned off during the low light conditions. During the dawn/dusk ambient light condition, the volunteers sat in the darkened bunker for approximately 10 min to allow their eyes to adjust to a light level that approximated dawn/dusk. More complete descriptions of the BLASER system are included in reports by O'Mara et al. (3) and Stamper et al. (2).

Procedure. After a brief question and answer period each volunteer was asked to participate. To begin the study, the volunteer was seated in the bunker so that he could comfortably view the terrain through the monocular tracking sight. Each tracking session started with the target on the left side of the terrain board. The trials were initiated by the commands "READY", "GO". After the trial the volunteers were instructed to "RELAX" until the next "READY" command. At this time, they were given their summary statistics (percent time-on-target and standard deviation score) for that trial. All volunteers tracked in both directions (left-to-right and right-to-left).

Training. The volunteers received 3 days of training prior to the test days. The first training day consisted of twenty-two 1-min trials, half under the bright ambient light condition and half under the dawn/dusk ambient light condition. The second and third training days were composed of thirty-two 15-sec trials, again half under each ambient light condition. Day 3 differed from Day 2 in that the volunteers were required to track the tank without the 5 mrad target patch mounted on the side.

Test Day. All volunteers received two test days. Each test day consisted of forty 15-sec trials, half under the bright ambient light condition and half under the dawn/dusk ambient light condition. The presentation order of the tanks was randomized in an exhaustive sequence so that half the volunteers tracked the tank with the aiming patch on the first test day and half the volunteers tracked the tank without the aiming patch. The lighting conditions were counterbalanced so that half the volunteers started in the bright light condition and half started in the dawn/dusk light condition.

Filters. For comparison purposes four of the five filters used in the earlier report (2) were also used in this study. There were four filter conditions for each light level which yielded a design that required 5 trials/filter/light level on each test day. The four filters used were: 1)Filter 1: 3mm thickness of KG-3 glass, 2)Filter 2: 3mm of KG-3 glass with a ruby laser multilayer dielectric refractive coating, 3)Filter 3: 3mm thickness of BG-18 glass, and 4)Filter 4: 3mm thickness of clear glass. The order of the filters was also randomized in an exhaustive sequence.

Test Scores, Statistical Analysis & Design. Horizontal and vertical Standard Deviation (SD) error scores which indicate the variability around a predetermined aiming point were collected with the BLASER simulator. The horizontal SD error scores were used in the Analysis of Variance (ANOVA) to evaluate tracking performance. SD error scores were computed from the following equation:

$$SD=(\Sigma X - (\Sigma X)^2/N)^{1/2}$$

The vertical SD error scores were highly similar but uniformly lower than the horizontal scores. For brevity, only the horizontal SD scores were presented in this report. ANOVA's were computed on the SD scores comparing trials with and without the aiming patch and each of the four filter conditions.

A three-way ANOVA was computed on the entire data set of the horizontal error scores to provide a basis for comparing these data to the earlier Stamper et al study (2). The three factors were: A(bright vs dim light) X B(target vs no-target) X C(filters 1-4). Based on the findings of that ANOVA two follow-up two-way ANOVAs were run including the factors of A(target vs no-target) X B(filters 1-4). One ANOVA was computed for each ambient light level. The ANOVAs were performed with BMDP Statistical Software program 2V (5). The 0.05 level of confidence was used for determining significance in all cases. The Least Significant Differences (LSD) test was used for the post hoc comparisons (6).

RESULTS

Figures 1 and 2 present the horizontal SD error scores for the four filters under bright and dawn/dusk ambient light levels respectively. Inspection among the four filter conditions in Fig 1 showed almost no difference among the filters with or without the aiming patch. As shown in Fig 2 the error scores recorded under dawn/dusk conditions were at least twice as large as those recorded under the bright light conditions; in the case of filters 2 and 3 the difference between conditions was even larger. The 3-way ANOVA of these data showed a highly significant main effect for ambient light level (Mean Square (MS)= 34.6, df=1; MS Error= 0.31, df=8; F= 112.87, $p < 0.001$) and a significant ambient light level by filter interaction (MS= 0.55, df=3; MS Error= 0.05, df=24; F= 10.29, $p < 0.01$).

The results of the 2-way ANOVA for the bright light condition showed no significant differences for absence or presence of the aiming patch or filters. For the dawn/dusk trials the ANOVA showed the effect of filters to be highly significant (MS= 0.63, df=3; MS Error= 0.03, df=24; F=23.43, $p < 0.001$). Post hoc LSD tests indicated that when the SD scores for aiming patch vs no aiming patch for each of the filters were compared, no significant differences were found. However, both sets of scores for filter 3 and the no aiming patch scores for filter 2 were significantly higher than the scores for the other filter conditions. The summary of the post hoc tests are listed in Table 1.

FIGURE 1. HORIZONTAL S.D. ERROR SCORES
Bright Ambient Light Condition

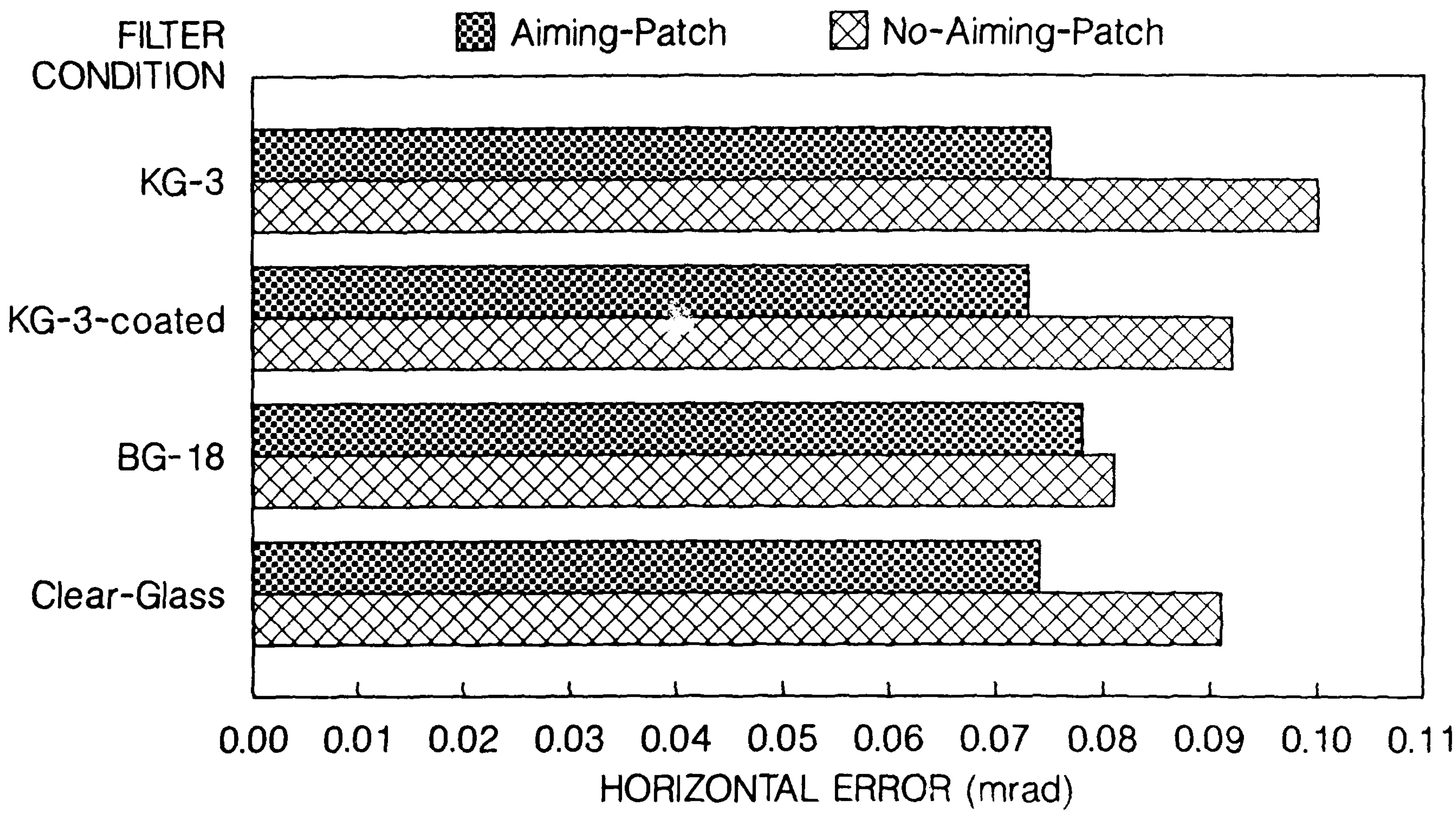


FIGURE 2. HORIZONTAL S.D. ERROR SCORES
Dawn/Dusk Ambient Light Condition

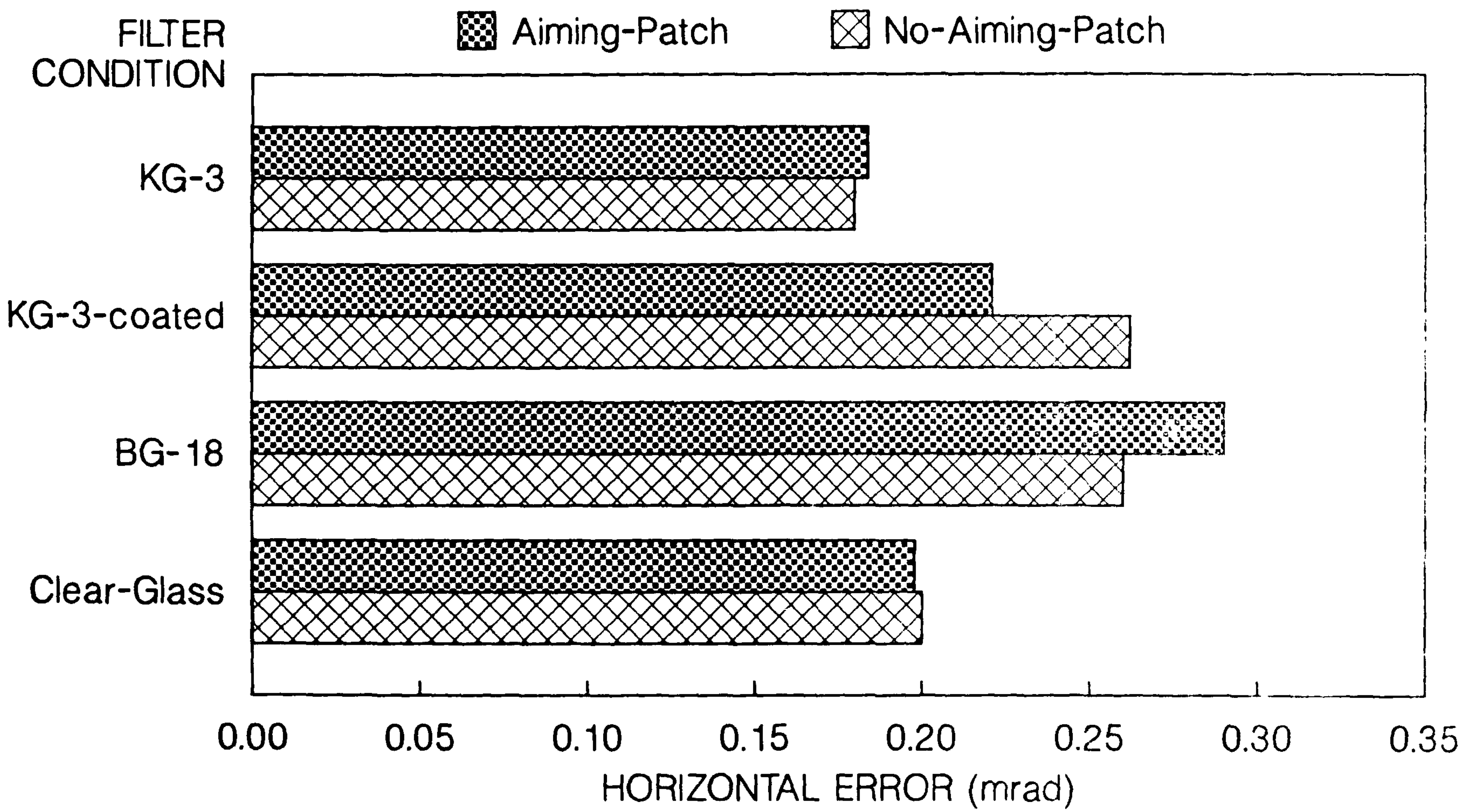


TABLE 1

	No Patch Filter 1	Aiming Patch Filter 1	Aiming Patch Filter 4	No Patch Filter 4	Aiming Patch Filter 2	No Patch Filter 2	No Patch Filter 3	Aiming Patch Filter 3
No Patch Filter 1	0	NS	NS	NS	NS	**	**	**
Aiming Patch Filter 1		0	NS	NS	NS	NS	**	**
Aiming Patch Filter 4			0	NS	NS	NS	NS	**
No Patch Filter 4				0	NS	NS	NS	**
Aiming Patch Filter 2					0	NS	NS	**
No Patch Filter 2						0	NS	**
No Patch Filter 3							0	**
Aiming Patch Filter 3								0

NS - not statistically significant
** - statistically significant

For comparison purposes the SD scores from the earlier Stamper et al (2) report for the same four filter conditions were included with the scores from the present study and presented in Figs 3 and 4. For the bright light trials (Fig 3) there was good agreement between the two studies and the 2-way ANOVA indicated no significant effect among the filters or the target/no target groups. However, under the dawn/dusk condition (Fig 4) a similar pattern of scores to those in Fig 2 is seen. The only exception is the even larger error for filter 3. The ANOVA indicated the effect of the presence or absence of the aiming patch was not significant. However, significant differences among the filters were noted, (MS= 1.26, df=3; MS Error= 0.19, df=3; $F = 39.71$, $p < 0.001$).

FIGURE 3. HORIZONTAL S.D. ERROR SCORES
Bright Ambient Light Condition

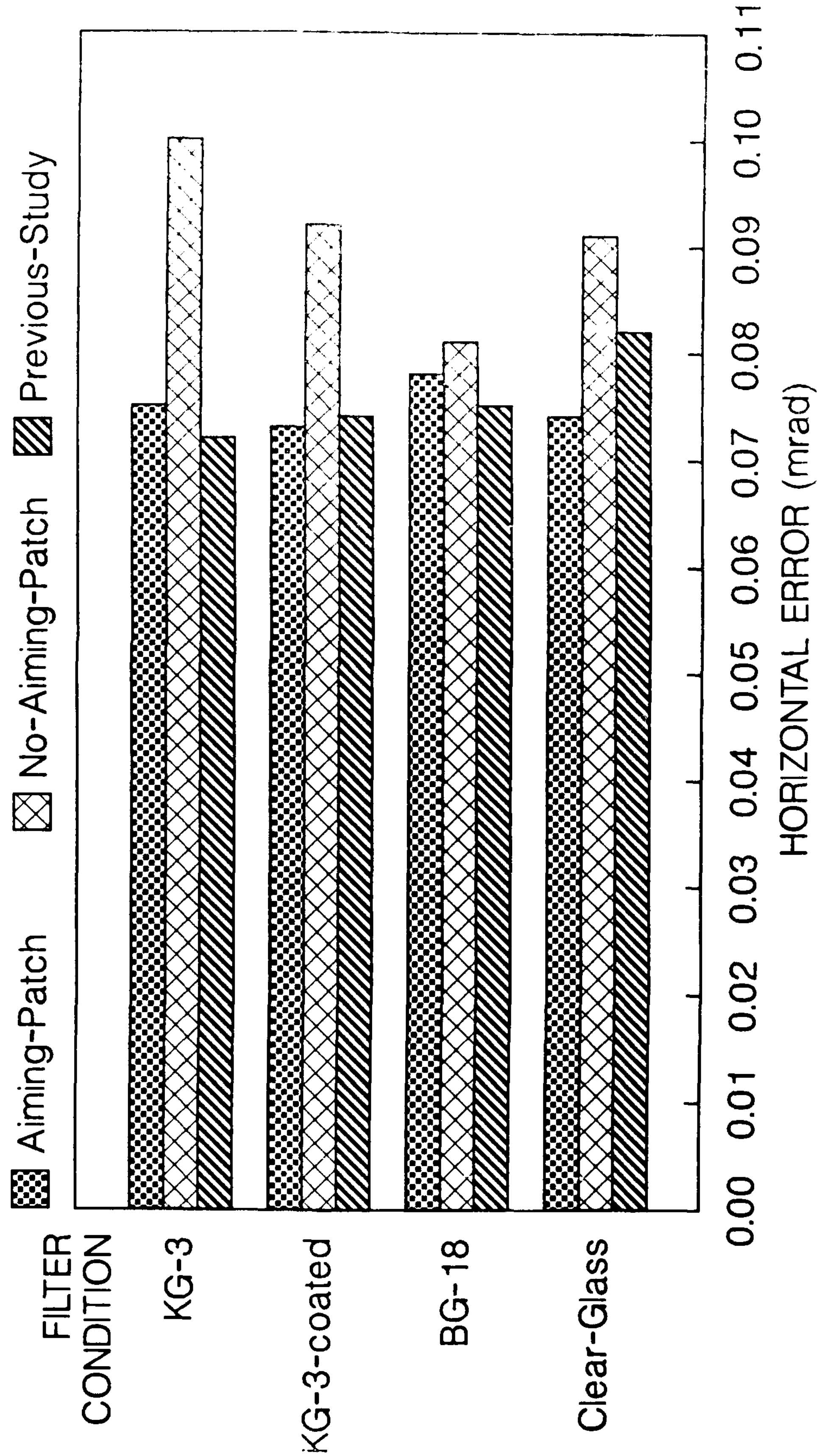
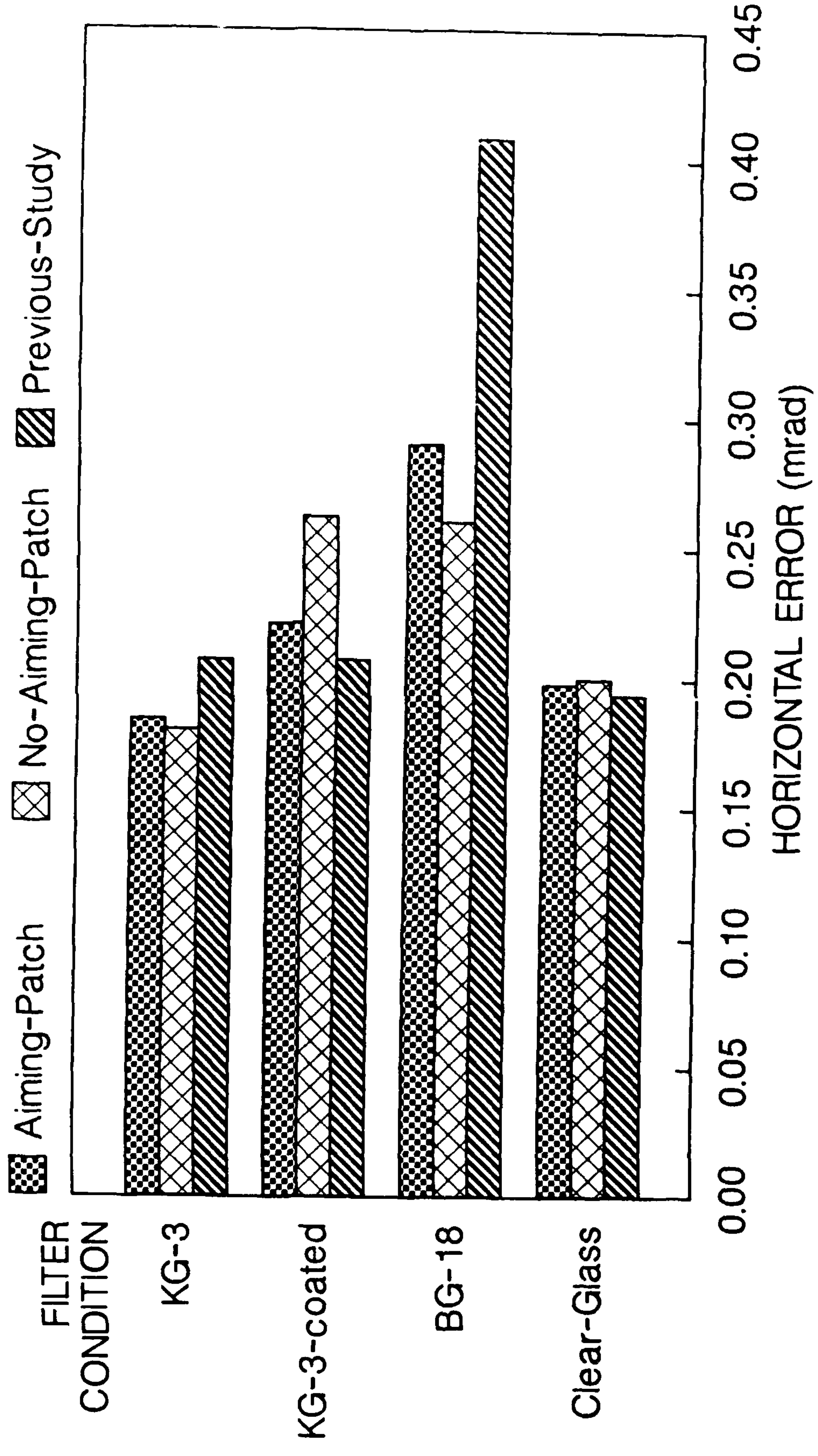


FIGURE 4. HORIZONTAL S.D. ERROR SCORES
Dawn/Dusk Ambient Light Condition



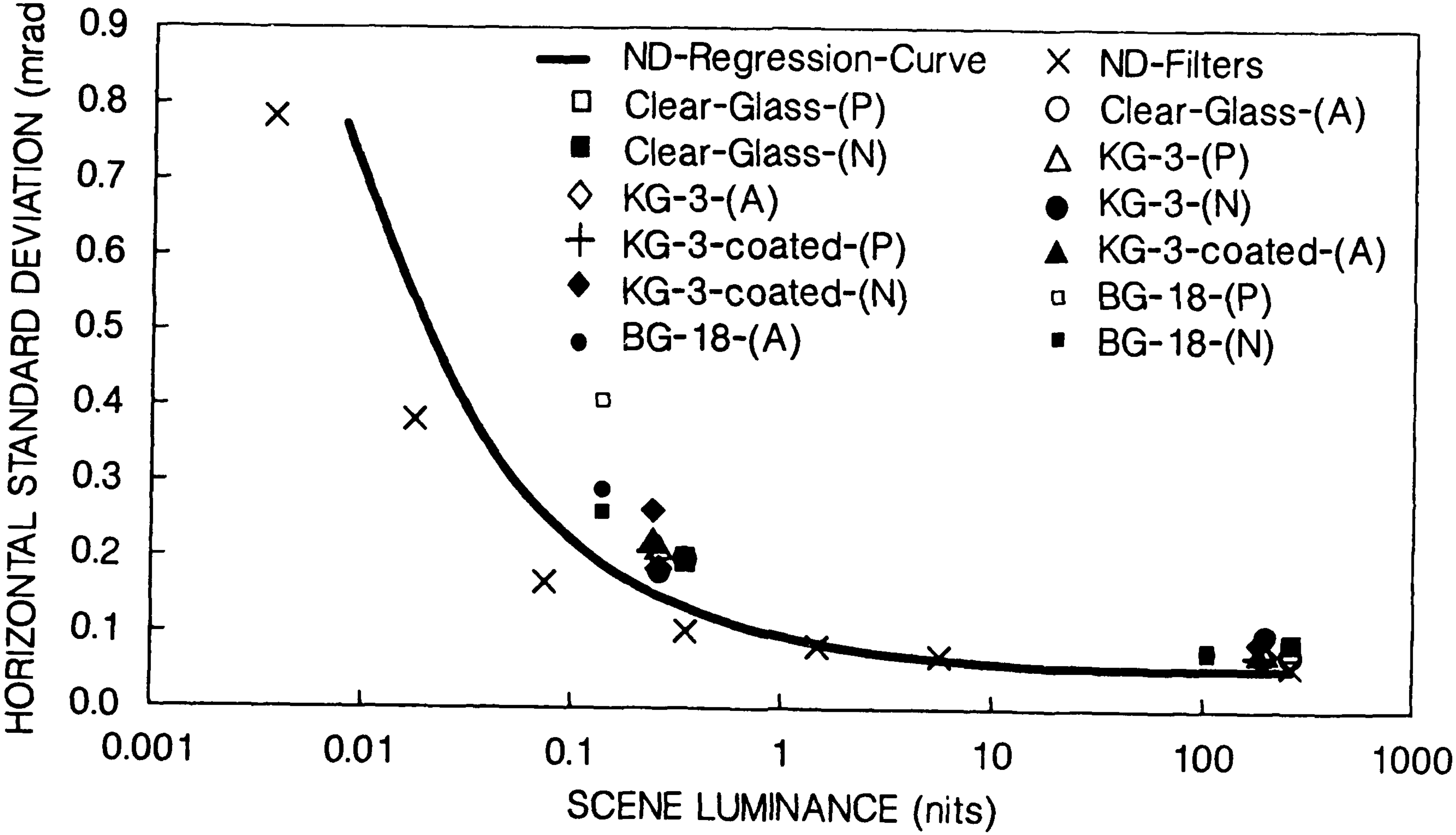
In Fig 5 the SD error scores from this study are presented as a function of luminous transmittance. Also presented are data from an earlier report by Molchany et al (15) who used the same tracking task to determine the effect of progressively reduced luminous transmittance on tracking error scores; transmittance was reduced with a series of neutral density filters. Under the bright light conditions the filters produced a pattern of similar error scores. But under the simulated dawn/dusk conditions used in this study the error scores seemed to rise more steeply than the scores obtained for the neutral density filters and for the points along the curve for the regression equation that was developed from that study.

DISCUSSION

Variables that influence pursuit tracking performance include luminance, target size, target contrast, and color (7-14). The effects of laser ocular protective materials on tracking performance were reported by Stamper (2); however, several readers (personal communications) questioned the possible effects of a high contrast aiming patch on the target vehicle. In this study, we examined the effects of the presence or absence of a high contrast aiming patch on pursuit tracking performance while using 4 of the same laser protective materials as used in this earlier report. We anticipated that the use of a high contrast aiming patch would not significantly effect pursuit tracking performance, especially under bright light conditions where the features of the tank were clearly defined. The data indicate that the presence of a well defined, high contrast aiming patch does not significantly improve tracking accuracy. Apparently, under bright ambient light levels the presence of clearly defined borders and contours on the tank itself enabled the people tracking the target to make the small adjustments necessary to maintain high aiming accuracy just as they were able to detect small discrepancies between the center of the bulls eye and the cross hairs of the tracking device.

Under dawn/dusk conditions the presence of ocular protective filters produced a significant decrements in tracking performance, but the presence and absence of the high contrast target patch did not differentially alter these effects. Low ambient light levels allowed the tank target to remain recognizable, but clear edge definitions were lost, including the target patch. During these trials keeping the cross hairs on a specific spot was difficult presumably because of the lost edge definition within the aiming area.

FIGURE 5. COMPARISON OF HORIZONTAL S. D. ERROR SCORES.



The significant filter main effect in the dawn/dusk ambient light condition was due to a further decrease in luminance caused by 2 of the filters. Molchany et al. (15) reported that pursuit tracking performance decreases rapidly below ambient luminance levels of 1.8×10^{-3} cd/m^2. As luminance decreases, visual cues such as borders and contours gradually become less apparent and eventually disappear. Therefore, under the dawn/dusk ambient light level the high contrast aiming patch became less discernible and was not a factor. Rather, when filters 2 and 3 were imposed on the tracking task, increased error scores were noted. While these differences appear to be small (up to ± .4 mrad) at range they could be a problem. For example, a Russian tank subtends an angle of approximately 7.0 mrad at 1 km, but at 2 km the size has decreased to 3.5 mrad. Because increased range produces a corresponding larger error, the tracking error at that distance has increased to ± 0.8 mrad. Extrapolating the increased error and decreased angular subtense of the target out to the range of the Extended TOW with non-cooperative targets, the potential to completely miss the target due to use of the wrong filter exists. Given the odds facing our troops in the field, this is unacceptable.

CONCLUSION

The results of this study indicate that the presence or absence of the aiming patch does not significantly affect the tracking error scores. These findings apply both to bright light and simulated dawn/dusk conditions. Also, as noted in the earlier report (2), Filter 3 (BG-18) is not the best laser ocular protection available. Under bright light conditions all of the materials are similar in their effects on tracking performance. However, under dawn/dusk conditions where the visual system is operating near its limits, problems may arise from the use of this filter.

REFERENCES

1. Belkin M, Tamir . Laser danger study - Working document from Israel Defense Force (U). Classified Secret USAMIIA CONTR NR-S-1260-79-N, March 1979.

2. Stamper DA, Levine RR, Lund DJ, Stuck BS, Molchany JW, Beatrice ES. Effects of five laser protective materials on simulator pursuit tracking under varied ambient light levels (U). Presidio of San Francisco, CA:Letterman Army Institute of Research, February 1984: Institute Report No. 166 (SECRET).

3. O'Mara PA, Stamper DA, Beatrice ES, Lund DJ, Jones RL, Serenbetz R, Hannon JP. BLASER: a simulator for the investigation of biomedical factors influencing laser-designator operators. Presidio of San Francisco, CA: Letterman Army Institute of Research, 1979: Technical Note No, 79-10TN.

4. Stamper DA, O'Mara PA, Beatrice ES Lund DJ. Tracking Performance with a viscous-damped mount under simulated conditions of varied ambient light level and velocities. Presidio of San Francisco, CA: Letterman Army Institute of Research, 1980: Institute Report No. 82.

5. Dixon WJ, Brown MB, eds. BMDP Statistical Software. Los Angeles, California: University of California Press, 1985.

6. Winer BJ. Statistical Principles in experimental design. New York: McGraw-Hill Book Co., 1971:199.

7. Steinman RM. Effect of target size, luminance and color on monocular fixation. J Opt Soc A 1965;55:1158-65.

8. Bloomfield JR, Graf CP, Graffunder K. Visual factors in target disruption. [Abstract] NTIS 1975.

9. Home R. The effects of colour and luminance filtering on military acquisition. 01 Division, Royal Signals and Radar Establishment, Malvern, Worcestershire, England.

10. van der Willit GL. Waarts RG. Contrast detection and its dependence on the presence of edges and lines in the stimulus field. Vision Res 1983;23:821-830.

11. Blackwell HR. Contrast thresholds of the human eye. J Opt Soc A 1946;36:624-643.

12. Teichner WH, Mocharnuk JB. Visual search for complex targets. Hum Factors 1979;21:259-275.

13. Luckiesh M. Light, vision and seeing. New York: D Van Nostrand, 1974.

14. Zoethout WD. Physiological Optics, 4th ed. Chicago: Professional Press, 1947.

15. Molchany JW, Stamper DA, Lund DJ. Pursuit tracking performance decrements associated with decreasing ambient illumination. Presidio of San Francisco, CA: Letterman Army Institute of Research, 1987: Institute Report No. 243.

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