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TITLE

BLUE BLOCKERS IN FLYING OPERATIONS

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BLUE BLOCKERS IN FLYING OPERATIONS

DCIEM Technical Memorandum OMD 95/1

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ABSTRACT

This technical memorandum reviews the open literature and research reports originating from civilian and military research establishments on the benefits of Blue Blockers (BBs) for target acquisition under various illumination and meteorological conditions. Although subjective reports from fighter pilots have been mainly favorable, all operational evaluations have failed to show any improvement in the visual acquisition of small targets under any atmospheric conditions. Objective experiments have been able to demonstrate the potential usefulness of the BBs for large low contrast target when viewed under flat light conditions. Reports have shown that the effectiveness of BBs was linked to the amount pigments encountered in the macula of the eye -the stronger the pigmentation the less effective the BBs. These results are discussed in relation to fighter and Search and Rescue operations and comments on color confusion, visual illusion and eye protection. Are also included recommendations for the purchase of a future neutral density filter. A detailed bibliography follows the text.

INTRODUCTION

1. The belief that Blue Blockers (BBs)- also referred to as yellow lenses- enhance visual performance is not new (Luckiesh, 1915). They have been inconclusively associated with improved sharp-shooting (Ross, 1950; Bierman, 1952), incorrectly prescribed as visual aids for twilight and night driving (Richards, 1953; Davey and Sheridan, 1953; Richards, 1964), and entertained lately as potential enhancers of visual performance for patients diagnosed with cataract and other macular degeneration (Yap, 1984; Zigman,

1990). However, the bulk of the evidence, fails to support their widespread popularity (Porkony et al. 1968; Clark, 1969a; Kelly et al. 1984; Kelly, 1990). Of all the claims made over the past 80 years, only that of skiers, claiming to be able to detect more easily relatively large tracks and depressions in snow under flat light condition with BBs, seem to have some validity (Kinney et al, 1983a).

2. This technical memorandum will explain the basic theory behind the optic filters known as BBs and provide some explanation as to their potential usefulness for fighter and Search and Rescue operations in the CF. Concerns with respect to color discrimination and visual illusions caused by the BBs will also be raised.

DISCUSSION

I. The theory behind the BBs

3. It is generally accepted that under natural lighting conditions visual performance improves as illumination rises (Shlaer, 1937). However, beyond a certain illumination level, the eye can no longer adapt to the increasing brightness and performance degrades. To overcome this problem, optic filters are generally introduced in front of the eye to reduce, to a comfortable illumination level, the amount of light reaching the retina. Optic filters reduce the illumination by either filtering the whole visual spectrum or selectively filtering specific frequencies. Filtering across the whole visual spectrum is done by Neutral Density Filters (NDFs) while selective filtering is done by specific filters such as BBs. In this later case the blue end of the visual spectrum is filtered out. Their short frequencies, more easily scattered by the atmosphere, are responsible for a phenomena known as glare which, among other things, decreases the apparent contrast. Photographers, have long recognized the positive effect of BBs in minimizing glare, or the negative influence of a bright blue sky, in improving the contrast of objects on photographic films (Eastman Kodak Co., 1946, 1949), a benefit likely to be transferred to the visual system (Zigman, 1990).

4. Filtering out blue frequencies increases the apparent relative image brightness despite reducing the total amount of illumination available to the retina (Luckiesh and Moss, 1925; Septon 1968). BBs provide an image that appears to be 45% brighter than that of a NDF of the same transmissivity (Kelly, 1984). At the present time NDFs used in the military air forces are 12% transmissive which might be too low for most daytime flying conditions (Task, 1989). When this value is multiplied by typical aircraft transparency transmissitivity of about of 0.5-0.6, only 6%-7% of the light available reaches the eye. The presence of a HUD further lowers this to 3% to 4% (Task, 1989). These percentage are significantly lower than the standard 15% prescribed for general use sunglasses (Farnsworth, 1948; Clark, 1969b) or the 12% of present military sunglasses (Task, 1989). The low level of transmissivity of the NDF coupled with the canopy and the HUD could well explain the pilots' preference for BBs since they do not decrease the available illumination as much while providing a transmissivity approaching 100% in the green to yellow-red spectrum (480nm to 600nm)-(Gentex, 1990). Another possible explanation could be the shift of the image color toward the yellow frequencies for which the human eye is more sensitive.

5. The increased relative image brightness and the eye's sensitivity for the yellow frequencies lead to the postulate that BBs would improve visual performance but objective evaluations of this later issue have been inconsistent. (Luckiesh and Moss, 1936; Luckiesh and Holladay, 1941; Verplanck, 1947; Bierman, 1952; Berte, 1953; Wyszecki, 1956; Allen, 1961; Luria 1972).

6. BBs have been tested extensively in laboratory set-ups against the naked eye or other optic filters to verify if they were objectively leading to an improvement in visual performance. The results showed that when transmissitivity of the BB was below the minimum required by the optic system to function at its optimal level, visual acuity was degraded despite the increase in perceived brightness (Lythgoe, 1932, Verplanck, 1945, Peckham, 1952, Dember , 1960, Raphelson and Kirchner, 1963). When the transmissitivity of the BBs was high enough as to maintain the visual system at its optimum, visual performance was neither degraded nor

improved (Porkony et al. 1968; Clark, 1969a). When tested in operational set-ups against clear lenses BBs did not demonstrate any improvement in the pilot's visual acuity under any meteorological conditions (Provines et al. 1992).

II. BBs in fighter operations

7. The effectiveness of BBs in ground target acquisition has been evaluated (Kinslin et al. 1968a, 1968b). Analysis of reaction times for ground target acquisition under hazy or cloudy conditions on static displays (Kinslin et al. 1968a) and along training routes at 500 ft to 1000 ft and 450 knts to 500 knts over various sky conditions were performed (Kinslin et al., 1968b). Although the pilots of both studies subjectively claimed that their visual performance was improved by the BBs, objective target acquisition data failed to show any overall advantage over NDFs. The results pointed out that the variety of targets and background colors present in such missions could cause a pilot wearing BBs to notice some targets more easily while others would be missed completely. It is likely that the subjective preference was based on those targets more readily seen rather than on the whole spectrum of targets present along the routes.

8. The subjective reports from many fighter pilots that BBs improve target acquisition in-flight (HQ TAC Langley AFB, 1989; ALSEO Meeting, 1994) is not supported by objective experimental results (Kinslin et al, 1968a, b; Provines et al. 1992) . Allen (1961) reported that BBs generally increase the subjective assessment of distance, and individual reports from a USAF survey (HQ TAC Langley AFB, 1989) revealed that some pilots felt further away from the ground than they really were. This erroneous perception of distance could also contribute to the difference between subjective and objective results.

9. It has been postulated that BBs should improve visual performance by increasing the perceived contrast between the object and the background (Miller, 1974). Some experiments have confirmed this hypothesis. Visibility of large low contrast objects -15′ wide holes at 150ft of distance or objects

characterized by spatial frequencies between 0.5cpd to 2-3cpd- under flat light conditions have been improved by BBs (Kinney et al., 1983a; Kinney et al., 1983b). However, the detection of large neutral targets, such as large defoliated areas, under hazy conditions were adversely affected by the use of BBs (Kinslin et al. 1968a). Further, in the case of small neutral colored objects, such as a foe viewed from 9 miles on final, characterized by a spatial frequency around 20cpd, BBs failed to improve detection whether under hazy or clear sky (Provines et al. 1992).

III. BBs in Search & Rescue operations

10. While the BBs failed to improve the detection of small neutral colored objects they nevertheless could be of some benefits in detecting relatively large low contrast targets under flat light viewing conditions (Richards, 1973; Schlichting et al, 1980; Luria et al. 1983; Kinney et al., 1983a, Kinney et al. , 1983b; Kelly et al., 1984; Yap, 1984). Search and Rescue observers are often required to spot relatively large depressions or mounts under flat light conditions over snowy areas. For these later BBs could be of some benefits.

11. Experiments carried out in the laboratory by Richards (1973) showed that the improvement in detecting low contrast middle range spatial frequencies (2-3cpd) was function of the intensity in coloration of the BBs. His analysis revealed a slight correlation between improvement in visual performance, coloration of the lenses and the pigmentation encountered in the back of the retina. This pigmentation, more or less apparent in each individual already, act as a blue filter. Thus individuals with no or light macular pigmentation showed their best performance with dark BBs while those with a strong pigmentation required a filter of much lighter coloration. From these data it would be reasonable to expect BBs to lead to an improved contrast discrimination performance for large low contrast targets under flat light for as long as the intensity of yellow coloration of the lens is appropriately matched to the individual's macular pigmentation.

IV. BBs, color discrimination, visual illusions, and visual protection.

12. BBs have been shown to cause problems in color discrimination especially with lenses of high color purity- the higher the purity the darker the color and the higher the color confusion (Berggren, 1970; Phillips & Konding, 1975; Thomas & Kuyk, 1988; Kuyk & Thomas, 1990). Richards (1973) showed that the optimum yellow filter should have a purity around 37%. However, in order to minimize color discrimination it is recommended that the upper limit purity or coloration for BBs not exceed 20-25% (Farnsworth, 1945, Matthews, 1949; Clark, 1969b; Luria et al. 1983).

13. Kuyk & Thomas (1988) evaluated various BBs for color confusion on task performance. Color confusion has been seen between blue and white, blue and purple, blue-green and green , blue-green and blue and yellow and orange (Kuyk & Thomas; 1990). Color confusion is more pronounced for small targets and does not seem to resolve as the illumination level rises.

14. From an operational point of view, BBs are most effective when the background is blue and the target yellow (Luria, 1972). But the visibility of yellow targets decreases as the background shifts away from the blues (Luria, 1972) and can sometimes become invisible (Ycavonne & Erickson (1992). There is no advantage to wearing BBs for blue targets seen against blue background unless the target contains a higher percentage of green or red. Brown targets are more easily picked up against a green background if haze is present but gray targets under the same conditions are almost invisible (Kinslin et al. 1968). BBs also distort or wash out colors on maps and multipurpose displays;. Discrimination between light green and pale yellow colored areas on a paper map becomes impossible (personal observation), blues on multipurpose display are difficult to see and yellows wash away (HQ TAC Langley AFB, 1989). The color confusion inherent with the use of BBs makes them potentially hazardous for use during IFR flying.

15. Beside the proved color confusion in operational settings, BBs have also been reported to increase subjective distress under high illumination level and often cause the disappearance of horizon lines (Allen, 1961, High

Contrast Visor Aircrew Survey, HQ TAC Langley AFB, 1989). They have been known to cause confusion between tall waving grass, small trees areas and small lakes any of these being potentially confused with the others (Kislin et al. 1968).

16. Another element to consider about the BBs is their lack of protection against IR radiation. IR radiation reaches potentially hazardous level at altitude and visual protection against them is a must for any optical filter used in flying operations.

CONCLUSIONS:

17. Although the subjective evaluations of BBs by fighter pilots have been mainly favorable, all operational evaluations have failed to show any improvement in the visual acquisition of small target under any atmospheric conditions. Only in the case of large low contrast targets seen under flat light conditions were these filters of some benefit. These results are tempered by the fact that, to achieve optimum improvement, the BBs have to be properly matched with individual's macular pigmentation while not exceeding 25% in purity. BBs cannot be used in all circumstances contrary to NDFs. Their performance decreases (i) as the background shift away from the blue frequencies, (ii) as the size of the target decreases, (iii) as the luminance decreases, and (iv) with the increasing age of the observer due to the natural yellowing of the lens (Luria, 1972).

18. Based on a review of the open literature and research reports originating from civilian and military research establishments, BBs cannot be prescribed safely for fighter operations but could be considered for use by Search & Rescue observers although the improvement brought in, believed to be around 5% to 10% is likely to be insignificant when ones consider interpersonal variation (Task, 1989).

19. A replacement NDF of higher transmissivity 25-35% (Task, 1989) with appropriate UV and IR protection would be preferred to the purchase of BBs because a NDF of 25-35% (i) does not degrade visual acuity and

maintains the visual system in an optimum illumination level, cause color confusion, create distress or false perception or require an individual prescription depending on the macular pigmentation of the user. Finally a NDF would be compatible for VFR and IFR flying, and would alleviate the problems associated with the integration of a third visor on the flight helmet.

RECOMMENDATIONS

20. BBs are not suitable for most flying environments. Any requests to introduce these devices should be reviewed considering their adverse effects on distance perception, interpretation of certain terrain features, the potential for hazards to disappear, the difficulties encountered in instruments readings and the loss of certain map features.

21. In the future it might be worth considering introducing a NDF of lower density if these prove to be superior in operational conditions.

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