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EYEPIECE SETTING FOR THE L1A1 WEAPON SIGHT.(U)
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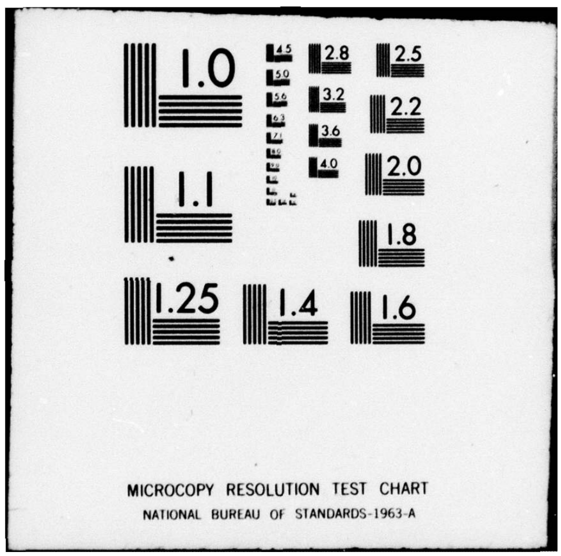
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6 EYEPIECE SETTING FOR THE L1A1 WEAPON SIGHT.

12 15p.

9 Technical rept.,

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ABSTRACT

Three experiments were performed in order to examine the suggestion that relatively high negative settings (-1.75 to -2.00 dioptres) of the L1A1 image intensifier eyepiece yield optimum visual performance. Although detection and recognition performance did not vary greatly as a function of the eyepiece settings (10% or less), the data suggest that the traditional setting of -0.5 to -1.0 dioptres be used. The relatively large advantage to be gained from selecting the user of the L1A1 is noted.

INTRODUCTION

DCIEM was asked by DLAEEM to determine the optimal dioptre-setting for the L1A1 fixed eyepiece. The L1A1 is an image-intensifying sight for use at night with short-range, direct-fire, infantry weapons.

The manufacturer's recommendation for the eyepiece setting was in the range of -1.75 to -2.00 dioptres (D). Typical settings for fixed eyepieces are in the range of -0.5 to -1.0 D for optical instruments used for viewing in daylight levels of illumination. Discussions with the manufacturer disclosed that the setting recommended was intended to compensate for the well-known fact that the human eye becomes somewhat myopic at lower light levels. The range of accommodation (focussing) of the eye decreases with decreasing luminance and/or luminance contrast, eventually reaching a state of fixed, or resting, focus at intermediate light levels. In general, it appears that this resting point of accommodation is in the range of -1.0 to -2.0 D and that the accommodation achieved in viewing a target is a compromise between accommodating on the target and accommodating at the resting-point: accommodation is almost always somewhat in error. At high luminance levels, however, small errors in accommodation are relatively unimportant because the small eye pupil gives good depth of field and, therefore, a sharp retinal image in spite of the error in focussing.

It is at the low levels of illumination then, when viewing distant targets, that the error in accommodation would result in considerable blurring of the retinal image and, presumably, decreased visual efficiency and it is for this condition that the manufacturer recommended the relatively high negative values of the eyepiece setting. However, it should be noted that, since an image intensifier does, in fact, intensify the image, the user's eye will be viewing at light levels much higher than ambient. In some of the image-intensifier experiments to be described, the observers' were viewing dark objects against backgrounds of the order of 10^{-5} and 10^{-4} ft-L; the measured luminance of the scene they were viewing through the eyepiece was of the order of 10^{-1} and 10^{0} ft-L, respectively. These values are relatively high and correction for myopia might not be required. The experiments in this study were intended to determine whether such high negative settings of the L1A1 eyepiece did, in fact, result in better performance than with the more traditional, less negative, settings.

<u>Experiment I: Procedure</u>

This experiment was conducted with the Starlight Scope, which has a variable eyepiece, because difficulties were encountered in attempting to modify the fixed eyepiece assembly of the L1A1 to make the dioptre-setting more easily variable.

The experiment was conducted in a dark, light-proof tunnel, using a Kodak 35 mm projector to present black and white target slides on a screen. The luminance of the target scene was controlled by Kodak neutral density filters. The targets were 16 black Landolt C's, whose diameter varied logarithmically from three minutes to 12 minutes of arc (the angle subtended at the objective of the sight). The break in the C, which varied with the diameter of the C, varied from 0.6 to 2.6 minutes. Each target appeared on a square white background which was 17 minutes on each side. Four positions of the break (up, down, left, right) were presented equally often and in pseudo-random order. The luminance of the white background was about 10^{-5} ft-L and the corresponding luminance seen through the scope was of the order of 10^{-1} ft-L. The viewing distance was 70 feet.

The observer's task was to report the position of the break in the Landolt C within 30 seconds. Each observer was presented with 80 slides at each of the four dioptre-settings used: 0.0, -0.5, -1.0, and -1.75 D.

The twenty observers were young and had 20/20 or better near and far acuity as measured by the Armed Forces Vision Tester.

Experiment I: Results

Fig. 1 shows visual performance (percent correct reports of the position of the break in the ring) as a function of target size for the four dioptre-settings. Each experimental point was derived from 100 reports. It can be seen that the maximum difference in performance as a function of diopter setting was about 10%. The Wilcoxen-Matched-Pairs-Signed-Ranks test (Siegel, 1956) was used to determine whether statistically significant differences existed. The 95% confidence level was used. Performance using a setting of either -0.5 or -1.0 D was superior to performance using either 0.0 D or -1.75 D. There were no differences in performance between -0.5 and -1.0 D, or between 0.0 and -1.75 D.

On the basis of this experiment, we could perhaps conclude that the recommended setting of -1.75 to -2.00 D is inappropriate, and that the eyepiece of the L1A1 should be set in the traditional range of -0.5 to -1.00 D. However the visual task involved is rather a "clean" laboratory task, and possibly a task more closely analogous to field conditions would be more appropriate for our purposes.

Experiment II: Procedure

In the second experiment, the newly-modified L1A1 was calibrated by means of a dioptre telescope for each of the same four dioptre settings used in the first experiment. The observers had to detect and recognize military-type objects such as soldiers, jeeps, tanks, etc., in a simulated natural setting. Each test slide had the same background and contained one target object selected from the array of silhouettes. There were two constraints on the location of a target within the scene:

a) The target was isolated on white ground, untouched by any other object in the terrain;

b) The target obeyed the perspective laws evident within the scene, retaining a size appropriate to its apparent distance from the observer, and proportional to the other objects in the terrain.

Obviously, because of the predetermined size and position of the available white areas, placement was limited, especially at close distances where targets were quite large. However, an attempt was made to randomize, as much as possible, simulated distance and location of targets within the terrain. Subjects were allowed to study the list of targets and a picture of the background scene before the session began. Correct naming of the vehicles (military and unfamiliar to many) was necessary for efficient scoring, and so target pictures were available for reference throughout the test. The observers were given a flashlight with masked bulb for this purpose, and cautioned to use it only when necessary.

Using each of the four dioptre settings, a given observer was presented with the 15 targets at 5 simulated distances; that is, the observer made 75 observations at each diopter setting. The range of target sizes, was from 1.9' to 37.9' of arc. The viewing distance was 30 feet.

A few test slides were shown to familiarize the observer with the appearance of the viewing screen through the scope, and with the possible areas where targets might appear. The scope was then fixed at one of the test settings, the 75 slides presented, and the observer asked to locate and identify the target which appeared in each one. For a detection report to be recorded as correct, the observer had only to locate the target with respect to the background. A correct recognition was recorded only if he could locate the target and point to the correct vehicle in the test target array.

Twenty male and female observers, all with 20/20 vision, ran in an experiment in which the luminance of the white portions of the background was 10^{-4} ft-L. An additional 10 observers ran twice each in exactly the same experiment with a background luminance of 10^{-5} ft-L. The luminance levels at the eyepiece of the scope were of the order of 10^{0} and 10^{-1} ft-L, respectively.

Experiment II: Results

Fig. 2 and 3 show detection and recognition performance as a function of target range at background luminances of 10^{-4} and 10^{-5} ft-L respectively. Each data point is derived from 300 observations. It can be seen that any differences in performance which can be attributed to the setting of the eyepiece are rather small - of the order of a few percent. Again the Wilcoxen signed-ranks-matched-pairs test was applied to determine the differences significant at the 95% level of confidence; only three were found. A setting of -0.5 D yielded recognition performance superior to performance using a setting of 0.0 D at both light levels, and at 10^{-5} ft-L, a setting of -1.0 D provided recognition performance superior to the performance using a setting of -1.75 D.

CONCLUSIONS

The results of Experiments I and II certainly cannot be considered to be evidence supporting the choice of -1.75 to -2.00 D as the optimum eye-piece setting for the L1A1 image intensifier. Although differences in detection and recognition performances in the second experiment which can be attributed to differences in the dioptre setting are small, the overall impression from the data of both experiments is that the traditional setting in the range of -0.5 to -1.0 D be used.

The data of these experiments exhibit a characteristic common to many studies involving humans -- the variation in performance among subjects is greater than the variation in performance due to changes in the variable of interest (dioptre setting in this case). This phenomenon is important in the present context because it points to the conclusion that the choice of who is to use the L1A1 is of more importance than the choice of the dioptre-setting. Let us use the recognition performance data of Experiment II (10^{-4} ft-L) to illustrate this point.

With a setting of -1.75 D the 20 subjects correctly located and recognized 630/1500 of the targets presented. With a setting of -0.5 D they correctly located and recognized 678/1500 targets. Thus, we might expect to improve performance by 7.6% (48x100/630) by changing the eye-piece setting from -1.75 D to -0.5 D. If, on the other hand, we decided not to change the setting but to allow only the best 25% of observers to use the sight, our data indicate that 848 targets would be recognized -- a gain of 34.6%. (The top 25% of the observers in this experiment correctly recognized 212/375 targets using the -1.75 D setting. 848 = 4x212). Thus the increase in performance to be expected on the basis of observer selection is about 4½ times the increase to be expected on the basis of dioptre-setting selection.

REFERENCES

SIEGEL, S. Nonparametric Statistics for the Behavioural Sciences, McGraw-Hill, 1956.

Figure 1: Average detection performance of 20 observers using the Starlight Scope with four different eyepiece settings (0.0, -0.5, -1.0, and -1.75 D). Each data point is based on 100 observations.

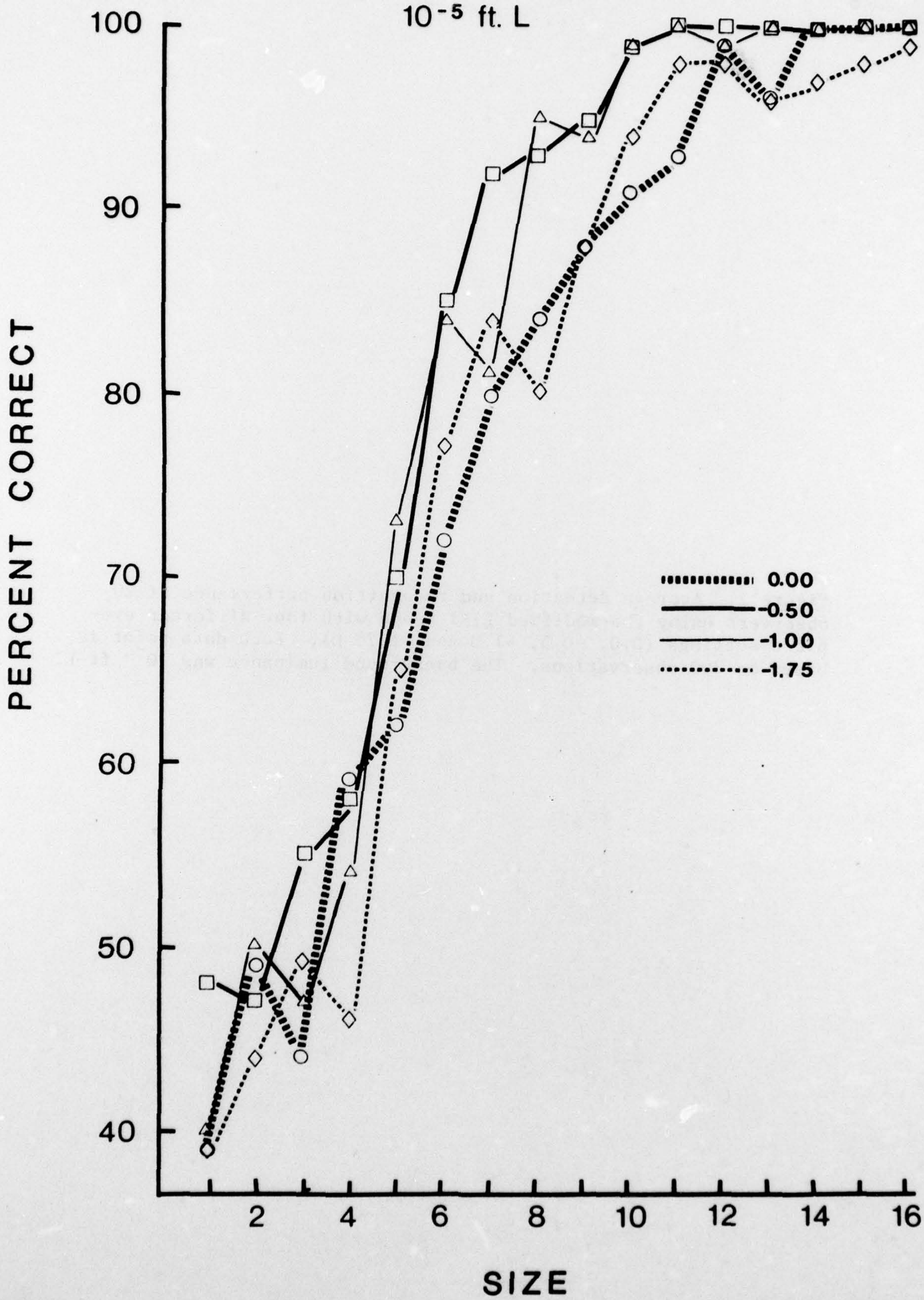

10⁻⁵ ft. L
PERCENT CORRECT
100
90
80
70
60
50
40
2
4
6
8
10
12
14
16
SIZE
0.00
-0.50
-1.00
-1.75

Figure 2: Average detection and recognition performance of 20 observers using the modified L1A1 Scope with four different eyepiece settings (0.0, -0.5, -1.0 and -1.75 D). Each data point is based on 300 observations. The background luminance was 10^{-4} ft-L.

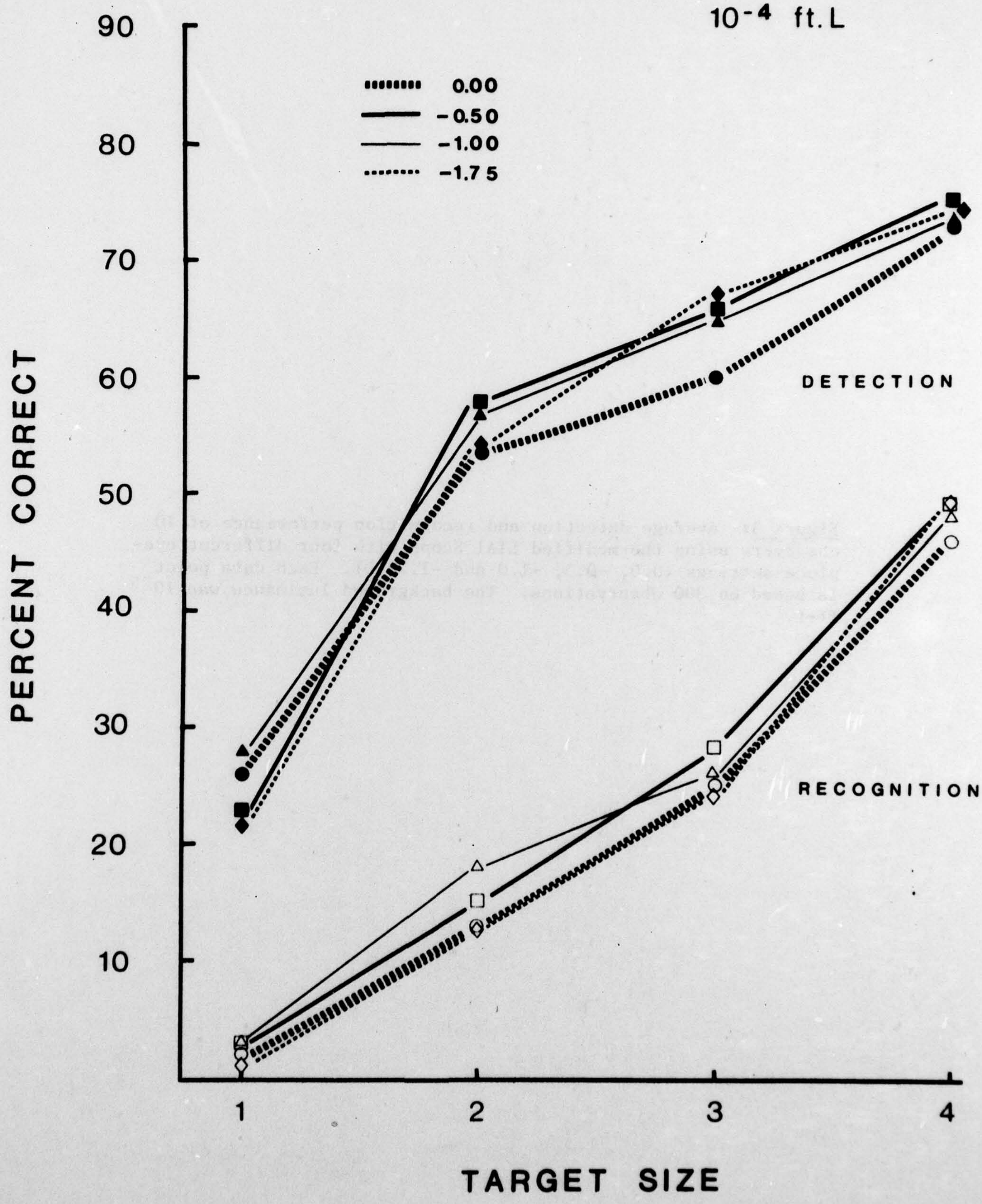
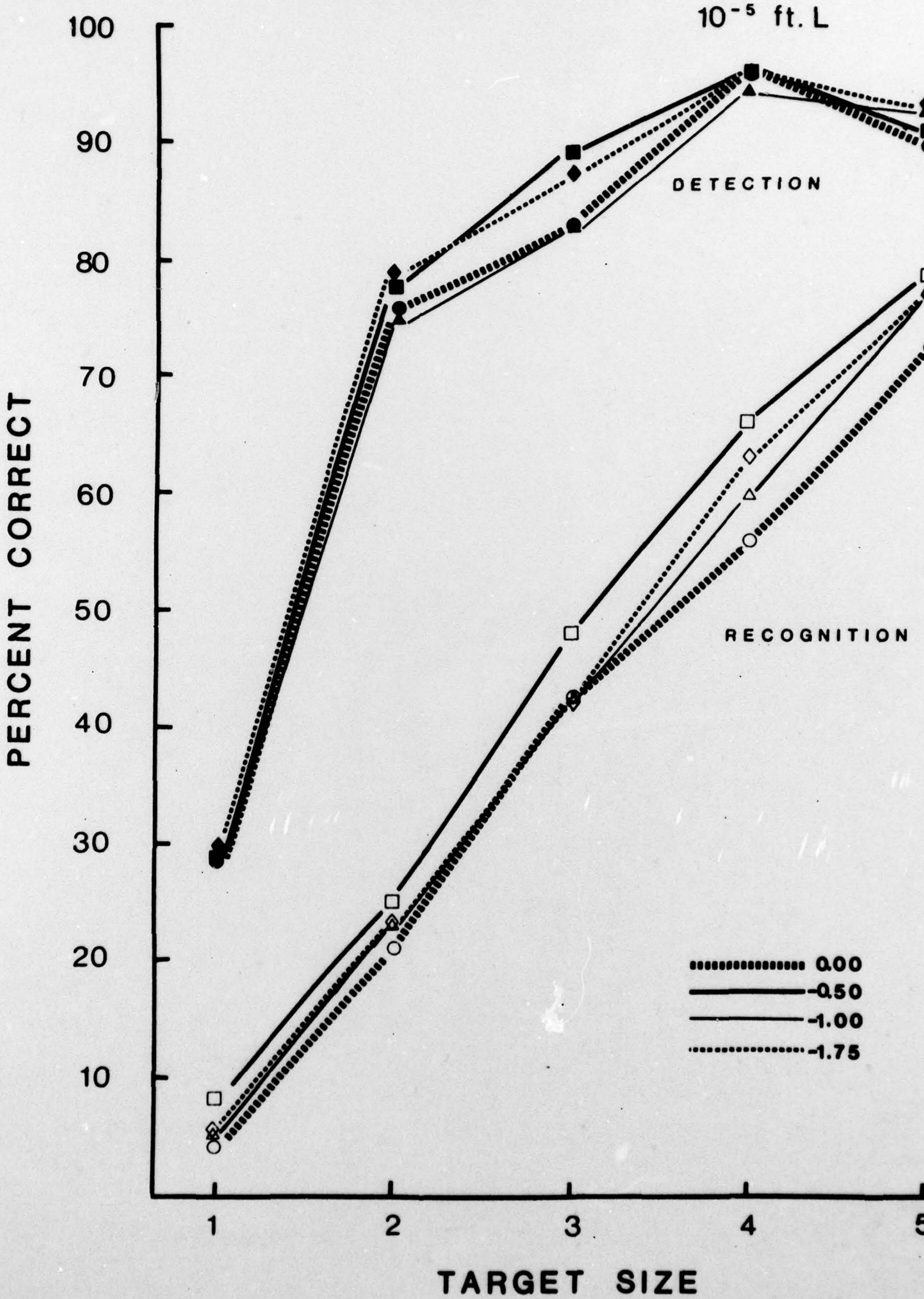

10⁻⁴ ft. L
0.00
-0.50
-1.00
-1.75
PERCENT CORRECT
90
80
70
60
50
40
30
20
10
DETECTION
RECOGNITION
1
2
3
4
TARGET SIZE

Figure 3: Average detection and recognition performance of 10 observers using the modified L1A1 Scope with four different eyepiece settings (0.0, -0.5, -1.0 and -1.75 D). Each data point is based on 300 observations. The background luminance was 10^{-5} ft-L.


10⁻⁵ ft. L
100
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80
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PERCENT CORRECT
DETECTION
RECOGNITION
0.00
-0.50
-1.00
-1.75
1
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4
5
TARGET SIZE