Technical Research Report 1169

IMPROVED SEARCH TECHNIQUES WITH PASSIVE NIGHT VISION DEVICES

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BESRL Technical Research Reports and Technical Research Notes are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Night Operations Program within the Behavior and Systems Research Laboratory (BESRL) is concerned with optimizing human performance in relation to night vision devices and related sensors. Specific aspects deal with determining: performance effectiveness of sensor systems; factors that affect performance; and means of improving effectiveness. The entire research program is responsive to requirements of the Combat Developments Command and is conducted under RDT&E Project 2Q024701A723, Human Performance in Military Systems, FY 1971 Work Program.

To further the research, a BESRL field unit at Fort Ord, California, with the support of the Combat Developments Command Experimentation Command (CDCEC), is currently conducting experimentation with passive night vision devices. Personnel of the Behavior and Systems Research Laboratory are deeply appreciative of the excellent support given the research program by CDCEC, both in personnel and materiel. Special acknowledgment is made of the efforts of the Commander, Brigadier General T. W. Brown, and of Project Team III which, under the command of Lieutenant Colonel J. Fulton, directly supported the research activity.

The level of effectiveness of the passive night vision devices is highly dependent upon how they are used. Previous research has demonstrated that the failure of operators to use procedures which lead to timely and comprehensive search is a major cause for failures in target acquisition. The purpose of the experiment reported here was to determine whether new search techniques and procedures could increase the effectiveness of soldiers using these devices.

BESRL research in night operations is conducted as an in-house research effort augmented by research contracts with organizations selected as having unique capabilities for research in this area. The present study was conducted under the program direction of Mr. Jack J. Sternberg, Behavior and Systems Research Laboratory, assisted by personnel of Manned Systems Sciences, Northridge, California, under the supervision of Mr. Douglass R. Nicklas.

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IMPROVED SEARCH TECHNIQUES WITH PASSIVE NIGHT VISION DEVICES

BRIEF

Requirement:

To improve the effectiveness of soldiers using passive night vision devices through new search techniques and procedures.

Procedure:

Fifty-four operators (players) using the Starlight Scope (SS) or the Night Observation Device, Medium Range (NOD) were given specialized search training consisting of two parts: 1) general search methods which included search pattern and adjustment of speed of search, and 2) specific search techniques. The specific search techniques involved continuous movement of the device, stopping only to examine some object of interest, and a discontinuous movement with the device moved in discrete steps and the image display examined before the device was moved again.

The performance of these players was compared to that of another group who were treated similarly in all respects except they did not receive the training on search method and pattern. Both groups were tested on the same terrain, which was complex and heterogeneous, extending 1500 meters. Targets of different type, contrast, and mode were placed in the area at various distances of 100 to 1200 meters from the players. Testing was conducted under starlight and full-moon illumination conditions. Search areas (scan angles) of 75° and 35° were used.

Findings:

Employment of the new search techniques and procedures resulted in a considerable increase in the number of targets detected; targets were detected in a shorter time.

Utilization of Findings:

Special search training which will assure a more timely and comprehensive coverage of the area to be searched should be given to soldiers using night vision devices. This training should emphasize: 1) use of a rectangular search pattern which will produce a systematic and comprehensive coverage of the search area on a regular basis, and 2) use of a variable scanning rate, with the rate of scan adjusted to the difficulty of the terrain being examined.

The search training and familiarization with the devices can be accomplished in two to three hours.

IMPROVED SEARCH TECHNIQUES WITH PASSIVE NIGHT VISION DEVICES

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IMPROVED SEARCH TECHNIQUES WITH PASSIVE NIGHT VISION DEVICES

BACKGROUND

Passive night vision devices developed for the Army have greatly increased night observation and target acquisition capabilities. However, the effectiveness of these devices is highly dependent upon how and under what conditions they are used. The BESRL research program with these devices has been designed to determine how effective they are under various conditions and also how effectiveness can be improved.

Previous research[1], [2], [3] has dealt with target-environmental factors such as light, distance, target type, movement, and contrast, and with use factors such as search area size, continuous military operations, basis of issue and mix, and search deployment. Early in the research, it was shown that the device operators were not performing effectively. It was demonstrated that the operator's failure to detect more targets was due not to inability to see and discriminate targets in the field nor to fatigue and lowered vigilance during prolonged use of the devices. It was also shown that the problem could not be eliminated simply by more practice in using the devices. The major cause seemed to be that the operators did not search the field thoroughly nor at an adequate rate. The purpose of the present experiment, therefore, was to determine whether new search techniques and procedures could increase the effectiveness of the soldiers using these devices.

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[1] Sternberg, Jack J. and James H. Banks. Search Effectiveness with Passive Night Vision Devices. Behavior and Systems Research Laboratory. Technical Research Report 1163. June 1970.

[2] Sternberg, Jack J., James H. Banks, and John P. Farrell (BESRL) and William A. Dalhamer and Donald Vreuls (MSS). Effect of Search Area Size on Target Acquisition with Passive Night Vision Devices. Behavior and Systems Research Laboratory. Technical Research Report 1168. In Press.

[3] Banks, James H., Jack J. Sternberg, and John P. Farrell (BESRL), and Charles H. DeBow and William A. Dalhamer (MSS). Effect of Continuous Military Operations on Selected Military Tasks. Behavior and Systems Research Laboratory. Technical Research Report 1166. In Press.

PROCEDURE

The night vision devices used in the present experiment were the Starlight Scope (SS) and the Night Observation Device, Medium Range (NOD). Testing was conducted on a complex and heterogeneous terrain which was flat to hilly, traversed by ravines and streams, with some large open grassy areas and some areas heavily cluttered with trees, brush, and rocks. The area to be searched extended to 1500 meters with targets placed at distances of 100 to 1200 meters from the players. Human and vehicular targets were presented both standing still and moving. Testing was conducted under starlight and full-moon illumination conditions. (As previous research had shown little difference in performance under half-moon and full-moon illumination, the half-moon condition was not included.) Search areas (scan angles) of 75° and 35° were used. For the 75° area, performance with both devices was measured under both illumination conditions; for the 35° area, data were collected only for the SS and only under starlight illumination. The 35° condition was included in the experiment because size of search area is an important factor influencing the degree of effectiveness of the device operator[4] and it was suspected that performance with the smaller search area might not be affected by search training in the same way as with the larger area.

The subjects, or players, were given specialized search training and their search performance was compared with that of a group which had previously been tested under the same conditions but without special search training.[5] The previous group had been tested on the same terrain, using the same procedures, and with targets in the same positions as in the present experiment. The players had received the standard Army training on search procedures and prior to the test had had 90 minutes of training and practice to familiarize them with device and appearance of the targets. The only difference in treatment was that the earlier group had not been given the special instructions on search methods and procedures that the present group had received. The search training for the present group consisted of two components: 1) general search methods and procedures, including search pattern and adjustment of speed of search; and 2) specific search techniques.

NEW SEARCH TECHNIQUES

Search Pattern. In a previous experiment it was found that, although players reported that they were systematically searching the entire area, large sections of the area were not searched for long periods because of backtracking and irregular search patterns. As a consequence, a large proportion of the targets which were missed by an operator were never even in the field of view of his device. Therefore,

[4] See Reference 2.

[5] See Reference 2.

training on a technique which would produce a systematic and comprehensive coverage of the search area on a regular basis was essential for improvement of search effectiveness.

The field of view of the two devices used in the present experiment was approximately 10°, and the elevation change in the terrain was approximately 12°. Thus, the entire area could be inspected with two traverses of a device, with an elevation change after each traverse. Players were therefore trained to use a rectangular search pattern in which the far half of the field was inspected during a left-to-right traverse with a device and the near half during a right-to-left traverse. Minor elevation changes during a traverse were permitted but backtracking was to be kept to a minimum. The rectangular search pattern was used because it seemed natural to most searchers and minimized the period of time that any section of the terrain was uncovered. Any pattern satisfying these requirements would probably have been equally satisfactory. In any eve t, the particular pattern used would have to be adjusted to the terrain being searched.

Adjustment of Speed of Search. Lack of timely search was the second element which had been identified as a contributor to poor search performance. The players were instructed, therefore, on what was felt to be the basic principle for timely search--namely, a tradeoff between need for rapid scanning of the entire search area and need for adequate examination of a particular portion of the terrain. The nature of this tradeoff was explained, along with the principle of adjustment of speed of scanning to the difficulty of the terrain being examined.

Specific Search Techniques. In previous experiments, it had been observed that most players moved their devices more or less continuously while searching, stopping only when they detected some object that they wanted to examine more closely. It seemed possible that this technique did not allow adequate time for examination of the image display, and hence reduced the probability of target detection. Therefore, the players were instructed on the use of two basic search techniques: 1) continuous movement (at a variable rate) of the device, stopping only to examine some object of interest; and 2) discontinuous movement with the device moved in discrete steps and the image display examined for some (variable) period of time before the device was again moved. Two variations of this second technique were introduced, differing in the size of the step. Operationally, this variation in step-size produced either an overlap or a non-overlap of the adjacent segments of the terrain which were viewed through a device on successive steps.

After 30 minutes of classroom instruction during the afternoon, the players were given 30 minutes of closely supervised training and practice in which they actually used the devices with daylight filters to search the terrain, employing the principles and techniques given during classroom instruction. Prior to actual night testing, the players were given an additional 90 minutes of training (45 minutes of device instruction and familiarization with the appearance of targets, and 45 minutes practice in finding and "shooting" targets). This 90 minutes of training was the standard training given for all BESRL experiments and has been shown to be adequate to bring players up to a stable level so that test performance is not contaminated by a continuation of learning.

Total training time was 2½ hours--30 minutes of classroom instruction on search procedures and specific techniques, 30 minutes of practice using these procedures and techniques, and 90 minutes of target familiarization and practice in finding and "shooting" targets.

During testing players searched for targets for six 30-minute periods using, at different times, all three search techniques. The general search methods and procedures involving the rectangular pattern and adjustment of speed of search were followed, regardless of which specific search technique was being employed. Search behavior and target acquisition responses were recorded electronically.

RESULTS

The data were analyzed to provide answers to three questions. 1) Was performance differentially affected by the use of the three specific search techniques--continuous movement, discrete movement with overlapping fields of view, discrete movement with non-overlapping fields of view? 2) Was performance improved by the special training on search methods and procedures, in comparison to performance of a previous group who were tested under basically identical conditions but who did not have this search training? 3) Was performance on a smaller search area (35° angle) affected in the same way by search training as performance on the larger (75° angle) search area? The two measures of effectiveness were percent of targets detected and average time required to detect these targets.

Search Techniques

The percentages of targets detected using the three specific search techniques are shown in Table 1. Average target detection time, in seconds, is shown in Table 2. With a 75° search area, performance was just as good using one technique as another. All the data were therefore combined, and the overall performance was used for comparison with the performance of a group which had not received special training on search methods and procedures.

Table 1

EFFECTS OF SEARCH TECHNIQUE, AMBIENT ILLUMINATION, AND DEVICE ON PERCENT TARGETS DETECTED (75° SEARCH AREA)

Ambient Illumination	Device	Search Technique: Discrete Overlap	Search Technique: Discrete No Overlap	Search Technique: Continuous	Overall
		%	%	%	%
Starlight	SS	21	23	24	23
	NOD	52	53	54	53
Full Moon	SS	65	57	65	62
	NOD	75	71	75	74

Table 2

EFFECTS OF SEARCH TECHNIQUE, AMBIENT ILLUMINATION, AND DEVICE ON AVERAGE TARGET DETECTION TIME (75° SEARCH AREA)

Ambient Illumination	Device	Search Technique: Discrete Overlap	Search Technique: Discrete No Overlap	Search Technique: Continuous	Overall
		(Sec.)	(Sec.)	(Sec.)	(Sec.)
Starlight	SS	44	39	45	43
	NOD	44	46	43	44
Full Moon	SS	35	33	33	34
	NOD	35	37	33	35

Training on Search Methods and Procedures

Performance of players in the present experiment was compared with that of players in the previous experiment who had not had special training in search methods and procedures to determine whether the special training on search methods and procedures had actually improved search performance. The effects of illumination and distance on performance by these two groups on the 75° search area are presented below.

Effect of Illumination. For both groups, testing was conducted under starlight and full-moon illumination conditions but actual light level was somewhat lower for the present (special training) group than for those in the previous experiment. The mean photometric readings, in footcandles, for the two groups are shown in Table 3. Although the differences appear small, small reductions in illumination at lower light levels can result in considerable impairment in performance, as shown in a previous experiment[8]. The level of performance of the special training group under the starlight condition was therefore probably lower than it would have been if the light level under that condition had been equivalent to that for the standard training group. The results presented therefore give a conservative estimate of the effects of the special training.

Table 3

MEAN ILLUMINATION (IN FOOTCANDLES) FOR THE STANDARD AND SPECIAL SEARCH TRAINING GROUPS (75° SEARCH AREA)

Illumination Condition	Group: Standard Training	Group: Special Training
Starlight	1.1×10^{-4}	7.6×10^{-5}
Full Moon	9.1×10^{-3}	7.2×10^{-3}

The percentage of targets detected on the 75° search area by the group with the standard training and the group with the additional special training are presented in Table 4. The relative percentage improvement resulting from the special training is also shown. The relative improvement was about equal for the SS and NOD. For both devices, the relative improvement was large under starlight (about 34%) and much more moderate (7% and 12%) under full moon.

[8] Farrell, John P., James H. Banks, and Jack J. Sternberg. Search Effectiveness with the Starlight Scope and 7 x 50 Binoculars. Behavior and Systems Research Laboratory. Technical Research Report 1164. June 1970.

Table 4

EFFECTS OF SEARCH TRAINING ON PERCENT TARGETS DETECTED
(75° SEARCH AREA)

Ambient Illumination	Device	Standard Training	Special Training	Relative Improvement
		(%)	(%)	(%)
Starlight	SS	17	23	35
	NOD	40	53	33
Full Moon	SS	58	62	7
	NOD	66	74	12

Average target detection time by the two groups is shown in Table 5. For both devices and under both illumination conditions, the time required for target detection was considerably reduced (by about 12 seconds on the average) by the special search training.

Table 5

EFFECTS OF SEARCH TRAINING ON AVERAGE TARGET
DETECTION TIME (75° SEARCH AREA)

Ambient Illumination	Device	Training Standard	Special
		(Sec.)	(Sec.)
Starlight	SS	62	43
	NOD	50	44
Full Moon	SS	47	34
	NOD	46	35

Effect of Distance. The three distance bands used were: 100-350 meters (near targets); 350-800 meters (mid targets); and 800-1200 meters (far targets). Targets in the first two bands were primarily personnel and in the far-distance band primarily vehicular.

The effects of distance on percent target detection and the relative improvement resulting from the special search training are shown in Table 6, and in Figures 1 and 2. The relative improvement resulting from the special search training was greater for the more distant targets than for the near targets. Under starlight illumination with the NOD, for example, the special training group showed a relative improvement of 35% overall (see Table 4) but this overall improvement was produced by a negligible increase (2%) in detection of near targets, a large increase (52%) for mid targets, and an enormous increase (171%) in detection of far targets; with the SS, the search training greatly improved the detection of near targets as well.

Table 6

EFFECTS OF SEARCH TRAINING ON PERCENT TARGETS DETECTED AT DIFFERENT DISTANCES (75° SEARCH AREA)

Ambient Illumination	Device	Target Distance	Training Standard	Training Special	Relative Improvement
			(%)	(%)	(%)
Starlight	SS	Near	29	36	24
		Mid	11	10	a
		Far	2	13	a
	NOD	Near	60	61	2
		Mid	31	47	52
		Far	17	46	171
Full Moon	SS	Near	72	72	0
		Mid	51	59	16
		Far	38	50	32
	NOD	Near	79	75	-5
		Mid	59	72	22
		Far	49	75	53

[a] Insufficient data

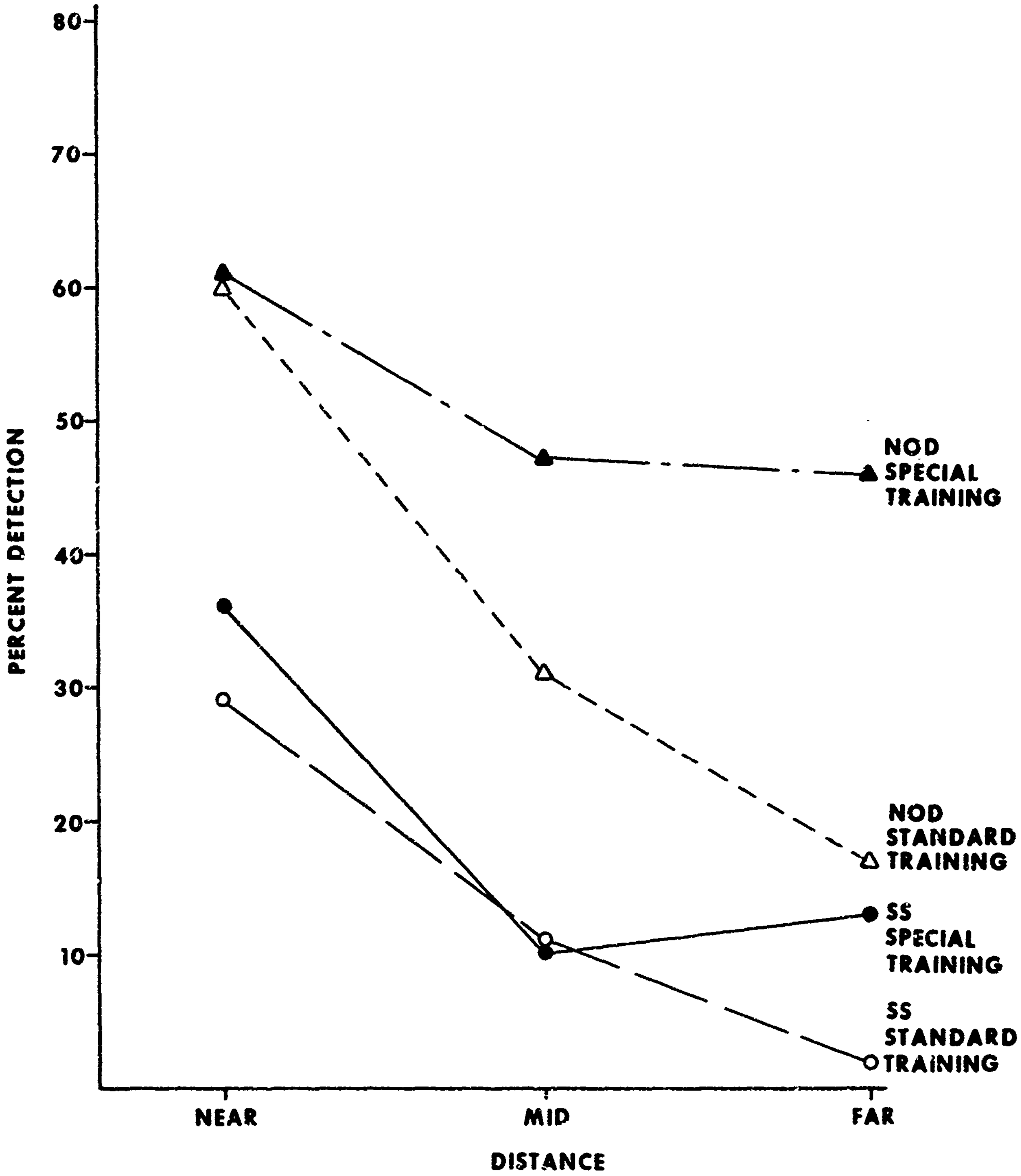
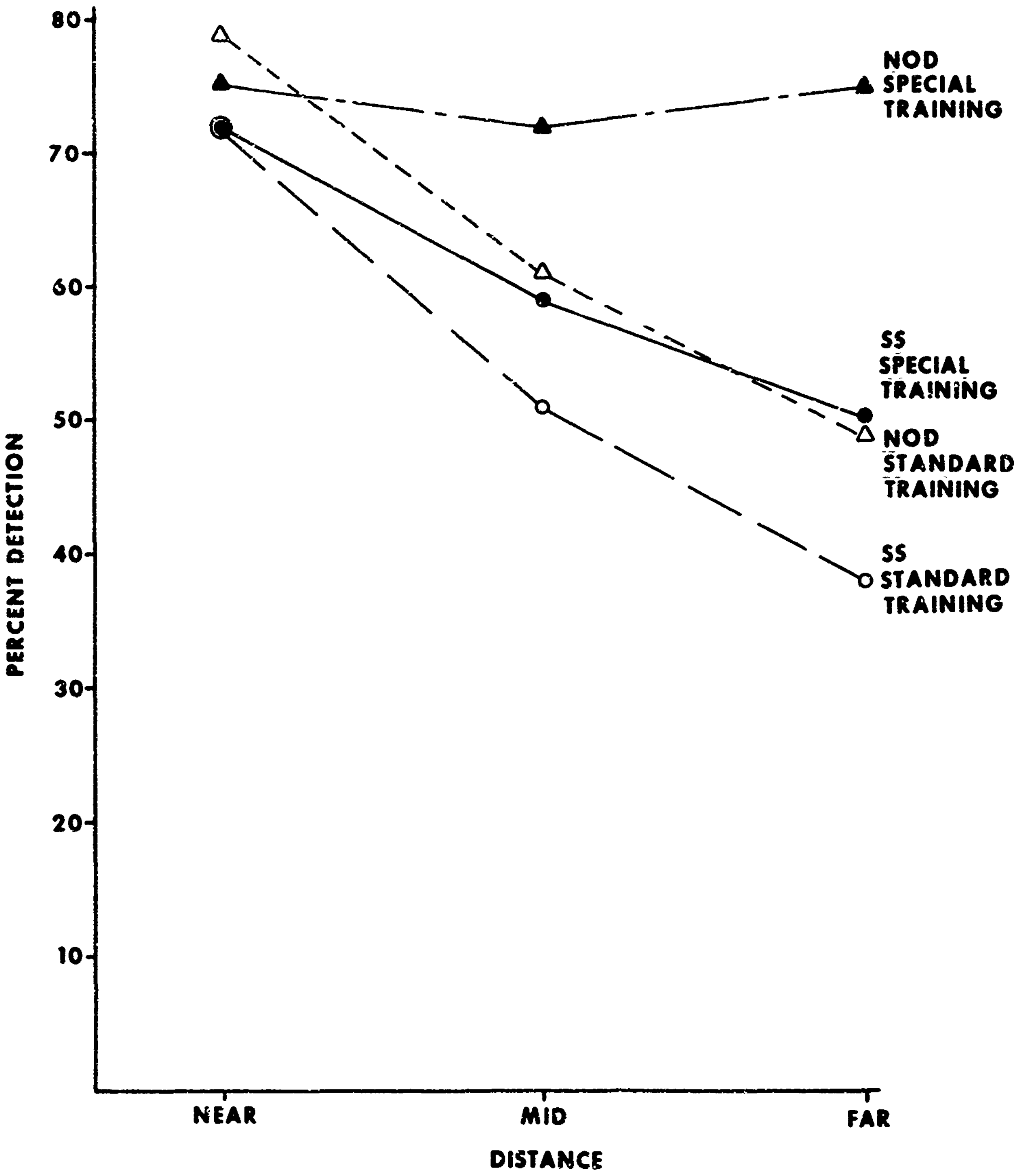


Figure 1. Percent target detections by distance of standard and special training groups under starlight illumination (75° search area)



. Figure 2. Percent target detections by distance of standard and special training groups under full moon illumination (75° search area)

Under full moon, the trends were the same and relative improvement was substantial, although less than under starlight. Figure 2 reveals a number of interesting findings: First, for all distances, SS operators with special training were able to detect as many targets as had previously been detected by NOD operators without the special training. Second, after special training, the NOD operators were able to detect three out of four targets presented, regardless of distance. The degradation in detection performance with increasing distance previously exhibited by the operators with standard training was, then, due solely to deficiencies in search procedures rather than to device limitations.

The effects of distance on target detection time are presented in Table 7. Target distance did not strongly affect detection time. For all distances, detection time was decreased by special search training.

Table 7

EFFECTS OF SEARCH TRAINING ON AVERAGE TARGET DETECTION TIME AT DIFFERENT DISTANCES (75° SEARCH AREA)

Ambient Illumination	Device	Target Distance	Training Standard	Special
			(Sec.)	(Sec.)
Starlight	SS	Near	61	46
		Mid	a	a
		Far	a	a
	NOD	Near	50	44
		Mid	46	45
		Far	57	44
Full Moon	SS	Near	45	33
		Mid	51	35
		Far	47	35
	NOD	Near	46	35
		Mid	42	31
		Far	52	39

[a] insufficient data

Search Area Size

Players using the SS under starlight illumination were tested with the search area (scan angle) reduced to 35° to determine whether performance on a smaller search area was affected in the same way by search training as performance on a larger (75° wide) search area. The data were analyzed to determine: 1) whether performance was differentially affected by the three search techniques, and 2) whether performance of the group with special training on search methods and procedures was superior to that of the group without this training.

Effects of Search Techniques. For the 35° area, percentage of targets detected and average detection time using the three search techniques are shown in Table 8. Fewer targets were detected when the technique which involved discrete movement with non-overlapping fields of view was used than with either of the other techniques. This finding was in contrast to that on the 75° area, in which no differences among the techniques were found. The techniques did not differ in terms of target detection time. As performance using the discrete-overlap and continuous movement techniques did not differ, these data were pooled for comparison with the performance of the group which had not had the special training on search methods and procedures.

Table 8

EFFECTS OF SEARCH TECHNIQUE ON PERCENT TARGET DETECTION AND TARGET DETECTION TIME WITH THE STARLIGHT SCOPE UNDER STARLIGHT ILLUMINATION (35° SEARCH AREA)

	Search Technique		
	Discrete		Continuous
	Overlap	No Overlap	
Percent Detection	47	32	43
Detection Time (Seconds)	41	41	42

Effects of Search Methods and Procedures. The effect of the special training in search methods and procedures on percent detections is shown in Table 9. For the special training group, on the 35° search area these values were obtained by pooling the data from the two superior search methods, and for the 75° search area by pooling the data from all three methods.

The special search training increased the percent detections for both size search areas (Table 9). The improvement in performance was much greater on the 35° area (80% relative improvement) than on the 75° area (35% relative improvement.

With the special training, operator performance on the 75° area (23% detections) was just about equal to that of the operator with standard training on the 35° area (25% detections). Thus, one man with the special training could cover a wide area as effectively as two men with standard training each covering half the area.

Table 9

EFFECTS OF SEARCH TRAINING AND SEARCH AREA SIZE ON PERCENT TARGET DETECTION WITH THE STARLIGHT SCOPE UNDER STARLIGHT ILLUMINATION

Search Area Size	Training Standard	Special	Relative Improvement
	%	%	%
35°	25	45	80
75°	17	23	35

Table 10 shows that for both size search areas the time required for target detection was decreased by the special training. Also, reduction in size of the search area did not affect target detection time after special training but decreased search time after standard training.

Table 10

EFFECTS OF SEARCH TRAINING AND SEARCH AREA SIZE ON AVERAGE TARGET DETECTION TIME WITH THE STARLIGHT SCOPE UNDER STARLIGHT ILLUMINATION

Search Area Size	Training Standard	Special
	(Sec.)	(Sec.)
35°	50	41
75°	62	43

CONCLUSIONS

In previous experiments, it was found that many targets which are within device capabilities are not detected by device operators. In the present experiment, techniques were developed which assured a more comprehensive and timely coverage of a search area. Employment of these techniques resulted in a considerable increase in the percentage of targets detected and a decrease in target detection time.

Special search training should be given to soldiers who will be using night vision devices. This training should emphasize:

1. Use of a rectangular search pattern which will produce a systematic and comprehensive coverage of the search area on a regular basis.

2. Use of a variable scanning rate, with the rate of scan adjusted to the difficulty of the terrain being examined.

Additionally, training should include familiarization with the devices, particularly diopter adjustment and focusing, familiarization with the appearance of targets viewed through the devices, and nighttime practice in search and target acquisition.

All this training can be accomplished in two to three hours.

TECHNICAL SUPPLEMENT

PROCEDURES AND SPECIAL EXPERIMENTAL TECHNIQUES

DETAILS OF EXPERIMENTAL EVALUATION OF NEW SEARCH TECHNIQUES

The procedures and special experimental techniques developed for BESRL's on-going research on search effectiveness with passive night vision devices are described in considerable detail. Further informational background is available in other reports[7],[8]. Actual training instructions are reproduced in the Appendix.

Night Vision Devices Tested

The experiment dealt with light intensifiers of two types: the Small Starlight Scope, AN/PVS-2 (SS); and the Night Observation Device, Medium Range, AN/TVS-4 (NOD).

The Data Acquisition System

The data acquisition system has three components: 1) the tripods which support the universal device platforms (UDPs) and the night vision devices; 2) the universal device platforms; and 3) the electronic control and data recording console. Nine heavy-duty tripods are used in line, each tripod being set into concrete for stability. The UDPs each consist of a metal housing attached to the tripod head, the night vision devices being attached to the UDP. The UDP rotates with respect to a fixed base and is adjustable for elevation. Each UDP contains two shaft encoders, one for azimuth and one for elevation, which indicate to within 0.1° the orientation of the instrument. Each UDP also contains a "trigger" microswitch which the player presses when he acquires a target. These microswitches are designed and located so that their use does not interrupt searching or disturb orientation of the device. Output from the microswitch and shaft encoders is transmitted by cable to the data recording console. For the present experiment, a precision-drilled metal collar was fastened to the base of the shaft encoder housing. This collar rode upon two adjustable spring-loaded ball bearings. When one ball bearing was loaded, with every 10° of lateral rotation the bearing engaged a hold drilled in the collar. When both bearings were relieved of tension, the housing rotated freely. The players could clearly feel and hear when a bearing engaged one of the holes, but the bearing was easily over-ridden by a slight increase in pressure. The purpose of this detent mechanism was to assist the operator to move his device in discrete steps of the appropriate size during training and testing.

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[7] See reference 1 in text.

[8] See reference 2 in text.

The electronic control and data recording console is van-mounted and contains a monitoring-control panel and a recorder panel. On the monitoring-control panel are a magnetic tape unit, numerical displays (NIXIE[9] tubes) for visual presentation of azimuth and elevation of selected subject stations on a real-time basis, and a number of selection buttons. Information recorded on the magnetic tape includes the beginning and end of target presentation, player number, azimuth and elevation of the devices used (sampled four times per second), and any responses by a player. A time base is provided by tape speed. Thus, both target acquisition responses and detailed recording of search behavior are on the tape and extractable by computer. The recorder panel contains a digital recorder which provides a graphic hard-copy display of the search behavior, target coordinates, and responses of any selected player, on a near real-time basis.

Ancillary Equipment

The communication system includes land-line telephone between the control center and personnel targets; radio communication between the control center and vehicular targets; telephone lines between the control center, engineer in van, and target monitor; and a two-way speaker system between the control center and the player cubicles.

Photometric readings were obtained with a Gamma Scientific Corporation model 2020 photometer[10] with S-11 photocathode and cosine-filter which gave an integrated reading, in footcandles, of illumination from the upper hemisphere. Readings were taken at regular intervals throughout the experiment.

Terrain

The terrain was part of the Hunter Liggett Military Reservation and provided use of a search area up to approximately 75° wide and over 1500 meters deep. In order to provide a realistic search problem, the area was complex, being flat to hilly, bisected by a road, traversed by ravines and streams, with some large open grassy areas and some areas heavily cluttered with trees, brush, and rocks. Skyglow was essentially eliminated because the test area was surrounded by mountains, and the nearest small town was 30 miles away. The terrain had a general north-south orientation, with the moon passing over the terrain roughly from right to left. Thus, when testing under moonlight, targets were not frontlighted during one portion of the session and backlighted during a later portion. (Previous research has shown that probability of detection changes considerably for front versus back lighting.)

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[9] Commercial designations are used only for precision in describing the experiment. Their use does not constitute indorsement by the Army or by the Behavior and Systems Research Laboratory.

[10] See footnote 9.

Targets

A total of 36 target locations were used in the testing session. All targets could be seen by the unaided eye during daylight. Targets at each location were presented once in a dynamic and once in a static mode, giving 72 target presentations per evening. The 36 targets were of two types--24 personnel and 12 vehicular. Three types of vehicle were used--1/4-ton truck, 5-ton truck, and armored personnel carrier (M-113). The personnel targets were soldiers dressed in fatigues, appearing either singly or in groups of two. The targets were of varying difficulty and were distributed throughout the terrain at distances of 100-1200 meters from the test stations. Targets were located in three bands: 100-350 meters (near-distance); 350-800 meters (mid-distance); and 800-1200 meters (far-distance). Contrast was manipulated by placing targets against suitable backgrounds--silhouetted against a tree line (low contrast) or against an open grassy area (high contrast)--but no attempt was made to rigorously define or measure target-background contrast. Placement of targets was carefully controlled so that target visibility remained constant for a given evening; e.g., changes in moon angle did not throw a shadow on a target during one part of a night's run. A complete description of the targets appears in Table 11.

Ambient Illumination Conditions

The average photometer readings (in footcandles) obtained under starlight and three quarter-full moon conditions were:

Starlight 75° area: 2.2×10^{-5} to 1.0×10^{-4}; $m = 7.6 \times 10^{-5}$

35° area: 6.4×10^{-4} to 8.6×10^{-5}; $m = 7.7 \times 10^{-5}$

Full Moon 75° area: 1.6×10^{-3} to 1.1×10^{-2}; $m = 7.2 \times 10^{-3}$

Subjects

The subjects--or players--were 54 enlisted men from the Experimentation Battalion (Armor), Hunter Liggett Military Reservation, California.

Experimental Design

Testing was conducted using two search area sizes (75° and 35°), devices of two types (SS and NOD), and under two illumination conditions (starlight and full moon). The primary data were collected on the 75° area. In this condition, each group of nine players was tested (four or five on each device) for two successive nights, alternating devices on the two nights. Testing was conducted under both starlight and full-moon illumination. On the 35° area, each group of players was used for only one night, and data were collected only for the SS and only under starlight illumination. This condition was included to determine whether an interaction existed between level of performance after search training and size of search area. Table 12 shows the number of subjects tested under each condition. It also reflects subjects deleted for technical and administrative reasons.

Table 11

DESCRIPTION OF TARGETS

Target[a]	Type	Azimuth	Elevation[b]	Slant Distance[c]	Range[d]	Search Area Sectors[e] 25°	35°
01A	1 Man	3.1	.9	281	Near	Left	Left
02A	1 Man	27.6	-1.0	97	Near	Center	Left
03A	1 Man	59.2	.6	228	Near	Right	Right
04A	1 Man	4.3	1.2	515	Middle	Left	Left
05A	1 Man	26.9	.4	299	Near	Center	Left
06A	1 Man	44.3	.6	270	Near	Center	Right
07A	2 Men	2.4	4.0	707	Middle	Left	Left
08A	2 Men	18.6	4.6	733	Middle	Left	Left
09A	Jeep	5.8	4.1	695	Middle	Left	Left
10A	APC	15.1	8.5	938	Far	Left	Left
11A	5 Ton	5.7	7.4	1003	Far	Left	Left
12A	APC	16.0	4.4	710	Middle	Left	Left
01B	1 Man	7.0	-0.1	165	Near	Left	Left
02B	1 Man	44.1	-1.4	108	Near	Center	Right
03B	1 Man	64.9	2.2	187	Near	Right	Right
04B	1 Man	11.1	0.5	251	Near	Left	Left
05B	1 Man	28.5	0.5	281	Near	Center	Left
06B	1 Man	57.2	1.9	286	Near	Right	Right
07B	2 Men	40.1	1.9	485	Middle	Center	Right
08B	2 Men	31.7	4.0	765	Middle	Center	Left
09B	Jeep	28.1	4.2	701	Middle	Center	Left
10B	APC	30.0	5.1	722	Middle	Center	Left
11B	5 Ton	44.9	6.8	1032	Far	Center	Right
12B	APC	45.3	6.5	1028	Far	Center	Right
01C	1 Man	22.2	-0.5	176	Near	Left	Left
02C	1 Man	53.1	-0.5	156	Near	Right	Right
03C	1 Man	66.5	1.2	187	Near	Right	Right
04C	1 Man	16.5	0.2	272	Near	Left	Left
05C	1 Man	38.1	0.4	391	Middle	Center	Right
06C	1 Man	61.6	3.2	301	Near	Right	Right
07C	2 Men	56.4	3.4	350	Middle	Right	Right
08C	2 Men	64.3	6.1	885	Far	Right	Right
09C	Jeep	68.3	6.3	910	Far	Right	Right
10C	APC	63.1	8.0	1091	Far	Right	Right
11C	5 Ton	57.1	6.0	919	Far	Right	Right
12C	APC	56.5	6.7	977	Far	Right	Right

[a] Target numbers are sequential. For a test scenario targets were presented in an order which counterbalanced all target characteristics and search area sizes.

[b] Plus or Minus reflects displacement from the calibration zero point; up (+); down (−).

[c] Slant Distance to nearest meter.

[d] Range denotes distance category: Near 100-350 meters; Middle 350-800 meters; and Far 800-1200 meters.

[e] Search area sector describes the location of the targets within a 25° or 35° sector. The targets are designated as left, center, and right for the 25° sector, and left and right for the 35° sector.

Table 12

NUMBER OF SUBJECTS IN EACH CONDITION

Illumination	Device	Search Area Size 75°	35°
Starlight	SS	18	17
	NOD	17	--
Full Moon	SS	18	--
	NOD	17	--

Orientation of Players

When players arrived at the test site, they were brought into a classroom for briefing and orientation. Designated military personnel explained to the players the importance of the research. A civilian scientist then explained the players' role and what would be occurring on the two nights they would participate. Players were next shown the target field, boundary limits, range demarcation points, and general terrain features. Players were then taken into the Experimental Control Center, and the equipment and functions were described to them. These briefings had two purposes: first, to increase the players' interest and involvement in the experiment and second, to explain how and why their performance with the devices would be monitored throughout the evening. This combination of approaches was effective in eliciting their cooperation and sustained participation.

Training

In a previous experiment[11/], poor search procedures were identified as a major cause of failures in target detection. The essential elements were lack of timely and comprehensive search. The purpose of the training program, therefore, was to correct these deficiencies. Training was given in two phases: afternoon and night.

[11/]See reference 1 in text.

Afternoon Training. Afternoon training began with a general description of the devices, including diopter adjustment and focusing. (The essential elements of this portion of training are described fully in the report just cited.) Training on how to search was then begun. (The actual training material is contained in the Appendix.) This training was divided into two primary components: 1) general search methods and procedures, including search pattern and adjustment of speed of search; and 2) specific search techniques.

Search Pattern. The players were instructed on use of a rectangular search pattern, with charts and photographs of the field as training aids. The elevation change in the terrain was approximately 12°. The field of view of the two devices was approximately 10° (somewhat more for the SS and somewhat less for the NOD). Thus, the entire terrain could be inspected with basically two traverses of the device with an elevation change of approximately 6° on each traverse. The players were told to start search at the upper left quadrant of the search area, traverse to the upper right quadrant, lower the device so that it was pointed at the lower right quadrant, traverse to the lower left quadrant, and to repeat this basic pattern during the entire time that they were searching. Backtracking was to be kept to a minimum. Elevation changes during the left-to-right (upper field) traverse and right-to-left (lower field) traverse were allowable if the change in elevation was not so great that the reticle of the device was pointed into the lower half of the field during the traverse in which the upper half of the field was supposed to be searched. The complement was true for the lower half of the field.

Enforcement of a basic search pattern with minimum backtracking and mimimum changes in elevation was intended to produce a systematic and comprehensive coverage of the search area on a regular basis. In the previous experiment, it had been found that a large proportion of the targets which were missed were never even in the field of view of the device. Although players reported that they were systematically searching the entire field, in actuality large sections of the field were not searched for long periods because of backtracking and irregular search patterns. The rectangular search pattern was used because it seemed natural to most searchers and minimized the period of time that any section of the terrain was uncovered. Any pattern satisfying these requirements would probably have been equally satisfactory. In any event, the particular pattern used must be adjusted to the terrain being searched.

Adjustment of Speed of Search. Lack of timely search was the second element which had been identified as a contributor to inadequate search performance. The players were therefore instructed on what was felt to be the basic principle for timely search--namely, a tradeoff between the need for rapid scanning of the entire search area and the need for adequate examination of a particular portion of the terrain. They were told that even when a target is captured in the field of view of a device, the display must be examined for some period of time if the target is to be discriminated from other objects in the terrain. On a portion of the terrain which is cluttered with trees, brush, and rocks, longer examination time is required for discrimination than on an open portion because of lower contrast, breaking-up of the target lines, and similarity of target to other objects. Speed of device panning should therefore not be constant but should be adjusted to the nature of the terrain. As a guideline for general rate of coverage, they were told to try to cover the entire search area at least once in two minutes but not more than two or three times, as the repeated search would not allow adequate time for examination of the image display.

Specific Search Techniques. In previous experiments, it had been observed that most players moved their devices more or less continuously while searching, stopping only when they detected some object in the terrain that they wanted to examine more closely. It seemed possible that this technique did not allow adequate time for examination of the image display, particularly on the more heavily cluttered portions of the terrain, and hence reduced the probability of target detection. During training, therefore, the players were instructed on the use of two basic techniques: 1) continuous movement (at a variable rate) of the device, stopping only to examine objects of interest; and 2) discontinuous movement, with the device moved in discrete steps and the image display examined for some (variable) period of time before the device was again moved to point it at the next portion of the terrain. Two variations of the second technique were used, differing in the size of the steps--in the first case the steps were movements of 5° between stopping for examination of the image display and, in the second case, movements of 10° before stopping. As the field of view of both devices is approximately 10°, operationally this variation in step size produced an overlap and a non-overlap condition in reference to the portion of the terrain actually included in the field of view of the device. To assist the players make discrete movements of the correct size, the detent mechanism described in the section on the data acquisition system was used. Under the continuous movement condition, the spring-loaded ball bearings were relieved of tension so that the devices rotated freely.

The players were instructed on the use of these techniques, using appropriate charts and demonstrations. It was emphasized that, regardless of the search technique being used, they were to follow the general search methods and procedures described earlier. Classroom instruction was then terminated.

Afternoon training continued with one hour of closely supervised training and practice in which the players actually used the devices with daylight filters to search the terrain (no targets were presented), employing the principles and techniques given during the classroom instruction. Afternoon training concluded with a test of each player in which he had to demonstrate successful use of the techniques and procedures which he had been taught.

Night Training. The night training session had three purposes: 1) to instruct the player on the adjustment of his device; 2) to teach him the appearance of targets when viewed through a night vision device; and 3) to allow him to develop facility in the rapid detection and simulated shooting of the targets. Training did not commence until at least the End of Evening Nautical Twilight (EENT), with the sun 12° or more below the horizon. The training session was conducted by the civilian scientist, with the engineer at the monitoring-control console; nine instructors assisted the players individually. The scientist first read a prepared script of general instructions. When the instructions became specific to the device, the individual instructors instructed the players, reading from a prepared script. The instructions included tripod height adjustment, diopter adjustment, objective lens focusing, limits of the search area, detent mechanisms, and procedures to be followed in shooting the targets.

When all adjustments were made and the players understood how to use the device, the second phase of training began. Five targets were presented, one at a time. Prior to presentation of each target, the players were told the type of target, its location, and that it would be lighted. The players were instructed to find the light and to "shoot" it. After all players had found and shot the target, the light was extinguished and the players were instructed to study and shoot the target again if they could see it. The engineer at the monitoring-control console compared player responses with a catalog of actual target locations and informed the scientist which players were having difficulty in finding the targets and/or were not following proper procedures. When all players had successfully responded to each of these five targets, an additional eight targets were presented, one at a time. For these targets, the players were not told the target location, but the target again was lighted. After most players had found and shot the lighted target, the light was extinguished and the players were instructed to study and shoot the target again if they could see it. Players having difficulty were assisted by their instructors. This completed the second part of the training session.

The purpose of the third phase of training was to provide practice in the rapid acquisition of targets so that subsequent performance during testing would not be influenced by additional learning. Thirteen targets were presented and no assistance, either by lights or instruction, was given. At the conclusion of training, players were given a 15-minute rest prior to the beginning of testing.

Total evening training time was approximately 90 minutes (15, 30, and 45 for Parts 1, 2, and 3, respectively). This highly structured training session had been found in previous research to provide sufficient familiarization and practice so that test performance was not contaminated by additional learning during testing. While training was performed on the same terrain used for testing, the practice target locations were different from the experimental target locations.

Testing

Testing began after the End of Evening Astronomical Twilight (EEAT), when the sun was 18° or more below the horizon, and was terminated prior to the Beginning of Morning Astronomical Twilight (BMAT), before the sun approached 18° below the horizon. Testing was scheduled so that the ambient illumination on any given night remained relatively constant. When testing was conducted under moonlight conditions, data collection did not commence until the moon had ascended to 25° above the eastern horizon and was terminated before the moon descended beyond 25° above the western horizon. These procedures minimized the ambient illumination changes during any given evening.

<u>Search</u>. Players were required to search the terrain continuously for six periods of 30 minutes each. During each period, 12 targets were exposed for two minutes per target, with approximately 30 seconds between target presentations. At one-half hour intervals, players were given a five-minute break in place. At one-hour intervals, the end of a scenario, they were given a 15-minute break, during which they were brought into the tent where they could smoke, warm up, and get coffee. During this break, the targets were relocated, and the detent mechanisms were changed to either 5° (overlap), 10° (no overlap), or free (continuous) search to adhere to the experimental design. Thus, all three search techniques were presented each night for one scenario (24 targets). Three scenarios were presented each night for a total of 72 target exposures. Full counterbalancing of the order of presentation of the techniques was not possible. The continuous-movement technique was therefore always presented second and the two discontinuous-movement (overlap and no overlap) were presented first and third, in counterbalanced order.

Each scenario consisted of 12 target locations, with each target presented in a static and dynamic mode to total 24 targets. The movement mode was balanced such that half the targets were static and half were dynamic for each sub-scenario, i.e., 12 targets were presented, six moving and six stationary. During the second portion of the scenario the targets were presented in the opposite movement mode, i.e., the same 12 targets were presented, the six that were static during the first portion were dynamic, etc.

All dynamic targets moved parallel to the line of player cubicles, i.e., across the line of sight of the players as they searched the field. Personnel targets moved at a walking pace and vehicular targets at approximately three or four miles per hour. The movement of each target was 1° of visual arc, the actual distance traversed being adjusted according to the distance of the target from the players. Each scenario included targets of all types, distances, and contrasts. Order of scenarios was systematically varied to counterbalance sequential effects. Basically, only one target was presented at a time (a two-man personnel target being defined as a single target), but three times in each sub-scenario, two targets (in different locations) were presented simultaneously to reduce the possibility that players would learn that only single targets were being presented. In this case, however, only the primary target was scored. To prevent players from using vehicle engine noise as a cue, three times in each sub-scenario one of the vehicular targets which was not exposed would run its engine for 30 seconds.

For the entire evening's run, targets were continuously observed by the target monitor on the test line. The monitor was equipped with a NOD and was thoroughly familiar with all target locations and the order of the scenarios being used on a given night. His primary responsibility was to verify that targets were up and down at the correct times, in the correct locations, and in the correct movement modes. In most cases, a one-word verification immediately followed the target status report. This procedure was utilized to maintain discipline and responsiveness of target personnel. Additional responsibilities of the monitor included reporting of light security violations, improper concealment or exposure of targets, and changes in ambient illumination and weather conditions.

Player behavior was continuously monitored by the instructor assigned to each player, by the training NCO, and by a civilian scientist also on the test line. In addition, an engineer at the monitoring-control console continuously monitored visual displays (NIXIE tubes) showing real time azimuth and elevation of each instrument to insure that all players were searching and following correct procedures.

For purpose of analysis, a player response was defined as a "hit" when the azimuth and elevation of the instrument were within $\pm 3°$ of the actual target location. The target detection data reported are based on this definition.

As indicated in the section on experimental design, the players who were tested on the 75° search area were used on two successive days. The second day of testing for these players began in late afternoon with a review of search methods and procedures. The players then moved to the booths for a warm-up period to prepare them for the second night of testing. Each player alternated type of device on the second night--those who had Starlight Scopes on the first night used NODs on the second, and vice versa.

The procedures followed on the second night were the same as those described for the first night, except that order of search techniques and order of scenarios were counterbalanced.

In the portion of the experiment in which a 35° search area was used, a minor change in procedures was required. Each sub-scenario was divided into two parts. The first part consisted of six targets that were located in the left sector of the search area. The second part of the sub-scenario consisted of targets in the right sector. Upon completion of six target exposures, the instructors assigned to each booth were required to move the limit pins to allow for search coverage of the appropriate area, i.e., limit pins were inserted to restrict search coverage to the left sector, for six targets, then changed to allow for coverage for the right sector.

This portion of the experiment differed, additionally, in that only Starlight Scopes were used and in that all 18 players (nine per night) were trained on the same day. The first group of nine was tested on the night immediately following afternoon training and the second group of nine on the night following the first group.

APPENDIX

INSTRUCTIONS GIVEN SUBJECTS IN SEARCH TRAINING

The actual search training instructions given the players in the experiment are reproduced below. These instructions were preceded by a military briefing on the importance of the research, a civilian briefing on the general nature of the experiment, a field orientation briefing on terrain features and boundaries, a briefing on the electronic data acquisition system which described in detail how player behavior would be recorded and monitored, and briefing on the adjustment, tripods, and detent mechanism of the data acquisition system.

1400-1430. General Training Session (Briefing Room).

"Tonight you will be searching for targets in the terrain that we showed you a few minutes ago. During the course of the night, you will be using some particular search methods and techniques. During the next half hour, we will describe them to you. After you are thoroughly familiar with the methods and techniques, we will take you out to the booths and give you training and practice in using them. Let me make this perfectly clear. This afternoon you are supposed to learn how to use these methods and techniques so you can use them properly tonight. If you do not understand anything that we tell you, ask a question. This is not just an exercise that we are going through. Pay attention and ask questions when you have them.

"I am now going to tell you something important. We are trying to find out which of these search techniques are best. We are NOT trying to find out how well you can find targets. This means that when you are supposed to be using one of the techniques, use it. We do not care that you think you can find more targets if you do it some other way. Let me emphasize, follow your instructions. To make sure that you do, we will have an instructor with each of you and we will monitor your behavior with our equipment in the experimental control center. Are there any questions now?

"O.K. Now I am going to tell you three things:

"First, I will describe the search pattern that you are to use for all the search techniques.

"Second, I will give you some general instructions on the search method that you should use for all the search techniques.

"Third, I will describe the search techniques themselves.

"Remember, any time that you have questions, I want to hear them. I will now describe the search pattern that you are to use. I will illustrate with this chart the search pattern you are to use regardless of the search technique."

(Chart)

Search Pattern. "Start your search in the upper left-hand corner of the field. Move your device across the upper part of the field to the right limit. When you reach the right limit, move the device down to the lower half of the field, until you get to the left limit. Then move your device to the upper left part of the field and repeat the procedure until you are told to stop. Remember, start searching in the upper left of the field. Move it across the field, staying in the upper part of the field, to the right limit. Move the device down to the lower right part of the field. Move it across the field, staying in the lower half of the field to the left limit. Then return to the upper left and repeat the procedure until you are told to stop.

"Are there any questions?

"Basically, you can search the entire terrain in two sweeps: left to right (upper field coverage) and right to left (lower field coverage) (demonstrate).

(Photo)

"This road roughly divides the field into two parts. You will search first the terrain on the far side of the road and then search the area on the near side of the road. When you are searching the upper part of the terrain, do not lower your device so the crosshair is pointing below the road. When you are searching the near half, do not raise your device so the crosshair is pointing above the road.

"Are there any questions?

"O. K. When you are searching the far half, you may want to raise the device a little or lower it a little so you can see better. That's O.K., but don't lower it so much that you point it at the near area. When you are searching the near area, you can move the device up a little, but don't raise it so much that you point to the far area. At night, there will be a row of lights following the line of the road to help you keep in the correct area.

"Are there any questions?"

Search Method. "Now, I am going to give you some general instructions on the search method. You should use this method, regardless of which search technique you are using.

"There are two things you have to do to detect a target.

"First, you have to point your device toward the target when the target is up.

"Second, even when you are pointing the device right at the target and it is somewhere in the field of view of the device, you have to SEE it. Sometimes this isn't so easy. If there are trees, brush and stumps, and so on, you have to really look hard before you find a target even though it is right out in the area where you are looking.

"The first point suggests that you should scan with your device as rapidly as you can because you know the targets are not going to be up there forever. The second point suggests that you mustn't move your device so fast that you don't have a chance to see the target even though you are pointing right where he is.

"This means that you have to adjust your speed of search to the terrain. When the terrain is open you can move your device across it pretty fast. When the terrain has a lot of trees or brush in it, you have to slow down and spend a little longer time studying the terrain in order to discriminate the target from the trees, brush, stump, or what have you.

"Let me repeat. When you come to an open spot, you can search it pretty rapidly. When you come to a spot that is cluttered with trees and brush, slow down. Adjust your speed to the type of terrain you are searching.

"Now, we want you to try to cover the entire field at least once every two minutes. You may go faster if you want, but try to search the entire area at least once every two minutes. Remember, if you go too fast, you may zip right past a target and never see it. If you go too slow, you may miss targets because you are not looking at the right place at the right time. Adjust your speed to the type of terrain you are searching, but try to search the entire field at least once every two minutes.

"Are there any questions?"

"I will now tell you what to do when you find a target. When you find a target, move your device so as to place the reticle, or crosshair, on the center of the target and gently press the firing button. This is how you shoot the target, so aim carefully and squeeze the button, just as you do when you are shooting a rifle."

Search Techniques. "Now I am going to describe the actual search techniques you will be using. There are three techniques:

1. Continuous search
2. Search and scan, with overlapping search areas.
3. Search and scan, without overlapping search areas.

"First, I will describe continuous search. When you use the continuous search technique, start at the upper left side, as I previously described, and slowly move the device across the field, searching the terrain as you go. When you see something that you want to examine more closely, stop. If you decide it is a target, shoot it and continue searching. If you decide it is not a target, continue searching. You may move the device up and down if you like, but remember to stay in the upper part of the field. When you get to the right limit, lower the device and move it slowly across the lower part of the field, searching as you move and stopping when you want to examine an area more thoroughly. Remember, adjust your speed to the terrain, taking more time with cluttered areas and less time with open areas. But try to cover the entire field at least once every two minutes. To repeat, move your device slowly across the field, stopping when you want to examine an area more thoroughly or when you want to shoot a target.

"Are there any questions?"

"The next technique we call the search and scan technique. In this technique, we use a mechanical device to help you to search by discrete steps. This technique requires that you move your device, stop, move your device, stop, and so on. Each time you stop, you examine the field, without moving the scope except for changes in elevation. Again, changes in elevation should be limited to the upper or lower half of the field, depending upon which half you are searching. We have placed lights at the mid-point of the field to assist you in knowing the top from the bottom half.

"You are to examine each portion of the terrain, satisfy yourself that there is no target, and then proceed to the next portion. Your rate of movement will vary; that is, sometimes a stop of one or two seconds for examination of the terrain is sufficient, and other times you may need perhaps ten seconds or more. Again, you are to cover both halves of the field at least one time every two minutes.

"As before, you will start in the upper left-hand corner, proceed to the right limit, drop to the lower half of the field and proceed to the left limit and repeat the procedure from upper left, etc. Again, when you find a target, place the reticle on the center of the target and fire.

"Now, this is very important, do not go beyond one stop at a time. If you should move through more than one stop, reposition the scope immediately to the stop nearest the last stop where you were searching and proceed. Do not reverse direction of search beyond one stop until either limit is reached. When the right limit is reached and you have finished searching the far area, move the scope down one-half the area of the field. Use the lights in the center of the field to tell how far down you should move. Then search the near area, examining all the terrain within the field of view of the device at each stop. The total field should be covered at least once every two minutes.

"Are there any questions?

"In the search and scan technique, you are going to be using two variations. In the first variation, the mechanical detents, or stops, will be placed at 5° intervals so that the part of the terrain you are looking at with your device in one position will overlap with the part of the terrain you look at in the next detent position.

"In the second variation, the mechanical detents, or stops, will be placed at 10° intervals so that the part of the terrain you are looking at with your device in one position will not overlap with the terrain you are looking at in the next detent position.

"With both of these variations, you use the procedures just described. When you are in a detent position, search the area before you go to the next position. You should also search as you go from one detent position to the next. If you see a target when you are moving, shoot it. But don't spend much time between detent positions.

"This concludes the briefings on the search procedures and techniques you will be using. Are there any questions on any of the material we have covered?....All right, we will have a 15-minute break before we assemble outside at the booths."

1500-1515. Diopter Adjustment (Players in booths)

1515-1545. Search Method Training (Players in booths)

Search-Scan. "During the next 60 minutes you will be using the scopes and the mechanical devices to further acquaint yourselves with the search techniques we described before. We will begin with the search-scan technique. Your scopes are adjusted for 10° intervals. During the practice phase tonight, you will have an opportunity to use the 5° and 10° setting prior to the actual testing.

"Note, again, the terrain variation in the field of search. It varies from cluttered to open, and flat to hilly. While you are searching the field, using either the free or the search-scan technique, the entire field should be covered at least once every two minutes.

"During the next ten minutes we will give you practice in the search-scan technique. We will announce when two minutes have passed each time. This will give you an indication as to how fast you are searching. Your job will be to search continuously, one stop at a time. Tonight you will receive additional practice. Ready, begin .... stop."

"Instructors, adjust the detents for 5°."

"O.K., now we will give you four minutes practice at 5°, and once again, we will announce when two minutes have passed. Ready, begin ...... stop.

"O.K., lets take a ten-minute break."

(Ten-minute break during which instructors remove detents.)

Continuous Search. "Now, we are going to give you practice for about six minutes using continuous search. Start in the upper left-hand corner, and move your scope continuously, but slowly, stopping when you wish to search for a possible target.

"As before, you may change your elevation, but do not go into the bottom half of the field. Continue your search until you come to the right limit, then drop down to the bottom half and search until you come to the left limit. At that point, move up to the left corner and repeat the procedure. As before, you should cover the field at least one time every two minutes. We will announce when two minutes have ended. Are there any questions? Ready, begin ...... stop."

1615-1630. Technique Test

"During the next fifteen minutes, each player will be asked to demonstrate his familiarity with each of the search techniques learned this afternoon. Each player, in order, will be asked to demonstrate the free-search technique. Beginning at the upper left, he will traverse across the field--keeping elevation constant--to right limit. Movement should be smooth and uniform. The scope is lowered one-half of the field and is moved from right to left limit. You should cover the field at least once every two minutes. Ready, number one booth, begin.......... stop. Number two booth.......number nine..........stop."

"Instructors, insert 10° detents."

"The stops have now been reinserted, and each player will be asked to demonstrate the scan-examination technique, using 10° stops. Be sure to advance only one stop at a time. Start at the upper left limit and traverse across, pausing only long enough at each stop to examine the terrain thoroughly. At the right limit, lower the scope one-half the field and traverse back to the left limit. Ready, begin booth number one, two, three......nine......stop."

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13. ABSTRACT

The NIGHT OPERATIONS Program within the Behavior and Systems Research Laboratory is concerned with problems in optimizing human performance in relation to night vision devices and related sensors. In the furtherance of this research, BESRL established a field unit at Fort Ord, California where, with the support of the Combat Developments Command Experimentation Command (CDCEC), studies are being conducted with passive night vision devices. Passive night vision devices developed for the Army have greatly increased night observation and target acquisition capabilities. Effectiveness of these devices, however, is highly dependent upon how and under what conditions they are used. Previous research (reported in Technical Research Reports 1163, 1164, 1166, and 1168) has demonstrated that the failure of operators to use procedures leading to timely and comprehensive search in a major cause for failure in target acquisition.

The present study, conducted by BESRL scientists with the assistance of personnel of Manned Systems Sciences, sought to determine whether new search techniques and procedures could increase the effectiveness of soldiers using passive night vision devices. The subjects (54 operators) using the Starlight Scope (SS) or the Night Observation Device, Medium Range (NOD) were given specialized search training and their training performance was compared with another group previously tested under the same conditions but without special training on search method and pattern. Both groups were tested on the same complex and heterogeneous terrain, extending 1500 meters. Testing was conducted under starlight and full-moon illumination conditions with targets of different type, contrast, and modes placed in the area at various distances of 100 - 200 meters

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
*Night operations research						
Human performance experimentation						
*Search techniques						
Technology						
Instrumentation						
Field experimentation						
*Sensors						
*Sensor systems						
*Passive night vision devices						
*Starlight Scope (SS)						
*Night Observation Device (NOD)						
Target detection						
Illumination conditions						
*Search pattern						
*Rate of scan						
Terrain characteristics						
Data acquisition system						
Search training						
Search area size						
Night observation						
*Target acquisition						
Distance						
Target presentation mode						

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13. Abstract - continued

from the players. Search areas (scan angles) of 75° and 35° were used. Search behavior and target acquisition responses were recorded electronically for data analysis.

Results showed a considerable increase in the number of targets detected for both devices; time required for target detection was considerably reduced by the special search training. Techniques developed in the present study assured a more comprehensive and timely coverage of a search area and pointed up the effectiveness of giving special search training to soldiers who will be using night vision devices. The training emphasis should be on use of 1) a rectangular search pattern to produce a systematic and comprehensive coverage on a regular basis; 2) a variable scanning rate with the rate of scan adjusted to difficulty of terrain being examined. A significant feature of this training is that it can be accomplished in two to three hours.