C-2001
dup.

AD

U. S. ARMY

Technical Memorandum 7-74

THE EFFECTIVENESS OF COLOR DEFICIENT INDIVIDUALS IN DETECTING AND IDENTIFYING TARGETS WITH VARYING DEGREES OF CONCEALMENT

John A. Whittenburg
Belinda Lowenhaupt Collins

SSTAR, Inc.

February 1974
AMCMS Code 673702.12.122

HUMAN ENGINEERING LABORATORY

ABERDEEN PROVING GROUND, MARYLAND

AMCMS Code 673702.12.122 Technical Memorandum 7-74

THE EFFECTIVENESS OF COLOR DEFICIENT INDIVIDUALS IN DETECTING AND IDENTIFYING TARGETS WITH VARYING DEGREES OF CONCEALMENT

John A. Whittenburg
Belinda Lowenhaupt Collins

SSTAR, Inc.
1920 Dogwood Lane
Vienna, Virginia 22180

February 1974

APPROVED: [signature]
JOHN D. WEISZ
Director
U. S. Army Human Engineering Laboratory

U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

ACKNOWLEDGEMENTS

The authors wish to acknowledge the many kinds of support provided by the Human Engineering Laboratory throughout the duration of the project. Dr. Leon Katchmar served as technical monitor on the project and performed this function in a highly professional and supportive manner. Dr. John Weisz, Director of HEL, also assisted the project in a number of different ways throughout its duration.

In addition, special mention must be made of the many individuals at HEL who contributed to the project. These include Dr. Leon Katchmar's secretary, Mrs. Gladys Turlington, who helped the project in a variety of ways; Mrs. Betty Morris and Mrs. Doris Eanes, who capably and willingly procured much of the literature used to support the project; and Mrs. Ida Corona, who assisted in the preparation of the illustrated data recording form.

Also, individuals who provided direct support to the classroom and field parts of the study deserve a great deal of credit. These individuals include Mr. Richard Krause, who functioned as the team leader and did so in a most effective manner. The other field team members included Mr. Herbert Fisher, Mr. Vince Stricker, Mr. Claiborne Smith, Mr. David Harrah, and Mr. Lester Jee. Their many duties included serving as controllers at each viewing position in the field, photometer operators, photographer, bus driver and as standard observers in Part II of the study. Their consistently high level of performance reflects the quality of staff at HEL.

Finally, appreciation is offered for the typing and editing support of Miss Debby Tuttle and Miss Betty Heydon. Both performed these functions in a highly efficient and effective manner.

FOREWARD

The activities and findings of Contract DAAD05-73-C-0527 concerning the effectiveness of color deficient individuals to detect and identify targets with varying degrees of concealment are reported in three different parts.

A ten-page summary of the field test activities and findings has been prepared for those readers who wish to receive a condensed presentation of the highlights of the study and its major findings.

A ninety-page description of the field test activities and findings has been prepared for those readers who wish to learn specific details concerning the background of the study, the design of the study, the activities carried out during the data collection phase of the study, the major and secondary findings, and recommendations for further efforts in the general area of target detection and identification.

Finally, a separately bound report presents the results of an intensive literature search which was performed during the project.

The separately bound report is divided into two major sections. The first section covers the general area of color blindness. The written subsections include color blindness and camouflage, color blindness, acquired defects, genetic defects and tests for color blindness. This section, in addition to having a written summary of the literature on color blindness, includes over 275 annotated references and approximately another 400 bibliographic references covering the general area of color blindness.

A second section contains over 150 annotated references. Of these, there are 27 annotated references on spectrophometric analysis of vegetation and man-made objects, 17 annotated references on infra-red reflection of vegetation, 12 annotated references on the characteristics and uses of filters, 9 annotated references on the use of aerial photography for detection purposes, 46 annotated references on camouflage techniques, equipment and effectiveness, 21 annotated references on the assessment of various types of film used in color photography, and 20 annotated references covering the general topic of human color and object perception.

This separately bound report may be of value for those readers who are or plan to conduct research or study in one of the related fields.

SUMMARY

Since WW II, the notion has persisted that color-defective individuals are superior to those with normal color vision in detecting camouflaged targets. The endurance of this belief is especially amazing since only one relevant and empirically-based study was uncovered after an intensive literature search; and, this 1943 study reported that normals were superior to color defectives in detecting camouflaged objects. Still, the potential military importance of this question requires that, at least, a limited effort be undertaken to resolve this matter. This is particularly compelling in view of the fact that the reported 1943 study used painted panels rather than camouflaged military targets positioned in realistic settings.

To maximize the chances of resolving this question within constraints posed by the small percentage of color-defectives--approximately 8% of the male population--available for testing, a fourfold strategy was selected.

1. Rely on chance in identifying a small number of soldiers who are color deficient. From a sample of 80-100 soldiers, by chance 6-8 of them would likely demonstrate some type of color deficiency.

2. Utilize filters which artificially induce different types of color deficiency. These filters can be worn by individuals with normal color vision.

3. Select other filters which take advantage of slight differences found in the spectral reflectance of natural terrain and camouflage netting. These filters can be worn also by individuals possessing normal color vision.

4. Divide the study into two parts. Part I involves a sample of U. S. soldiers who have no prior knowledge as to the number, types or locations of the targets in the test area. On the other hand, to reduce the potential influence of individual differences on the results, Part II would be made up of standard observers who would know how many targets there are in the test area, their identification and their location. Rather than measure target detection and identification, in Part II, the relative "discriminability" of camouflaged targets would be used as the criterion measure for determining the relative effectiveness of different types of filters.

Within the scope of this strategy, a twofold objective was formulated: namely, (1) to determine the relative effectiveness of real/induced color deficiency on detection, identification, or discriminability of targets possessing varying degrees of concealment, and (2) to determine the relative effectiveness of filters which utilize differences in spectral reflectances of camouflaged targets and surrounding natural objects.

The field study was conducted at the U. S. Army Aberdeen Proving Ground, Maryland. The site selected was relatively clear and flat with few and widely scattered bushes and trees and a solid treeline formed the background to the area. The site permitted an almost unobstructed view of the area for a distance approaching 2 miles.

Twelve target situations were selected. The targets selected varied with respect to size, shape, tactical function and degree of concealment. Three military targets were used to create nine of the target situations and camouflage nets only were used to create the other three target situations. The three military targets included an M-48 tank, a 1/4 ton jeep and a 155 millimeter howitzer - towed. Degree of concealment ranged from locating targets in the open area to using both natural and artificial means to blend the targets into the background.

Two viewing positions were selected. From the far viewing position, the distance of the targets ranged from 1055 meters to 2952 meters. From the near viewing position, the targets ranged from a distance of 88 meters to 880 meters. In addition to the two viewing conditions, two different viewing times were selected; i.e., in the morning and in the afternoon. Finally, four different types of filters were selected. The Wratten gelatin filters designated 44A and 32 were selected because they artificially induce a marked deficiency, respectively, in the red and green color acuity of individuals. Filters designated 12 and 82C were selected to enhance slight differences in the spectral reflectance properties of camouflage nets and natural terrain. In addition, the Wratten filter 12 absorbs light below 500 nm, i.e., it absorbs in the blue end of the visual spectrum. The filters were fitted into goggles to be worn by designated individuals during the field test. In the case of the 12 and 82 filters, one filter covered the left eye and one the right eye.

Part I of the study involved 72 soldiers who had just completed basic combat training and were ready for airborne training. Of the 72 soldiers available for the study, 12 revealed some type of color deficiency. Of the remaining 60 soldiers, 12 were assigned to the red-minus filter (44A), another 12 to the green-minus filter (32), another 12 to the spectral reflectance group (12 and 82C), and the remaining 24 were assigned to the normal color vision group. That is, they wore no filters nor revealed any type of color deficiency. Half of the soldiers in each group were tested in the morning and half in the afternoon. All of them initially viewed the test area from the far viewing position and then from the near viewing position.

In Part II of the study, four individuals served as standard observers. Two of the standard observers were assigned research project personnel and the other two were civilian personnel from the Human Engineering Laboratory in Aberdeen, Maryland, assigned to support the field study. All standard observers performed all conditions, i.e., a.m. and p.m., far and near viewing positions, and involving all types of filters; i.e., 44A, 32, and 12/82C. In addition, two types of goggles used to protect the eyes against laser beams used in target ranging were included in the study design.

For Part I of the study, all of the assigned troops prior to the field test received color vision tests. The American Optical Company's 1965 edition of the pseudo-isochromatic plates was used initially to screen for color defectives. The Farnsworth-Munsell 100 Hue Test was then used to measure the type and degree of color deficiency of those identified as having some color deficiency. Results of the testing revealed that 2 of the 12 color defectives merely had low color discrimination, 4 were moderately defective deutans (green-blind) and 3 protons (red-blind). The remaining 3 revealed severe defects and were classed as deutans with one evidencing a secondary tritan (blue-blind) axis.

The remaining 60 soldiers were matched on the basis of distant visual acuity (ortho-rater test), prior hunting experience, whether they wore glasses or not, and their performance on the Wilkin's "Group Embedded Figures Test." The matched soldiers were then randomly assigned to one of the remaining four experimental groups; i.e., filter 44A group, filter 32 group, filter 12/82C group or the normal color vision group.

In addition, limited target identification training was given, using thirty 35 mm. slides of 15 targets including the three selected for the field test. Finally, instructions were issued in the classroom on how to use the illustrated data recording forms, on which both target detection and target identification information were to be recorded.

During the field test, two soldiers at a time were tested from the far and then the near viewing positions. Each pair were allowed a maximum of 10 minutes at each viewing position. Controllers located at each viewing position issued data recording forms, provided final instructions, took notes regarding the search and target detection/identification recording behavior of the soldiers and ensured that no communication occurred among the soldiers. Special efforts were taken during the conduct of the study to minimize any talking among the soldiers regarding the test area or targets seen in the area.

During the conduct of the field test, a number of supporting activities were accomplished. These included taking 35 mm. color pictures and infrared pictures of the target area in the a.m. and p.m. and from both the far and near viewing positions, using a tripod mounted photometer to record the average brightness contrast of targets to background, using Landolt rings and a standard observer to record the transmissivity of the atmosphere and collecting surface meteorological data such as sun angle, wind direction and speed, degree of cloud cover, temperature and relative humidity.

The findings obtained from both Parts I and II of the study were similar. Specifically, no real differences were found in target detection, identification or discriminability between real/induced color defectives and those with normal color vision. Also, filters selected to take advantage of differences in spectral reflectances between target and background were found to be no more effective overall in target detection, identification or discriminability than use of unaided normal vision.

In addition to the above two major findings, a number of other findings were obtained.

1. Individual differences contributed substantially more to target detection and identification than any of the viewing conditions studied. Some of these individual differences are accountable and include whether the individual had prior hunting experience, his distant visual acuity and performance on the Embedded Figures Test. However, it was possible to reduce individual differences through the use of standard observers who performed the task of ranking camouflaged targets according to their relative discriminability. Even when individual differences were substantially reduced, the filters investigated revealed little or no differential influence on the discriminability of targets compared with each other or with unaided normal vision.

2. In addition to individual differences, the size and degree of concealment of each target played a most significant part

in contributing to the obtained detection and identification scores. In this case, the effort was deliberate and was quite successful in manipulating target detection, identification, and discriminability in the expected directions. However, the relative importance of target size vs. target/background contrast with respect to target detection was not determined in this study.

3. Detection performance was superior to identification performance, primarily because efforts were made to conceal to varying degrees 9 out of 12 targets. This finding highlights the importance of camouflaging targets even in the middle of an open field. The use of camouflage--although it increases apparent target size--clearly degrades detection performance and severely degrades identification performance.

4. Distance from the targets is more influential than time of day with respect to detection, identification, and discriminability. Time of day has its greatest influence on the detection of <u>some</u> targets from the near viewing position, while filters and the interaction of filters and time of day have their greatest impact on the detection of <u>some</u> targets from the far viewing position. With respect to target identification, the experimental conditions studied (filter and time of day) have their greatest impact from the far viewing position.

5. In contrast to both normal color vision and real/induced color defectives, the filters selected to enhance spectral re-

flectance differences performed detection and identification more effectively in the morning than in the afternoon. This is consistent with expectations.

Finally, based on the findings from the field study, observations made by project personnel and the results of the literature search effort, six recommendations are offered for consideration. These are presented in Chapter V of this report.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)