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Long Range Target Recognition and Identification of Camouflaged Armored Vehicles

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William L. Warnick, Garvin D. Chastain,
and William H. Ton
HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street
Alexandria, Virginia 22314

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5001 Eisenhower Avenue
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This report reviews the literature on recognition and identification of camouflaged (pattern painted) armored vehicles. In addition, the report contains the results of two experiments in long-range recognition and identification of camouflaged armored vehicles as viewed through the COBRA/TOW weapons sight (13X magnification) at scaled ranges of 2500, 3000, 3500, and 4000 meters. HO scale models and varied terrain backgrounds were employed. The experimental procedures may be useful in a formalized recognition and identification training program for helicopter crewmen.

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LONG RANGE TARGET RECOGNITION AND IDENTIFICATION OF CAMOUFLAGED ARMORED VEHICLES

William L. Warnick, Garvin D. Chastain, and William H. Ton
Human Resources Research Organization

Submitted by:
George M. Gividen, Chief
ARI FIELD UNIT AT FORT HOOD, TEXAS

May 1979

Approved by:

Frank J. Harris, Acting Director
Organizations and Systems
Research Laboratory

Joseph Zeidner, Technical Director
U.S. Army Research Institute for
the Behavioral and Social Sciences

FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation and Review). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

A war using modern weapons systems is likely to be both intense and short. US man/weapons systems must be effective enough, immediately, to offset greater numbers of an enemy. Cost-effective procurement of improved or new combat systems requires testing that includes evaluation of the systems in operational settings similar to those in which the systems are intended to be used, with troops representative of those who would be using the systems in combat. The doctrine, tactics, and training packages associated with the systems being evaluated must themselves also be tested and refined as necessary.

This report presents the results of experimental studies designed to determine how well Attack Helicopter (AH) pilots can identify camouflaged (pattern painted) vehicles viewed at simulated ranges from 2500 to 4000 meters against varying target backgrounds. The studies also explore training methods by which the capabilities of helicopter crewmen to identify vehicles at extended ranges may be raised to near-perfect accuracy.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract DAHC19-75-C-0025, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 1978 Work Program.

JOSEPH ZEIDNER
Technical Director

LONG RANGE TARGET RECOGNITION AND IDENTIFICATION OF CAMOUFLAGED ARMORED VEHICLES

BRIEF

Requirement:

The work of this study is that originally referred to in paragraph 2.2.6 of the Statement of Work dated 16 May 1977, under the title, "Long Range Target Recognition." The actual requirements were submitted in a Human Resources Need (HRN) statement by the Sixth US Cavalry Brigade (Air Combat) (6th ACCB), Fort Hood, Texas. Brigade authorities were primarily concerned with target identification by Attack Helicopter (AH) crewmen. Under contract to ARI, the HumRRO staff initiated a research investigation into this problem area.

Previous studies had revealed that potential targets can be positively identified at ranges of 3000 and 4000 meters under near optimum conditions employing the COBRA/TOW (XM65) weapons sight. However, further research was needed to fully examine the effects of degraded viewing conditions on the ability of crewmen to identify targets. Degradation would be by camouflage, partial obscuration, textured background, etc. The following objectives were developed for the study:

- To determine whether AH crewmen who had received previous training in armored vehicle identification could recognize and identify camouflaged (pattern painted) armored vehicles when viewed against a textured background at standoff ranges of 3000 and 4000 meters.
- To determine whether AH crewmen who had received previous training in armored vehicle identification could recognize and identify camouflaged (pattern painted) armored vehicles when they were emplaced in a terrain model at scaled distances of 2500 and 3500 meters.
- To determine whether AH crewmen could be trained to identify camouflaged (pattern painted) armored vehicles at standoff ranges.

Procedure:

Scale (1:87) models of armored vehicles pattern painted in the standard Army US summer and Europe verdant colors were presented to AH pilots/gunners at scale ranges from 2500 to 4000 meters. Two experiments were designed and carried out. The first study was concerned with viewing the painted vehicles against a uniformly green textured background. The second study examined observation of the vehicles while they were situated on a terrain model. The observers viewed the models through a 13X magnification optical aid (COBRA/TOW weapons sight (XM65)) situated in a static Cobra AH.

The experiments were designed to provide information on the Pretraining recognition and identification capabilities of the pilots, their performance during Training, and their Posttest recognition and identification performance. The first experiment used scale models of five different armored vehicles, the second experiment used ten different armored vehicles. Two additional vehicles (AMX-30 tank and PT-76 Soviet light tank) were introduced during the Posttest phase of the first experiment to test the reactions of the pilots to unfamiliar vehicles. The model vehicles were presented in five different views: right and left sides, right and left obliques, and front.

Principal Findings:

- AH crewmen could recognize and identify pattern painted armored vehicles at scaled ranges of 3000 and 4000 meters when viewed against a uniformly colored textured background. Pretraining identification scores averaged 62% and rose to 96% and 98.6% during the Training and Posttest phases.
- AH crewmen could recognize and identify pattern painted armored vehicles which were positioned on a terrain model at scaled distances of 2500 and 3000 meters. Pretraining identification scores averaged 46.5% and rose to 79% and 90% during the Training and Posttest phases.
- Target view was significantly related to recognition and identification performance. The front view degrades performance more than any of the five target views.
- The addition of camouflage patterns to the armored vehicle increases the number of learning trials needed to reach the learning criterion as established in these studies for recognition and identification performance.

Utilization of Findings:

The majority of pilots preferred the training employed in both experiments when compared to conventional training. The use of models and the terrain simulation more closely approximate actual field conditions than their standard training.

The series of studies which have been conducted indicate very strongly that recognition and identification performance can be dramatically improved by the infusion of the type of training employed in these studies.

Further research is planned to explore more fully the effects of degraded viewing conditions on recognition and identification of armored vehicles. The 6th ACCB at Fort Hood has requested aid in the development of a unit training program which will incorporate the training methods and results from the previous and current research studies.

The information provided by these studies can aid other operational units in the development of their own highly effective recognition and identification training programs.

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Chapter 1

INTRODUCTION

This report is based on research which is a continuation of work started in May 1976 in response to a Human Resources Need (HRN) statement submitted by the Sixth US Cavalry Brigade (Air Combat) (6th ACCB). At that time the Brigade indicated that priority should be given to work in the target identification area. In subsequent meetings with Brigade personnel, it was determined that their primary concern was the training of target recognition and identification skills for Attack Helicopter (AH) crewmen. Specifically, the Brigade was concerned about the adequacy of their current training programs for developing the capability to identify targets at long range.

The initial study[1] in long range recognition and identification dealt with two major objectives:

- To determine whether helicopter crewmen could recognize and identify armored vehicles at the standoff ranges (3000 and 4000 meters) necessitated by modern battlefield conditions. (Recognition was defined as labeling a vehicle as friendly or threat. Identification meant specifically labeling a vehicle as an M60, T-54, Chieftain, etc.).

- To determine whether helicopter crewmen could be trained to identify armored vehicles at standoff ranges.

A secondary objective was to obtain preliminary information on the extent of the problem so that some immediate guidance could be provided to the 6th ACCB. This information was required to evaluate the effectiveness of the Brigade's present training and help them to develop better training in long range target recognition and identification.

During the 1976-1977 contract year, two experiments were conducted using scale model vehicles at scaled ranges of 3000 and 4000 meters. The first experiment was exploratory in nature, while the second experiment was larger and based on results from the preliminary experiment. The observers used optical aids to view the scale model armored vehicles: 7x50 binoculars were used in the preliminary experiment, and the XM65 gunsight (13X) in an AH in the main experiment.

Viewing conditions during these first two experiments were nearly optimal. All target vehicles were painted a solid olive drab color, the

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[1] E. M. Haverland and J. L. Maxey. *Problems in Helicopter Gunnery*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, May 1977 (in process).

viewing platform was a textured homogeneous green color, and the scaled distances precluded any detrimental effects from rain, fog, or heat scintillation. The target array was composed of only five different vehicles. These experiments were purposely simple for two major reasons: (1) the experimenters were not positive whether armored vehicles could be reliably recognized at extended ranges, even with the 13X weapons sight; and (2) the experimenters did not want to confound their initial results with other factors such as camouflage, partial obscuration, noise, vibration, etc., all of which degrade visual recognition and identification abilities.

The principal findings were that:

- Helicopter crewmen could recognize and identify the armored vehicles at scaled ranges of 3000 and 4000 meters. Pretraining recognition averaged from 76% to 96% correct for the five armored vehicles, while Pretraining identification averaged from 48% to 77% correct under the relatively ideal viewing conditions of these experiments.

- All of the helicopter crewmen who served as observers in these experiments were able to learn to recognize and identify the armored vehicles to a level of almost 100% correct.

- Target view was found to be the only factor significantly related to recognition and identification performance. Differences in recognition and identification performance at the two different ranges (3000 and 4000 meters) were not statistically significant. Likewise, differences in recognition and identification performance for the five target vehicles were not statistically significant.

On the basis of these results, it was recommended to the 6th ACCB that a separate research program be established to examine long range recognition and identification. This program would systematically explore factors which might degrade AH crewmen's visual performance. The research reported in the following pages is, therefore, a logical extension of the work described above. These experiments were concerned with the effects of camouflage (pattern painting) on the ability of observers to recognize and identify armored vehicles at standoff ranges. The overall research strategy involved an initial measurement of the AH crewman's performance under ideal conditions, followed by measurement of performance in a series of experiments in which viewing conditions were progessively degraded.

Military Problem

The probability of engaging targets at extended ranges is becoming greater as technology extends hit capabilities beyond ranges which were once considered extreme. To counter the likely numerical superiority of potential enemies, our AHs have been equipped with a TOW weapons system with long range capability. By flying Nap-of-the-Earth (NOE) and firing the TOW weapon at standoff ranges (e.g., beyond 3000 meters), the AH will be far less vulnerable to threat forward air defense systems.

Earlier work in this area showed that aircrew personnel using the XM65 weapons sight could readily identify uncamouflaged armored vehicles under simulated range conditions at ranges of 3000 and 4000 meters. These studies provided baseline data on recognition and identification of olive drab armored vehicles. However, almost every modern army employs some kind of painted camouflage pattern on their vehicles to hinder detection, recognition, and identification. Hence, the generalizability of studies which have use monochromatic vehicles is unknown.

More interest in camouflage has been generated in the last several years than at any time since WWII. This has been prompted by increased emphasis on passive countersurveillance technology. This new interest includes development and testing of *pattern painting designs and techniques*, artificial garnish, reduction of thermal signatures and other efforts.

Probably the simplest form of countersurveillance is pattern painting of vehicles. It requires a minimum amount of effort in manpower and materials. Once completed, pattern painting is easily maintained and can be easily changed if required by operations in difficult geographical zones.

As weapons systems become more costly and more lethal, measures to protect what are now called "critical systems" are being currently explored. Such systems (main battle tanks, infantry fighting vehicles, etc.) are the basic instruments of favorable exchange (kill) rates, and their vulnerability must be reduced as far as possible without degrading their effectiveness. In this context, camouflage is seen as a means of reducing vulnerability.

The concept of the Active Defensive Posture requires weapons systems to displace (move) much more frequently than we have in the past. Therefore, camouflage methods and techniques for the future must stress portability and ease of employment.

The effects of pattern painting on recognition and identifcation at standoff ranges are not well known. At standoff ranges both friendly and threat armored vehicles subtend very small visual angles--approximately three to four minutes of arc when viewed by the unaided eye. Even with the 13X optic of the XM65 COBRA-TOW weapons sight, images of armored vehicles are still so small that only gross target features are clearly recognizable. A further complication arises from the similarity between friendly and threat vehicles in terms of shape, overall physical dimensions, and location of external items such as bore evacuators, machineguns, etc.

When the initial work in long range target recognition and identification was started, it was realized that a series of studies would be required in order to examine factors which degrade viewing conditions. Factors such as pattern painting, various degrees of obscuration, noise, vibration while flying, atmospheric conditions, illumination levels, and target/background characteristic differences need to be examined. However, such an "ambitious" program of research was beyond the time and resources available.

The two studies described in this report were planned to determine whether reliable target recognition and identification of pattern painted targets was possible at ranges of 2500 meters to 4000 meters. In addition, information concerning possible training program development was also provided.

Research Problem and Approach

Recognition and identification. The focus of these studies is on armored vehicle recognition and identification. Recognition is generally defined as placing a perceived object in some class; for example, recognizing that the target is a wheeled vehicle versus a tracked vehicle, or a tank as versus an antitank weapon. Identification is generally defined as a more specific naming of an object; for example, specifying that a tank is a British Chieftain.

Perhaps the most important general classification that an AH pilot/gunner can make on the battlefield is the distinction of whether an armored vehicle is a friendly or a threat. Therefore, in this research, recognition is restricted to the labeling of the target vehicles as friend or threat. A very narrow definition of identification is used in this study. Correct identification is defined as specifically labeling the armored vehicle with its correct military designation or its most commonly used name.

Literature review. A literature survey was conducted as part of the overall research approach in order to provide a broader information base concerning recognition and identification of camouflaged vehicles. It was decided to conduct a very specific search of the research documents available primarily in the archives of the Defense Documentation Center (DDC).

Experimental conditions. The basic requirements for research and the constraints under which it has been carried out, together determined the overall design of the experiment. It was decided to proceed with a reduced-scale approach for the following reasons: (1) reduced cost; (2) many of the vehicles needed in the target array are not available in this country, full-scale models are too expensive to fabricate; (3) experimental control is easier to maintain; and (4) the support demands on the 6th ACCB were minimal.

The primary drawback of reduced-scale simulation is that ideal viewing conditions do not allow the operation of degrading factors as atmospheric haze or scintillation. Since a static helicopter was used, further degradation from vibration or motion effects was also eliminated. The combination of the scaled ranges used in these studies and the quality of the 13X optics also contributed to ideal viewing conditions. The testing site was located on the Fort Hood Army Airfield and provided fairly ideal lighting conditions.

In the first study scaled ranges of 3000 and 4000 meters were used. In the second study the ranges were limited to 2500 and 3500 meters.

The molded plastic scale models used in these studies were painted in a 4-color camouflage pattern. In the first experiment the vehicles were displayed on a target presentation board (with a vertical background) which was covered in medium dark green textured papier mache. The textured background resulted in moderate brightness and color contrast ratios. In the second study, the models were presented with an appropriately scaled terrain background.

In previous studies, illumination levels were recorded throughout the observation trials. However, these workers found that ambient illumination was not related to recognition or identification performance. Illumination levels were recorded during the first camouflage pattern study of the current effort and were discontinued for the second camouflage study.

Overview of the Report

Chapter 2 describes the results of the literature review. Chapter 3 describes the two experiments and gives the results of each. Chapter 4 discusses and summarizes the results of both experiments.

Chapter 2

LITERATURE REVIEW

Introduction

The literature review was confined to those studies which dealt with recognition and identification of camouflaged armored vehicles. The object was to locate literature which might aid in the planning of the research. The primary reference source was the Defense Documentation Center (DDC).

The term *camouflage* encompasses many methods used to change or alter the ways in which an object is perceived. Camouflage may consist of hiding, blending, disguising, or decoying to achieve countersurveillance and countertarget acquisition. Thus, camouflage encompasses both concealment and deception. Camouflage is used in combat to deny, degrade, deceive, delay, or otherwise interfere with the surveillance of enemy forces.

More specifically, camouflage has three purposes on the battlefield: (1) it enhances the survival of primary fire power; (2) it enables movement with reduced materiel losses; and (3) it reduces casualties.

Background

Pattern painting was seldom used by US troops in WWII. For the most part, US Army vehicles went to war in olive drab with white stars as recognition markings. From WWII until the 1970s, little research was undertaken into armored vehicle camouflage. According to Binder,[1] from WWII until 1975, typical US practice considered camouflage painting as the responsibility of the individual unit or crew. This lack of a comprehensive camouflage policy was legitimatized by pointing to the wide variety of environments likely to be encountered by the US Army. As a result of this policy, no steps were undertaken to standardize camouflage beyond the basic and general recommendations contained in Army field manuals.

In 1974, the Army adopted a program for camouflage painting vehicles and equipment. The patterns and techniques were developed by the Army Mobility Equipment Research and Development Center (MERDC) at Fort Belvoir, Virginia. A pattern was prepared for most vehicles in the Army inventory. Variations were based upon the area and climate where the

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[1]G. Binder. "Modern U.S. Army 4-Color Camouflage," *Armored Forces Vehicles G-2 Magazine*, 5(6), September-October 1975.

vehicle was to be operated. Eight possible combinations of colors were developed. This provided a system that could be adapted quickly to seasonal changes, different climate, and variations in terrain.

The basic MERDC camouflage pattern is a 4-color pattern consisting of wavy, irregular patches of color. This pattern is intended to breakup the vehicle's outline and make it less conspicuous. In 1976 camouflage painting was temporarily suspended until paints of new formulation could reach the field. These new paints are similar in chromaticity to the old but have been reformulated to reduce the possibility of detection by infrared sensors.[2]

The renewed interest in camouflage, according to O'Neill and Johnsmeyer,[3] was prompted in part by development in countersurveillance technology.

Binder[4] reported that the need for pattern painting and other methods of disguise and concealment have assumed new importance since combat vehicles have become the prime target for a host of ground and air-launched, optically tracked guided missiles. He also states that the need for new and effective camouflage techniques is further indicated by the likelihood that NATO forces will no longer be able to guarantee air supremacy. O'Neill and Johnsmeyer[5] feel that our critical weapons systems (XM1, infantry fighting vehicles, etc.) must be capable of moving frequently, especially under the Active Defense Posture. The Active Defense Posture requires frequent movements which preclude the use of relatively immobile camouflage netting, or even the gathering of natural live foliage. It is assumed utilization of traditional camouflage techniques may prove too time-consuming, with the result that tactical movement would be seriously slowed. Therefore, O'Neill and Johnsmeyer feel that the use of traditional camouflage measures should be abandoned in combat as a necessary tradeoff for mobility.

In a somewhat more moderate vein, Farrar, et al.[6] conclude that no one camouflage pattern will suffice under all tactical conditions.

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[2] G. Binder and J. Steuard. "Modern U.S. Army 4-Color Camouflage," *Armored Forces G-2 Magazine*, 5(8), March-April 1976.

[3] T. R. O'Neill and W. L. Johnsmeyer. *DUAL-TEX: Evaluation of Dual-Texture Gradient Pattern*, Technical Report, Office of Military Leadership, US Military Academy, West Point, New York, April 1977.

[4] Binder, *op. cit.*

[5] O'Neill and Johnsmeyer, *op. cit.*

[6] D. L. Farrar, T. S. Schreiber, R. T. Batcher, R. A. Barnum, and J. H. Ott. *Measures of Effectiveness in Camouflage. Part I. Review, Analysis, and Systemization. Vol I. Measures of Effectiveness and the Role of Models in Evaluating Camouflage*, Report No. CAMTEC-TR-PT-1-Vol-1, Battelle-Columbus Laboratories, Camouflage Technology Center, Columbus, Ohio, April 1974.

These researchers point out:

> There is no single level, single assessment, or single measure of effectiveness that is adequate for all purposes or all viewpoints. Instead, there is a series of assessments corresponding to the scope (perspective) or level of the questions being asked about the camouflage and deception problems and all its ramifications.

Cheney, et al.[7] support this contention in their reports by saying: "The most a camoufleur can hope to do is to devise a system which will be to his advantage most of the time in most places, or in the most important places." They go on to discuss the many micro-environments, each with its own set of colors which vary over time. In addition to color, the micro-environments also have a characteristic but time-variant texture. Cheney, et al. point out that there is a limited amount of information on texture and conclude that the camoufleur can maybe only be aware of the existence of micro- and macro-textures. Cheney, et al. feel that:

> The camoufleur should try primarily through deployment doctrine not to become an obvious textured anomaly in the micro-environment with any one vehicle or present an anomalous textured pattern with a group of vehicles in the macro-environment.

This concept is interesting as it indicates that the camouflage pattern for a single vehicle may need to be different from that for multiple vehicles depending on their employment. Their idea of a textural spectrum, which must be considered when employing single as versus multi-vehicle deployment, is unique and worth further study.

Cheney, et al. also report some findings from a recent NATO study of terrain in Western Europe. They are summarized as follows: At 3000 meters it is virtually impossible for a moving tank to detect and identify a stationary tank. Detection starts to occur at about 2000 meters and improves as the distance lessens. A stationary tank, on any but the most open terrain, will not generally be visible at ranges greater than 2000 meters, even with a clear line-of-sight. The NATO study also noted that firing the tank's main gun at ranges shorter than 1 km will generally disclose the tank's firing position to the enemy; thus, camouflage will be of little value at ranges less than 1km. Thus, camouflage could be available in protecting a tank from ground detection at ranges from 2000 to 1000 meters.

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[7] T. A. Cheney, G. V. Guiness, and R. J. Eckenrode. *Concealment for Armor and Aircraft*, Vol 1, Final Technical Report, Dunlap and Associates, Inc., June 1966.

Foreign Research

A few reports mention camouflage research efforts by the British and German armed forces. However, most of the relevant information is anecdotal in nature. No foreign sources were disclosed by the computer search of DDC files.

A secondary source, Humphreys and Jarvis,[8] contains information on foreign research into the effectiveness of pattern painting. They reported some Australian research which used scale models. The Australians found that pattern painting significantly reduced the rate of vehicle recognition at all angles of view and in all lighting conditions. Swedish tests were quoted which showed that detection range for static targets was decreased and acquisition times for moving targets was increased. (Details of the Australian and Swedish tests are classified.)

Humphreys and Jarvis further report that the British consider pattern painting as not economically justified by the results. However, after pressure from the British regimental staff, the British Army relented on the basis that pattern painting improves troop morale. Currently, the British pattern is a 2-color NATO green and black pattern, similar to the Australian pattern used in Vietnam. Low gloss paint is used, with infrared reflectances comparable to those of real foliage when photographed with camouflage detection film.

Experimental Studies of Camouflage Effectiveness

Studies employing scale models of armored vehicles on simulated terrain tend to yield equivocal evidence concerning the effectiveness of pattern painting as an effective camouflage technique. However, the few field studies found using actual vehicles on real terrain indicate that pattern painting is an effective passive countermeasure to visual detection, recognition, and identification.

Whitehurst[9] conducted two model experiments to determine the effects of pattern contours, the number of colors used in the pattern, and the chromaticity of the colors used on an observer's ability to detect

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[8] A. H. Humphreys and S. V. Jarvis. *Camouflage Pattern Painting Report of the USAMERDC'S Camouflage Support Team to MASSTER*, Report 2090, US Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia, February 1974.

[9] H. O. Whitehurst. *The Effects of Pattern and Color on the Visual Detection of Camouflaged Vehicles*, Report No. NWC-TP-5746, Aircraft Weapons Department, Naval Weapon Center, China Lake, California, April 1975.

military vehicles with unaided vision. Scale model (1:84) Armored Personnel Carriers (APCs) were painted in either the MERDC or Swedish patterns. Both patterns were constructed using either three or four colors. A target painted a solid forest green was used as a control. The target vehicles were presented at scaled ranges of 425 and 550 meters.

Under the conditions of the study, the multi-color vehicles were no more difficult to detect than the solid forest green color. Whitehurst's findings did not support the hypothesis that pattern contour and number of colors increase the difficulty of detecting targets. As would be expected, target location was found to significantly affect search time. The data also indicated that acquisition of approximately 80% of the targets could be accomplished within approximately 9 seconds. Pattern color and the size of color patches were held constant in this study. Whitehurst concluded that "differences in pattern painted vehicles obtained in field tests may be attributable to the fact that pattern color and size were allowed to vary." This conclusion would not apply to field tests with the MERDC patterns as the size and color ratios are held fairly constant among patterns developed for a particular vehicle.

In Whitehurst's second experiment, the following colors were used: a solid olive drab, a MERDC pattern with a base coat of flat green, a British pattern contour with a base coat of flat green, a German pattern contour with a base coat of flat green, a MERDC pattern with a base coat of flat dark olive, a British pattern with a base coat of flat dark olive, and finally, a German pattern with a base coat of flat dark olive. The British and German patterns specified two colors but four colors were used to keep the number of pattern elements fairly constant across pattern types.

The results in the second experiment indicated that the pattern type did not affect target acquisition performance. This result held even when the vehicles were partially masked from view. However, the colors of the base coat did affect search time. The dark olive green targets were found to be significantly more difficult to detect than the green targets. This finding led to a recommendation concerning the selection of colors in a pattern. If two colors appear equally difficult to detect, it is probably better to go with the darker color. There were no significant differences between the olive drab target and either of the two groups of pattern targets. Target location was again found to significantly affect search times. Whitehurst also noted differences in detection ability between their observers due to differences in visual acuity. As far visual acuity improved from 20/20 through 20/12, the probability of target detection in a given period of time increased.

Whitehurst's basic conclusions do not support the need for pattern painting if the simulated conditions of the experiment in fact match those found in the real world environment. However, it was felt that pattern painting may be justifiable for other reasons, such as troop morale.

Grossman[10] conducted two laboratory experiments using terrain models to assess the effects of pattern, range, lighting, and target location on the ability of subjects to visually detect tank targets. In the first experiment the patterns used were the MERDC, Swedish, and German designs. In addition, a single olive drab control target was used. Targets were placed at simulated ranges of 425 and 550 meters. The MERDC pattern proved more difficult to detect than any of the other three patterns. There were no differences in detection times between the Swedish, German and the olive drab targets. To obtain a cumulative detection rate of 80% took approximately 9 seconds of search time.

Grossman's second experiment used patterns based on the MERDC, Swedish, German, and British designs. As previously, a single-color olive drab control target was also used. The British and German patterns used two colors, while the others used four colors. It was found that targets were more easily detectable when shadows were not present, and that there was little difference among the camouflage patterns. The overall results indicated that pattern did not significantly affect detection time. Grossman's results indicated that target location and lighting conditions significantly affect the detectability of a vehicle. However, neither lighting nor target location interacted with pattern to produce differences in pattern effectiveness at the ranges tested. The results also indicate that obliterating a portion of the vehicle outline by placing it behind terrain or foliage is a very effective method of camouflage.

Grossman's two experiments strongly suggest that pattern painting does not effectively reduce the detectability of a vehicle. In fact, Grossman stated, "There is little evidence to suggest that a pattern is more effective than a single color, when the color used is similar to the color that is in the background."

A third scale model study was conducted by Grossman.[11] In this study, scale model tanks and APCs were used as target vehicles. One of the goals of the experiment was to evaluate the effectiveness of disrupters as a camouflage technique. A disrupter is a rapidly deployable mechanism, resembling an umbrella, which is used to break up the geometric shapes of military vehicles. Two additional objectives were to: (1) Determine whether the MERDC patterns reduced a vehicle's detectability more than the uniform olive drab, and (2) assess the differences in the detectability of an M60 tank and an M113 APC. The tanks had

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[10] J. D. Grossman. *Effectiveness of Camouflage on Visual Detection*, Report No. NWC-TP-5745, Aircraft Systems Department, Naval Weapons Center, China Lake, California, April 1975.

[11] J. D. Grossman. *Effect of Disrupters, Pattern Painting, and Vehicle Type on Target Acquisition*, Report No. NWC-TP-5798, Systems Development Department, Naval Weapons Center, China Lake, California, October 1975.

ither 12, 6, or no disruptors and the APCs had either 9, 5, or no ruptors. Targets were placed at a scaled distance of 1500 meters from the viewing subjects. Each subject advanced 60 meters at 10-second intervals until the target was found.

Grossman reported that disruptors were ineffective in reducing detection range. No differences in detection ranges were found between vehicles having disruptors and those without them. It was felt that these results were due to the failure to place disruptors on the most conspicuous parts of the vehicles; i.e., track and suspension areas. Comments from the subjects suggest that the vehicle tracks and the shadows of the visible underside contribute most to detection. Disruptors and pattern painting therefore leave the most conspicuous part of a vehicle completely uncamouflaged.

As for the secondary objective, the MERDC tank, olive drab APC, and olive drab tank were about equally easy to detect. The MERDC APC was much more difficult and detection was essentially at the chance level.

Grossman's results suggest that future efforts should concentrate on reducing the conspicuousness of structural aspects of tanks and APCs. Additive camouflage techniques then might become effective. One of the areas suggested for research concern the effectiveness of permanent or temporary fender skirts.

Field Studies Dealing with Camouflaged Armored Vehicles

The studies which have had probably the greatest impact on shaping the Army's policies concerning camouflage are those by Humphreys and Jarvis,[12] Jarvis,[13] and Marrero-Camacho and McDermott.[14]

The MASSTER effort (Marrero-Camacho and McDermott) evaluated a large variety of camouflage equipment and techniques (e.g., face paint, drape nets, helicopter hub and blade covers, etc.). The only aspect of the MASSTER report covered in this review deals with camouflage paint patterns and colors for tactical vehicles. The basic MERDC pattern and color combinations were evaluated. The color and percentage ratios are as follows: forest green, 40%; field drab, 40%; sand, 15%; and black,

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[12] Humphreys and Jarvis, *op. cit.*

[13] S. V. Jarvis. *Fort Knox Test of Camouflage Pattern Effectiveness*, Technical Memorandum, US Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia, August 1974. (Memorandum UNCLASSIFIED.)

[14] G. Marrero-Camacha and R. B. McDermott. *Camouflage Evaluation Report (Phase I)*, MASSTER Test Report No. FM 153, Headquarters, Modern Army Selected Systems, Test, Evaluation, and Review, Fort Hood, Texas, January 1974.

5%. The MERDC pattern was not compared against other patterns and colors; instead, it was compared with vehicles that were painted with single colors, usually olive drab or NATO green. They found that overpainting the usual white star marking found on US Army vehicles with lusterless black paint was effective in reducing vehicle detection. The highest overall effectiveness rating was given to the MERDC pattern and colors. Its effectiveness in disrupting features was cited as the basis for choice.

In conjunction with the overall MASSTER evaluation, an experiment was conducted using plywood panels painted with various patterns and colors. Subjective ratings from observers were employed and the results indicate that the comparative effectiveness of camouflage patterns and color varied with range, light, background, and foreground conditions. However, the MERDC pattern and color combination was ranked at the top or very near the top of all schemes evaluated under most conditions. A serious flaw in this study was the use of subjective ratings in lieu of experimental manipulations. A second difficulty arises from the absence from the evaluation of alternative pattern painting techniques. Hence, these findings, despite the great effort expended, can only be regarded as incomplete.

A unique side benefit attributable to pattern painting was discovered during the MASSTER evaluation. It seems that observations made with image-intensification devices revealed that the solid, single-colored vehicles presented more intense images than the camouflage pattern at 400 meters range and less. The pattern vehicles presented a more disrupted, less intense image. When aerial infrared imagery was used, all vehicles, regardless of pattern, were discernible as uniformly intense hot spots.

It was also noted that camouflage painting alone is ineffective in concealing military equipment unless it is properly sited to blend with the surrounding terrain. Humphreys and Jarvis support this contention. They feel that pattern painting materially reduces the threshold of visibility of the item and its recognition characteristics as a military object. It also provides an excellent base for further, more complete camouflage. The MERDC pattern, at the time of the Humphreys and Jarvis and MASSTER tests, was a new experimental approach to pattern painting within the US Army. It was the first significant innovation since WWII toward establishing a coordinated and comprehensive program for camouflage painting. A good source for more information concerning the MERDC pattern painting is Technical Bulletin 43-0209.[15]

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[15] US Department of the Army. Technical Bulletin 43-0209, "Color, Marking, and Camouflage Painting of Military Vehicles, Construction Equipment and Materials Handling Equipment," October 1976.

As Pabon[16] reported, the Materiel Testing Directorate compared the performance of trained observers (ground and aerial) in detecting pattern painted versus camouflage-augmented M60A1 tanks. The camouflage-augmentation techniques used were devices such as nets, brackets, and textured surfaces. Tanks were presented either stationary or in motion. The observers employed ground and aerial surveillance tactics and attempted to detect and identify the target within an array composed of tanks and distractors. The distractors were APCs and a prototype infantry fighting vehicle. The distractors were all pattern painted. The results were:

- Camouflage application degrades the detectability of the stationary tank for both ground and aerial observers.
- During the day the dust and noise signature cues created by moving tanks completely nullified the effect of camouflage.
- During night observation trials both stationary and moving vehicles were approximately equally difficult to detect.
- The stationary pattern painted tank was identified more quickly than the stationary camouflage-augmented tank.
- In target acquisition (after the tank had been initially detected) the camouflage application in general did not affect the observer's performance. Acquisition times for both vehicles were not significantly different.

In a well-designed field study, Barnes and Doss[17] found that pattern painting alone was not sufficient. The researchers found that a camouflage-augmented tank (nets, disruptors, etc.) was more difficult to detect than a pattern painted tank. This report focused on aircrew target detection performance. Performance was measured under two con-

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[16] R. J. Pabon. *Statistical Analysis Report of the M60A1 Camouflage Test*, Technical Report 11-76, Directorate of Combat Operations Analysis, US Army Combined Arms Combat Developments Activity, Fort Leavenworth, Kansas, November 1976.

[17] J. A. Barnes and N. W. Doss. *Human Engineering Laboratory Camouflage Applications Test (HELCAT) Observer Performance*, Technical Memorandum 32-76, US Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland, November 1976.

ditions: (1) detection while flying a nap-of-the-earth route reconnaissance, and (2) detection while searching from a pop-up position. Under the route reconnaissance condition, the mean value of the normal straight-line target detection range was 236 meters against the camouflaged tank and 828 meters against the patterned tank. This difference was statistically significant. Mean detection time for the patterned tank was 42.40 seconds, while 75.00 seconds was required for the camouflaged tank. This difference was also significant. Under the pop-up condition the pilot/observer required 36.6 seconds to locate a patterned tank parked adjacent to a wooded area. Only 40% of the subjects detected the augmented tank and it took an average of 95 seconds to locate it.

Eye-scan measurements taken during the experiment indicated that, in general, the subjects did not follow the search pattern techniques set forth in Army Field Manual 1-80.[18]

Sumrall,[19] as summarized in Grossman,[20] mentioned that in WWI and WWII the US Navy experimented with patterns for their warships. They employed "dazzle" patterns which used disruptive coloration to change the appearance of forms and were found to be very effective in confusing observers' estimates of a ship's heading, speed, and range. The Navy found it much easier to confuse than to attain invisibility. The patterns that were finally adopted by the Navy were based on the dazzle principle.

Dual-Texture Pattern Gradient Evaluation

The ideal camouflage pattern should offer maximum concealment value under all common threats and terrain conditions without requiring the use of extensive garnishment. The pattern developed by the Psychology Committee at the US Military Academy seems to offer some promise in meeting these criteria. The pattern they developed is derived from that developed by the US Army Mobility Equipment Research and Development Command (MERADCOM). Two laboratory and field experiments were conducted to evaluate this development, termed the "Dual-Textured Gradient Pattern" (DTG). The laboratory study was conducted by O'Neill and Johnsmeyer.[21] The field study was carried out by O'Neill.[22]

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[18] US Department of the Army. Field Manual 1-80, "Aerial Observer Techniques and Procedures," 30 July 1974.

[19] R. F. Sumrall. "Ship Camouflage (WWI, WWII): Deceptive Art," in *US Naval Institute, Proceedings*, 99(2), February 1977, 67-81.

[20] Grossman, *op. cit.*

[21] O'Neill and Johnsmeyer, *op. cit.*

[22] T. R. O'Neill. *DUAL-TEX 2: Field Evaluation of Dual-Texture Gradient Pattern*, Technical Report, Office of Military Leadership, US Military Academy, West Point, New York, May 1977.

Both studies agreed that the DTG pattern was not readily distinguishable from the standard pattern at longer ranges without optical enhancement. At longer ranges the DTG pattern merges into a *macro-pattern* of broad light and dark areas which matches the texture of the background. At closer ranges, under optical magnification, a *micro-pattern* resolves which again matches the background. The DTG pattern consists of a large number of differently painted small squares. The authors emphasize that the DTG pattern *was not* designed for use with garnishment.

The laboratory study simulated summer and winter environments by using 35mm color slides of various panels painted with various patterns taken during the appropriate season. Targets were photographed at distances ranging from 78 feet to 675 feet. The slides were taken at 25-foot intervals. Subjects viewed the projected slides on a large screen. The target object was a 4 x 8 foot wooden panel painted either a pattern or a solid color. The following groups of patterns were evaluated: (1) summer condition; US Army standard pattern, DTG, dark green panel (control target), and (2) winter condition; US Army standard pattern, DTG, Swedish, and solid white panel (control target). Subjects were 260 students from the US Military Academy at West Point, New York. Results for the summer condition indicated that the means for the standard and control panels did not differ significantly. Overall, the DTG pattern mean differed from those for the other two patterns beyond the .01 level of significance, indicating the DTG was hardest to detect. Under the winter condition the DTG was harder to detect than the standard and Swedish patterns. Little difference was found between the white control and DTG panels.

O'Neill and Johnsmeyer report some support for the hypothesis that detection of camouflage is a combination of visual search habits and fairly specific and stable perceptual organizing properties. During this laboratory study, some subjects were unable to recognize the DTG panel even when the target outline was traced on the screen by the experimenter. yet, the patterned panels were clearly visible to other subjects. This appears to:

> ...illustrate which is probably the most important single factor in camouflage detection: knowing the nature and location of the target will defeat any measure known. If you know what the target looks like and where it is, its signature will usually be overwhelming; but does not mean it will be easily detected by a naive observer.

As noted previously, the O'Neill study was conducted in a field environment. Subjects were 10 warrant officer attack pilots and 28 EM artillery observers of the 82d Airborne. All subjects had received some vehicle recognition training. The target vehicles were M113 APCs painted either in the standard 4-color Army pattern (forest green, light green, field drab, and black) or in the DTG pattern which used the same four colors. Natural garnishment was applied to the front of to each vehicle, the commander's station, and the ventilator dome. Subjects observed the targets through a TRW-3 Russian commander's sight affixed on a T-62 tank. This sight has relatively low magnification. Target vehicles were presented against the edge of a tree line at a distance of 926 meters. Subjects were told to search for any military target (type was not specified) located between the 8 and 30 range lines on the sight. Subjects were given 60 seconds to observe the target area. Mean times to detect the standard US Army pattern was 22.32 seconds, while 40.35 seconds was required for the DTG. This difference in mean detection times was significant. However, the DTG pattern was more difficult and time-consuming to apply than the normal US Army pattern, although the difference in difficulty did not appear to be unreasonable.

New Concepts in Camouflage

Degan, et al.[23] reported two field demonstration evaluation which dealt with new concepts for concealing armored vehicles. These techniques have their historical basis in the illusions produced by famous magicians such as Houdini and Blackstone. These illusions were "done with mirrors." Degan and his co-workers used a flat mirror which reflected the ground or sky onto a vehicle and thus camouflaged it from view. This particular application used a Mylar mirror which was easily erected and was highly portable. Only the front view of a 1/4-ton vehicle was used and the surrounding environment was primarily foliage.

In the first test the vehicle was placed at a range of 250 meters, as observers moved toward the vehicle in 50-meter increments. On the average, the mirror was not detected until the subjects had approached to within 50 meters.

In the second study, the mirror was set up approximately 150 meters from the observation area in a depression. Several clumps of willows were the only vegetation present. The surrounding area consisted of mowed grass. A mirror was positioned in front of the target truck which reflected onto the vehicle an image of a willow clump. The observers were unsuccessful in two attempts to locate the target vehicle. These two tests indicate that military vehicles can be effectively concealed by the use of mirrors.

Cheney, et al.[24] report another innovative effort. The purpose of their study was to generate new concepts for concealing armored vehicles.

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[23] W. J. Degan, S. N. Penick, and G. L. MacPherson. *Camouflage by Reflectance of the Natural Terrain*, Technical Note 73-03 (Final Report), US Army Land Warfare Laboratory, Aberdeen Proving Ground, Maryland, August 1972.

[24] Cheney, Guiness, and Eckenrode, *op. cit.*

Primary emphasis was on the evaluation of different kinds of disruptors and the development of rapidly deployable and retractable camouflage systems. Effectiveness of a particular method was expressed as a percentage of improvement over the use of olive drab painted vehicles under the same conditions of observation. Observers viewed scale model M60 tanks and M113 APCs on a terrain board at a scaled range of 1045 meters. Target detection occurred when the observer first correctly suspected that an object was military. Identification took place when the observer correctly named the vehicle. An observer's baseline detection ability was based on observation of uncamouflaged vehicles under the same conditions. Effectiveness of each camouflage concept was measured against a criterion of 30% improvement in detection and a 50% improvement in recognition compared to uncamouflaged vehicles. Four concepts met these requirements: (1) folded honeycombs, (2) ejectables, (3) air-supported fence, and (4) form filler. All four concepts were basically disruptors which extended out from the vehicle, thus breaking up its outline.

Cheney, et al. found that identification became more difficult as the view was changed from a side view to an oblique view, and then finally, to a front view.

The identification of the APC was based on its compact geometric shape and its track and suspension outline. Other characteristics did not emerge until the vehicle was viewed at a relatively close range. The data indicated that the tank's signature was perceived as a composite with no distinct components in the sense that specific cues were perceived at various ranges. The cues which appear the most important were the turret/hull outline (small mass on top of a large mass), gun barrel, track and suspension, and turret rear overhang. Of these, the gun barrel was the most frequently utilized cue. However, the geometric outline of the vehicle was a critical cue in all observation trials. The following guidelines for camouflage were recommended:

- Close off the underside (tracks and suspension) and/or site the vehicle in defilade positions to aid in concealing the tracks and suspension.

- Investigate techniques to make the gun barrel more free form and provide segmented masking of muzzle and barrel sections.

- Mask the turret rear overhang.

From these recommendations there is an apparent need for a camouflage material which will quickly render the vehicle less discernible to recognition and identification. The material should be light, portable, easy to apply, and easy to color match. Cheney, et al. mention *foam* as a candidate material, although little appears to have been written about it. These writers felt that foam possessed certain inherent properties which encourage its use. Foam constructions are readily portable, will not tear, and afford a flexibility which cannot be achieved with paints or nets. Unlike nets, the foam will not prevent objects being camouflaged from being put into instantaneous use. The color of foam can be widely varied and they are available with a smooth lusterless surface. By use of different colors or shades, patterns could be achieved that would effectively camouflage a variety of objects.

Cheney, et al., in their review of the literature, found that the work done at Fort Rucker in Project OBSERVE was the only study in which data were collected on a large number of targets which varied systematically along more than one dimension. This field study used aircraft and aerial observers to observe ground targets from the air. It was found that targets smaller than five square mils were undetectable by most observers. Under optimum observation conditions, relatively unconcealed targets larger than 50 square mils were usually detected if they were exposed for five seconds or more under good viewing conditions. Using five mils as an accepted visibility threshold, they computed that if an object were broken up into segments smaller than 8 x 8 feet it would escape detection at a range of 3600 feet. Breakup into progressively smaller segments would be required with decreased range. They concluded that at a range of 1200 feet, patterns should be no larger than 2.5 feet on a side. Some of the same rationale was used in the development of the DTG pattern.

In a sharply different area of study, O'Neill and Johnsmeyer[25] looked at the role of individual differences as they affect target recognition/identification performance. These authors contend that:

> Despite the continuing development and deployment of modern antiarmor systems, the greatest burden must still be borne by the crewmen to acquire, identify, engage and destroy enemy targets. A logical and economical first step is to establish selective testing sysyems which will identify soldiers with the highest potential for mastering these critical tasks. The detection and identification of targets is vital to the functions of ground and aerial scouts, vehicle commanders, and gunners. Identification and selection of soldiers with high aptitude is a continuing goal, and a vital one.

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[25] T. R. O'Neill and W. L. Johnsmeyer. *Investigation of Psychometric Correlates of Camouflaged Target Detection and Identification*, Technical Report, Office of Military Leadership, US Military Academy, West Point, New York, May 1977.

Battlefield targets are seldom clear and unambiguous. Identification of soldiers with high potential for acquisition and identification of camouflaged targets is a reasonable goal for research.

O'Neill and Johnsmeyer hypothesized the existence of three perceptual skills which may defeat the effects of camouflage: (1) perceptual organizing properties (Gestalt properties), (2) cue-search skill, and (3) perceptual set. One of the objectives of the study by O'Neill and Johnsmeyer was to isolate and study the effects of the first two of the three hypotheses--Gestalt properties and cue-search. Two paper-and-pencil instruments--the Degraded Letters Test and the Cue-Search Test--were evaluated in a laboratory situation as possible predictors of individual ability to detect and identify camouflaged targets. Both tests appeared to offer promise, but verification of their efficacy would require validation under field conditions.

General Recommendations for Camouflage

Listed below are some general principles, rules, or recommendations which were derived from two sources concerning camouflage.

The report by Cheney[26] states that the essential properties of good camouflage are:

- The capacity of the material to reflect infrared radiation must be as similar as possible to that of the surrounding terrain.

- Colors must be as pure and as saturated as possible.

- The brightness of the individual colors must be such that the brightness of the camouflage agrees with that of the terrain.

- Matte finishes are best to avoid reflections.

- The pattern used to camouflage should be as broken and undefined as possible. With a broken pattern in a vegetated landscape, such as a jungle, the natural shadows and lighting will help produce the desired effect.

Wise[27] published an historical recounting of American military camouflage and markings from 1939 to 1945. Much of the information appears to be based on research that was conducted during the war years

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[26] T. A. Cheney. *Concealment for Armor and Aircraft*, Final Technical Report, Vol 2, Dunlap and Associates, Inc., June 1966.

[27] T. Wise. *American Military Camouflage and Markings 1939-1945*, Almark Publishing, Ltd., Surrey, England, 1973.

and substantiates much of what has been rediscovered today. These findings are as relevant today as they were then and are included here so they may not be lost.

- Regularity of shape will identify an object and shadow will reveal the shape of an object far better than its own outline.

- For concealment from ground forces a background should be chosen which will visually absorb the subject without changing the appearance of that background more than is necessary.

- Evergreens make the best natural camouflage as they last longer without wilting.

- Foliage should be positioned so that the top of the leaves are right side up. The upper surface of most leaves are waxy and considerably darker than the underneath sides.

- Paint is most effective when used on fixed installations. Its main limitation is that it has no texture of its own and *texture is one of the major factors of successful camouflage*. (Italics added by present authors.)

- The use of paint for camouflaging vehicles may be split into four basic principles: color matching, countershading, coinciding patterns, and disruptive patterns.

- The color used must be several shades darker than the surrounding terrain in order to be matched. This is because a textured surface of the ground looks darker from the air.

- The selection of semi-gloss or lusterless olive drab was chosen as the most average color for blending with all the various terrains our forces operated on in WWII.

- When selecting a second or third color for use in a pattern, the greater the contrast in colors to the surroundings the more visible the object will become. Contrasting colors, especially light ones, when used in a foliated terrain tend to attract the eye, and in this type of terrain much is to be said for retaining the basic single color, which should be toned down to the darkest color in the surrounding terrain.

- In countershading, to reduce the natural reflection and shadow outline, paint should be applied to blur the outline; for example, dark paint to surfaces reflecting the most light, light paint to surfaces in the shadow. *This method of shading can play a particularly important part in the camouflage of gun barrels*. (Italics added by present authors.)

* Methods of dealing with gloss: Cover areas with a film of oil and earth, or sand. Paint edge of gloss areas in black paint.

* Camouflaged patterns used should be related to nearby shadows and ground shapes, making the pattern shapes general, not definitive. Regular outlines, regular spacing, and symmetrical shapes should be avoided.

* Patterns should be bold and contrast between light and dark paints very pronounced. This is because when observed from a distance and especially from the air, color perception is diminished so that feeble contrasts in color, or small patterns, will fade, leaving the object plainly visible.

* The most difficult shape to simulate is a shadow. Black paint may appear very light under certain light conditions. When viewed from the air, shadows are the blackest part.

* In the case of aerial observation, color perception diminishes at high altitudes and patterns therefore tend to merge into shades of gray.

* If patterns are too small, they will merge into overall color and will not conceal shape. Also, small differences of color cannot be distinguished from the air, causing small patterns to be ineffective.

* Size of pattern will depend on size of the object being camouflaged.

Wise pointed out that the first known appearance of US Army vehicles in camouflage paint during the WWII period was in the summer of 1941 during summer maneuvers. He also stated that disruptive patterning became more common during the Italian Campaign, especially as the warfare became more static. Camouflage in Germany was achieved mainly by using pine branches.

Summary and Discussion

The literature clearly illustrates that different results have been obtained depending on whether a study was conducted in the laboratory or in the field. Laboratory results have shown that olive drab or dark green vehicles do just as well as pattern painted vehicles. The field evaluations show that the pattern painted vehicles have been shown to be very effective when compared to a uniform olive drab color. The actual source of these contradictory findings is largely unknown, but as was pointed out earlier, at least one of the field studies was methodlogically flawed.

The literature seems to support the contention that there is no single universal camouflage pattern that will suffice under all conditions. Evaluation of the DTG pattern seems to indicate, within some constraints, that it closely approximates a universal pattern.

The only systematic US research effort conducted appears to be the studies by MERDC at Fort Belvoir, Virginia. Some foreign countries evidently have conducted extensive research into the area of camouflage patterns; however, little empirical evidence of effectiveness was uncovered. There is a clear need to gather and synthesize this research by other nations. There is also a need to conduct further research into the development and evaluation of different patterns for use in various operational areas. Research into the development of special patterns for use in various geographical areas would appear to be valuable to afford better protection for critical weapons systems.

Military personnel feel that pattern painting does have a positive effect on the morale of troops and does make them more camouflage-conscious. The pattern painted vehicle also requires less effort to conceal it further with garnishment.

The use of psychological tests should be investigated for identifying individuals who have a high potential in detecting and identifying camouflage targets. Preliminary studies using the Degraded Letters Test and Cue-Search Test have shown some promise.

As a research area, the detection, recognition, and identification of vehicles employing camouflaged patterns appears to be virtually untouched.

Chapter 3

EXPERIMENTAL STUDIES IN LONG RANGE TARGET DETECTION

Experiment 1: Target Recognition and Identification of Camouflage Patterned Armored Vehicles Against a Homogeneous Green Textured Background

In the two studies reported by Haverland and Maxey,[1] scale model olive drab armored vehicles were viewed at long range against a homogeneous medium-shade green textured background. The effects of camouflage patterns were not investigated in these studies. As a consequence, it was decided that a logical extension of this work would be a replication employing camouflaged vehicles. It was felt that a comparison of Haverland and Maxey's results with those obtained with patterned vehicles would yield information on the unique contribution of camouflage pattern to performance in recognition and identification performance.

Description of the Experiment

Experimental Design

A simple design was employed. Each observer first received a pretest, followed immediately by training, and finally, each observer received a posttest. This design is identical to that used by Haverland and Maxey in their work. Models of seven HO (1:87) scale armored vehicles were presented to the observers: M60 tank (US), M113 armored personnel carrier (US), Chieftain tank (UK), T-54 tank (USSR), ZSU 57/2 air defense system (USSR), AMX-30 tank (French), and the PT-76 armored reconnaissance vehicle (USSR). The AMX-30 tank and PT-76 ARV were used only in the posttest.

Each scale model was presented in five different views (right side, left side, right oblique, left oblique, and front) throughout the three conditions of the experiment.

Two groups of six observers each participated in the experiment. One group viewed all targets at a scaled range of 3000 meters, while the other group viewed all targets at a scaled range of 4000 meters.

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[1] E. M. Haverland and J. L. Maxey. *Problems in Helicopter Gunnery*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, May 1977 (in process).

For purposes of this study, recognition was defined as the observer's *judgment whether a vehicle was either a friendly or a threat vehicle.* Identification was defined as the observer's *naming the vehicle by type; e.g., M113 APC, PT-76, etc.* Each observer was first asked to indicate whether the vehicle was a friendly or a threat vehicle, and then to name (identify) the vehicle.

Pretest. During the Pretest condition each observer received 25 target presentations (all five targets in all five views). (See Appendix A for score sheets.) Targets were presented in blocks of five, each block containing all five target vehicles. Views were randomized within each block. The observers were unaware of the block design, as the presentation sequence was continuous. During the Pretest, the observers received no feedback regarding the correctness of their responses. The Pretest was designed to provide baseline data and evaluate the effectiveness of any previous training the observers may have received.

Training. During the Training condition each observer was given up to a maximum of 50 presentations (each vehicle presented twice in each of the five views). During Training, the observers were given feedback concerning the correctness of their responses. If a response was incorrect the observers were given the correct information. Presentations were blocked in the same manner as in the Pretest. Training was terminated when the observer correctly identified all of the targets in two successive blocks of five presentations.

After the training criterion had been reached on each observer, the experimenter examined the results to see which vehicle(s) presented the most difficulty to that observer during the Pretest and Training phases. The observer was then shown comparison views of these vehicles while the experimenter pointed out the main identifying features of each vehicle. The observer was also shown single views of any aspect angle of any vehicle which caused difficulty.

Posttest. In the Posttest the observer was initially presented with a series of 25 targets (all five targets in all five views) but in a different order than they were seen in the Pretest. No feedback was given to the observer during Posttest. At the end of the Posttest each observer received an additional series of seven target presentations--the five basic vehicles used in the Pretest and Training, plus two additional vehicles (AMX-30 and PT-76) which had not previously been shown in this experiment.

Summary of the experimental conditions. The Pretest was intended to provide a data base for the assessment of each observer's initial recognition and identification capability. The data from the Pretest was also intended to provide some insight as to the adequacy of current training programs on recognition and identification of armored vehicles at standoff ranges. The Pretest data were also intended to provide information on the effects of range, vehicle type, and vehicle view on recognition and identification performance.

The Training condition provided information about the amount of training required to achieve 100% accuracy of identification.

The Posttest served as a criterion test of final identification performance. The introduction of the two additional vehicles in the last series of seven target presentations was intended to provide information on the reactions of the observers to unfamiliar targets.

Observers. The 12 observers were officers from the Sixth US Cavalry Brigade (Air Combat) (6th ACCB), Fort Hood, Texas. All of the observers were qualified helicopter pilots, and all had received some formal training in target identification.

Simulation of the environment. Model (1:87) armored vehicles were presented to the observers at an appropriately scaled distance. The scale distances used produced visual images approximating those of full-scale vehicles as seen through the XM65 weapons sight (13X) at ranges of 3000 and 4000 meters. The calculation of the approximate scaled ranges were:

For 3000 meters, 3000 ÷ 87 = 34.48 meters (113 feet)
For 4000 meters, 4000 ÷ 87 = 45.98 meters (151 feet).

The 1:87 scale was selected for this series of experiments due to the ready availability of a wide variety of models of both threat and friendly armored vehicles. These models, even when viewed from a distance, contain considerable useful detail. Larger, more highly detailed models are available, but their use would require a much larger unobstructed space. In addition, there are fewer vehicles available in the larger scales. This lack of variety would produce a very limited target array of friendly and threat vehicles.

Camouflage patterning. The 1:87 models were painted in the summer US and European-verdant camouflage pattern. The verdant pattern features an emphasis on green to allow blending-in with trees, shrubs, and grass. The colors used and their percentage of distribution over the vehicle are as follows: forest green, 45%; light green, 45%; sand, 5%; and black, 5%. The painting was accomplished by a commercial model building firm in accordance with pattern diagrams from Army camouflage publications (see TC 5-200[2]). To the extent possible, all vehicles in the target array were painted with identical camouflage patterns.

The test site. The test site was located at the Fort Hood Army Airfield. A Cobra Attack Helicopter (AH) with an XM65 weapons sight was

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US Department of the Army. Training Circular 5-200, "Camouflage Pattern Painting," US Army Engineer School, Deputy Commadant for Combat and Training Developments, Fort Belvoir, Virginia, 28 August 1975.

made available for the research. The AH served as the observation point. The stationary AH was placed facing along a north-south axis with an unimpeded line-of-sight for over 151 feet. An Auxiliary Power Unit (APU) provided electrical power to the XM65 weapons sight. A crew chief was also assigned to provide maintenance support.

Two target presentation points were set up along the line-of-sight to the north of the AH. Thus, the sun was always at right angles to the line-of-sight. The near-target presentation point was 34.48 meters (113 feet) from the AH, corresponding to a range of 3000 meters. The far-target presentation point was 45.98 meters (151 feet), corresponding to a range of 4000 meters.

The vehicles were displayed on a platform which was placed at the target presentation point. This platform consisted of two 12 x 24 inch plywood panels joined at a right angle forming an "L" and was covered with dark forest green papier mache. One panel provided a horizontal surface on which the targets were placed, while the other panel formed a vertical background surface behind the target.

The target presentation platform was mounted on a small box which placed the platform approximately 12 to 15 inches off the ground. In effect, this placed the objective lens of the XM65 weapons sight at a scaled altitude of approximately 100 meters above the level of the targets. A Spectra illumination meter was used to measure the ambient illumination during the experiment. A field telephone was used to provide communications between the experimenters and the observer.

Order of target presentation. The target presentation sequences for this experiment were the same as those used by Haverland and Maxey.

During Pretest, a different random order of the 25 target presentations was used for each of the six observers.

During Training, each observer received two blocks of 25 target views. The target presentation sequence was prepared as follows: for the first block of 25 presentations, targets were presented in a different random orders than were used in Pretest; for the second block, the orders of presentation were reversed with the left-right aspects of the side and oblique view reversed.

In the Posttest, the observers received 25 presentation in a unique random order followed by an additional seven target presentations (5 previously seen targets and 2 "ringers"). In the final seven presentations, each of the target vehicles was shown in a randomly selected single view. The two additional "ringer" targets were inserted randomly in the presentation sequence. These two vehicles always appeared consecutively and the order of their appearance was balanced for the 3000 meters and 4000 meter presentations. The views of these "ringer" vehicles were assigned so that the views of each vehicle were balanced, as well as possible, over the 3000 meter and 4000 meter range groups. One of these orders of presentation for all three conditions is shown in Appendix A.

Conduct of the Experiment

The data for this experiment were gathered starting the second week of January 1978. Four observers were tested each day, as weather permitted, at 0900, 1000, 1300, and 1400. The experimenters met each observer at the AH. The experimenter obtained the following information from each observer: name, rank, MOS and job, unit assignment, use of corrective lenses, and asked each observer to estimate the hours of recognition/identification training he had previously received. The experimenters then read general instructions to the observer. (See Appendix B.) The observer then entered the helicopter and was familiarized, if required, with the XM65 weapons sight. The experimenter then went to the target presentation point and placed a scale model M48 tank on the target presentation platform. The observer was asked to focus the sight so that he could clearly see this target vehicle.

Following these instructions the Pretest was administered. The experimenter, following a unique target presentation list for each observer, selected the appropriate target, placed it in the middle of the target presentation platform at the proper angle, notified the observer, and started a stopwatch. The experimenter then monitored the field telephone for the observer's response. When the observer responded, or after 15 seconds, the experimenter made the appropriate entries on the target presentation list (including noting the reading on the illumination meter), presented the next target vehicle. These procedures were continued until all 25 vehicles in the Pretest presentation series had been presented. The observer was then given a short rest break.

Training followed using procedures identical to the Pretest, except that feedback was given to the observer after each target vehicle presentation. If the observer's response was correct, he was told that it was correct. If either the recognition or identification response, or both, were incorrect, the observer was given the correct information, and features of the target were pointed out that distinguished it from other similar targets. The observer's responses were recorded on the target presentation list. Presentation of target vehicles was continued until the observer had correctly identified two successive groups of five targets, or until all 50 targets had been presented. The observer was then given a second rest break. After this rest break the following instructions were read to the observer:

> We will now complete the third phase of testing. As I indicated in my introductory remarks, in this phase you will be presented with a number of targets at 3000 (or 4000) meters scale range. As before, you will observe the targets through the gunsight. When a target is presented you will have five seconds to indicate if it is a threat or a friendly target and name it correctly. If, after five seconds, you cannot do this, we will proceed to the next target. After all targets have been presented, the testing will be completed. Remember, if you cannot identify a target, tell me, "I don't know." Do you have any questions? OK, we will now begin.

The Posttest was then conducted, following the same general procedures as those used in the Pretest (no feedback was given). However, instead of 15 seconds, only five seconds were allowed for the observer to respond to each target vehicle. After the 32 target presentations were completed, the observer was given information on his recognition and identification performance. Finally, before each observer was dismissed, he was requested not to tell anyone about the details of the research procedures to avoid influencing the performance of subsequent observers.

Results

The results of this experiment are presented primarily as percentages of correct recognition and identification as achieved by the observers. Statistical analyses are presented in greater detail in Appendix C.

Derivation of Recognition and Identification Scores

Each observer received a score for each target presented for both recognition and identification--0 if incorrect and 1 if correct. Tabulation of instances when the observer could not recognize or identify the vehicle were made as a separate category. Table 3-1 illustrates the scoring scheme.

The rules for scoring recognition were relatively lenient, while rules for scoring identification were relatively strict. For example, observers often simply responded with the name of a vehicle. If the target vehicle presented was a threat vehicle, and the vehicle named by the observer was also a threat vehicle, but not the correct one, recognition was scored as correct (1), but identification was scored as incorrect (0). If the target vehicle was a friendly vehicle, but the vehicle named was a threat vehicle, recognition and identification were both scored as incorrect (0).

Table 3-1. Illustration of Recognition and Identification Scoring

Target Presented	Observer Response: Recognition Friendly/Threat	Observer Response: Identification Name of Vehicle	Scores Assigned: Recog.	Scores Assigned: Ident.	Scores Assigned: Unknown
M60 Tank (US)	Friendly	M60	1	1	--
M60 Tank	US	Don't know	1	--	0
M60 Tank	Threat	Don't know	0	--	0
M60 Tank	Don't know Can't recognize	Don't know	--	--	0
M60 Tank	-----	M60	1	1	--
M60 Tank	Friendly	Leopard	1	0	--
Chieftain (UK)	British	Don't know	1	--	0
Chieftain	Friendly	Chieftain	1	1	--
Chieftain	Threat	T-62	0	0	--
Chieftain	Don't know	Don't know	0	0	0

NOTE: If the observer responded "unknown," don't know," "I can't recognize," or "I can't remember the name," a 0 was entered in all three scoring categories.

In order for identification to be scored as correct, the observer must have correctly named the vehicle with its official Army nomenclature or a commonly used military name. Identification of the T-54 tanks as a "T-55" was accepted as correct because of the very minor observable differences between the two vehicles. However, if an M113 APC was called an "M114," the response was scored as incorrect (0).

<u>Pretest performance</u>. Table 3-2 shows the overall percentage (mean) responses for the 25 Pretest presentations.

Table 3-2. Overall Pretest Recognition and Identification Performance

	Recognition	Identification
Correct	86.3%	62.3%
Incorrect	11.3%	29.0%
Unknown	2.3%	8.7%

Recognition and identification scores were computed separately for each target range (3000 and 4000 meters). There were no significant differences in performance of observers between the two ranges. This finding confirms the results of previous studies.

The Pretest scores for this study and the Haverland and Maxey "Main Experiment" were almost identical. Correct recognition in both studies was 86% and correct identification was 61% in the Haverland and Maxey study and 62% in the current study. These results indicate that the camouflage pattern painting did not hamper the observer's recognition and identification performance, at least when seen against a homogeneous background.

Analysis of variance for the recognition and identification scores revealed a significant difference in accuracy of identification between the type of vehicle presented. A significant interaction also appeared between vehicle type and presentation view. The latter finding suggests that some vehicles are more difficult to recognize as a function of the view being presented.

Analysis of the recognition data showed an overall significant effect of vehicle view, and as was the case for the identification data, the vehicle type by view interaction was significant. Table 3-3 summarizes data for both recognition and identification by vehicle and view.

Table 3-3. Percent Correct Recognition and (Identification) During Pretest by Vehicle and View

View	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS
	Vehicle				
Side Right	91.7 (50.0)	91.7 (83.8)	83.3 (50.0)	83.3 (66.6)	83.3 (75.0)
Side Left	83.3 (50.0)	91.7 (66.6)	91.7 (41.7)	100.0 (66.6)	91.7 (58.3)
Oblique Right	91.7 (7.50)	91.7 (75.0)	91.7 (33.3)	83.3 (75.0)	66.7 (58.3)
Oblique Left	75.0 (33.3)	91.7 (91.7)	91.7 (58.3)	100.0 (83.3)	100.0 (83.3)
Front	91.7 (91.7)	75.0 (66.6)	41.7 (16.7)	67.7 (33.7)	91.7 (75.0)
TOTAL	86.7 (60.0)	88.3 (76.7)	80.0 (40.0)	86.7 (65.0)	86.7 (70.0)

Misidentifications. When observers incorrectly identified a vehicle, it was considered important to know with which other vehicle(s) it was being confused. Such information can be used to develop training programs in vehicle identification which emphasize distinctions between frequently confused pairs of vehicles. Table 3-4 shows the frequencies of the various misidentifications of the five target vehicles in the Pretest phase of the experiment. Also shown are the numbers of "unknown" (could not identify) responses. Table 3-4 shows that of the five basic vehicles, the Chieftain tank was most often misidentified, and was commonly confused with the Soviet T-62 tank. Fortunately, it was called a friendly more frequently than a threat vehicle. The most familiar vehicle should have been the US main battle tank, the M60. However, Table 3-4 shows that this vehicle was confused with a wide variety of vehicles, most commonly the French AMX-30. The Soviet T-54/55 was frequently misidentified as a Soviet T-62 tank, but was rarely confused with a friendly vehicle. All of the vehicles were misidentified a number of times.

Table 3-5 is a comparison of misidentifications observed in the present study with those found in the Haverland and Maxey study. Comparison of performance between the two studies show slight differences, but in general, misidentification performance in both experiments was essentially the same.

Table 3-6 shows the vehicle misidentifications by vehicle view. The figures indicate that no one particular view was more difficult than any other. Surprisingly, the side and oblique views were misidentified more than the front. Of the five vehicles, the Chieftain and M60 tanks were missed the most. Out of the total of 87 misidentifications, 54 mistakes were made on these two vehicles.

Table 3-7 shows the number of nonidentifications which were made. In these situations the observers could not identify the vehicles which were presented. There were 26 such instances and out of that total, 18 were concerned with either the T-54/55 tank or ZSU 57/2 ADS.

Table 3-8 gives a more detailed breakdown of the nonidentification data.

Training performance. Table 3-9 shows the percent correct for both recognition and identification trainin performance. Comparison of Table 3-9 with Table 3-2 shows that the training raised performance from Pretest Levels for both recognition and identification. However, the difference between Pretest and Training recognition scores is small.

The recognition scores obtained during Training were consistently high over all vehicles. The obtained variance was so small that it was felt that little would be added by statistical analysis of the recognition data. However, identification performance was more variable and

Table 3-4. Pretest Misidentifications by Name

Vehicle Name Given	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS
	Vehicle Displayed				
Friendly Vehicles					
AMX-30	10	--	4	--	--
Centurion	--	--	8	--	--
M114	--	2	--	--	--
Leopard	1	--	7	1	--
M48	2	--	--	--	--
American APC	--	4	--	--	--
British	--	--	2	--	--
A1	2	--	--	--	--
M60A1	--	--	--	1	1
Unknown (Friendly, but couldn't identify)	1	1	2	4	5
Threat Vehicles					
Russian 57	1	--	--	--	--
Russian 57 antiair	1	--	--	--	--
T-62	--	--	8	9	1
BRDM	--	2	--	--	--
ZSU 23/4	--	--	--	--	1
T-34	1	--	--	--	1
T-54/55	4	--	2	--	2
ZSU w/2 barrels	--	--	--	--	1
Russian ZSU	--	--	--	--	1
ZSU 57/2	--	--	--	--	1
BRM	--	4	--	--	1
Unknown (Threat, but couldn't identify)	--	1	1	4	1
Couldn't identify as either Friendly or Threat	1	--	2	2	2
TOTAL	24	14	36	21	18

Table 3-5. Comparison of Misidentifications Between Vehicles (Percent Correct), Pretest

	M60	M113	Chieftain	T-54/55	ZSU 57/2
Experiment 1	60	77	40	65	70
Haverland & Maxey Experiment	63	77	55	48	63

Table 3-6. Misidentifications During Pretest by Vehicle View

Vehicle View	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS	TOTAL
Right Side	5	2	6	3	1	17
Left Side	5	3	7	3	3	21
Right Oblique	3	3	8	2	2	18
Left Oblique	8	1	5	1	2	17
Front	1	3	6	2	2	14
TOTAL	22	12	32	11	10	87

Table 3-7. Nonidentifications by Vehicle View During Pretest Condition

Vehicle View	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS	TOTAL
Right Side	1	--	--	1	2	4
Left Side	1	--	1	1	2	5
Right Oblique	--	--	--	1	3	4
Left Oblique	--	--	--	1	--	1
Front	--	4	1	6	1	12
TOTAL	2	4	2	10	8	26

Table 3-8. Nonidentifications by Vehicle During the Pretest Condition

	M60 TANK	CHIEF TANK	M113 APC	T-54/55 TANK	ZSU 57/2 ADS	TOTAL
Friendly Vehicle	1	1	1	4	5	12
Threat Vehicle	1	1	1	4	1	8
Could not recognize as either friend or threat	--	2	--	2	2	6
TOTAL	2	4	2	10	8	26

Table 3-9. Recognition and Identification Performance During Training

	Recognition	Identification
Correct	93.5%	96.3%
Incorrect	6.2%	3.5%
Unknown	.3%	.2%

reliable differences were obtained among the target vehicles and the various presentation views. Table 3-10 summarizes the recognition and identification data by vehicle view.

Misidentifications. Tables 3-11, 3-12, and 3-13 show the misidentifications by vehicle and by view. The Chieftain was the most difficult of the five basic vehicles, with the T-54/55 running a close second. The T-54 was commonly confused with the M60 (six times). The front view caused the most difficulty in training.

Posttest performance. As expected, Posttest performance surpassed the Training performance. Table 3-14 shows the mean identification percentages across the three experimental conditions. The obtained Posttest identification performance was identical to the performance reported by Haverland and Maxey. This was also true for identification (98.6%) and recognition (99%).

The lack of variance resulting from the generally high level of performance precluded statistical analysis. Table 3-15 summarizes recognition and identification scores for the five criterion vehicles and the two unfamiliar vehicles for the five views.

Performance on the two unfamiliar vehicles. Table 3-16 shows the percentage correct and incorrect identification for the AMX-30 and PT-76. The AMX-30 was the most difficult of the two vehicles to identify. The majority of the observers incorrectly identified it as a Soviet T-54/55. Identification performance for the AMX-30 (.7%) fell below the 15% figure found by Haverland and Maxey, while the percent correct for the PT-76 was virtually the same. The PT-76 was rarely confused with friendly vehicles. In the majority of the cases it was recognized as a threat vehicle. Statistical analysis of the recognition data for these two vehicles showed the obtained differences to be statistically reliable. In addition, when compared to the other five vehicles in the array, the AMX-30 recognition score was significantly lower. This was not the case for the PT-76. Identification of the AMX-30 was significantly inferior to identification of the PT-76. The AMX-30 and PT-76 identification scores were also significantly inferior to that obtained for the remainder of the array.

Table 3-10. Percent Correct Recognition (Identification) During Training by Vehicle and View

View	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS
Side Right	100.0 (95.8)	100.0 (95.8)	100.0 (100.0)	100.0 (100.0)	95.8 (95.8)
Side Left	100.0 (100.0)	95.8 (95.8)	100.0 (95.8)	95.8 (87.5)	95.8 (91.7)
Oblique Right	100.0 (100.0)	100.0 (100.0)	100.0 (95.8)	95.8 (95.8)	100.0 (91.7)
Oblique Left	100.0 (87.5)	100.0 (100.0)	91.7 (87.5)	95.8 (95.8)	100.0 (100.0)
Front	87.5 (87.5)	100.0 (95.8)	79.2 (66.7)	83.3 (79.2)	100.0 (95.8)
TOTAL	95.8 (94.2)	99.2 (97.5)	94.2 (89.2)	94.2 (91.7)	98.3 (95.0)

Table 3-11. Misidentifications by Vehicle View During Training

VEHICLE	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS	TOTAL
Right Side	1	1	--	--	1	3
Left Side	--	1	--	3	2	6
Right Oblique	--	--	1	1	2	4
Left Oblique	3	--	3	1	--	7
Front	2	1	8	5	1	17
TOTAL	6	3	12	10	6	37

Table 3-12. Nonidentification by Vehicle View During Training

View	M60 Tank	Chieftain Tank
Left Side	--	1
Front	1	--
TOTAL	1	1

Table 3-13. Misidentifications During Training

	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS
Friendly Vehicles					
AMX-30	2	--	--	1	--
APC	--	2	--	--	--
Leopard	--	--	1	--	--
Centurion	--	--	4	--	--
Chieftain	--	--	--	--	1
M60	--	--	--	6	1
Do not know	--	--	1	--	--
Threat Vehicles					
T-54/55	4	--	3	--	1
BRM	--	1	--	--	--
T-62	--	--	4	3	--
ZSU 57/4	--	--	--	--	1
ZSU	--	--	--	--	1
ZSU 23/4	--	--	--	--	1
Do not know	1				
TOTAL	7	3	13	10	6

Table 3-14. Identification Performance for all Three Test Conditions

	Pretest	Training	Posttest
Correct	62.3%	93.5%	98.6%
Incorrect	29.0%	6.2%	1.4%
Unknown	8.7%	.3%	--

Table 3-15. Percent Correct Recognition (Identification) for the 7 Vehicles

	Vehicle						
View	M60 TANK	M113 APC	CHIEF TANK	T-54/55 TANK	ZSU 57/2 ADS	AMX-30 TANK	PT-76 ARV
Side Left	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (0.0)	100.0 (100.0)
Side Right	50.0 (50.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (0.0)	50.0 (25.0)
Oblique Right	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (50.0)	50.0 (100.0)
Oblique Left	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (50.0)	50.0 (100.0)
Front	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (0.0)	50.0 (100.3)
TOTAL	91.7 (91.7)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	100.0 (100.0)	0.0 (83.0)	60.0 (58.3)

Table 3-16. Identification Performance for the AMX-30 and PT-76

	AMX-30 (French)	PT-76 (USSR)
Correct	.7%	58.3%
Incorrect	91.7%	33.3%
Unknown	--	8.3%

Effects of illumination on recognition and identification performance. Photometric readings were taken continuously throughout each observation in the study. The data were analyzed and a correlation computed between illumination and visual identification. As in the previous experiments, there was no significant relationship between illumination level and observer performance.

Relationship of prior training to performance. The amount of previous training reported by the subjects was correlated with overall performance at the two ranges for recognition and identification. The resulting correlations (Pearson Product Moment) were +.30 and +.24, respectively, which do not differ significantly from zero.

Conclusions and Discussion: Experiment 1

- When presented against a homogeneous background, camouflage does not affect recognition and identification performance.

- Recognition and identification performance scores of nearly 100% were obtained following 20 to 25 minutes of training.

- If properly trained, AH pilots can identify armored vehicles at ranges of 3000 and 4000 meters using the XM65 weapons sight.

- The front view degrades recognition performance more than any other view.

- Accuracy of recognition and identification from a particular viewing perspective varies with the type of vehicle.

- During the Training phase the two vehicles most commonly misidentified were the Chieftain, followed by the T-54/55.

- The poor performance on the two unfamiliar vehicles probably reflects the emphasis of current training which stresses threat vehicles and places less importance on NATO vehicles or those from other friendly countries.

- The majority of the results in this study substantiate the findings of the previous work conducted by Haverland and Maxey.

Experiment 2: Target Recognition and Identification of Camouflaged Patterned Armored Vehicles Embedded in a Terrain Model

This experiment was designed to study further degradation of viewing conditions and to place the problem of recognition and identification into a environment more closely resembling the "real world." The primary objective was to determine whether AH pilots could recognize and identify camouflaged armored vehicles embedded in terrain at scaled standoff ranges. A secondary objective was to provide data concerning the usefulness of scale model simulation in the development of recognition and identification training for AH pilots and other aircrew personnel. It was also considered important to obtain data on a larger target array.

Description of the Experiment

Method

The basic experimental design was the same as used in Experiment 1. Pretest, Training, and Posttest conditions were employed. The target array was composed of 10 HO scale (1:87) armored vehicle models. The vehicles used were: Chieftain tank (UK), Saladin scout car (UK), Flakpanzer antiaircraft weapon (FRG), Marder APC (FRG), AMX-30 tank (French), M60A1 tank (US), T-54 tank (USSR), and T-62 tank (USSR). The vehicles were camouflage painted as described for Experiment 1.

Each model was displayed on a 2-foot square terrain model. The models were presented in an open space on the terrain board with a background of trees, shrubbery, and surface contours. No attempt was made to mask the vehicles. Vehicles were emplaced in the same area of terrain throughout the experiment. (See Figures 3-1, 3-2, and 3-3.)

Each observer was first asked to indicate whether the vehicle was a friendly or a threat vehicle (recognize), and then to specify the vehicle by type or give its common name (identify).

Prior to conducting this study, the experimenters viewed the models on terrain from a scaled distance of 4000 meters through the 13X optic. They found that it was extremely difficult to recognize and identify vehicles at that distance due to the small apparent size of the vehicles and a tendency for them to blend with the terrain. It was therefore decided to use scaled ranges of 3500 and 2500 meters.

Two groups of 10 observers participated in the experiment. The first group viewed all targets at a scaled range of 3500 meters, while the second group viewed all targets at a scaled range of 2500 meters.

Figure 3-1. Relationship of aircraft and model/terrain simulation at the testing site.

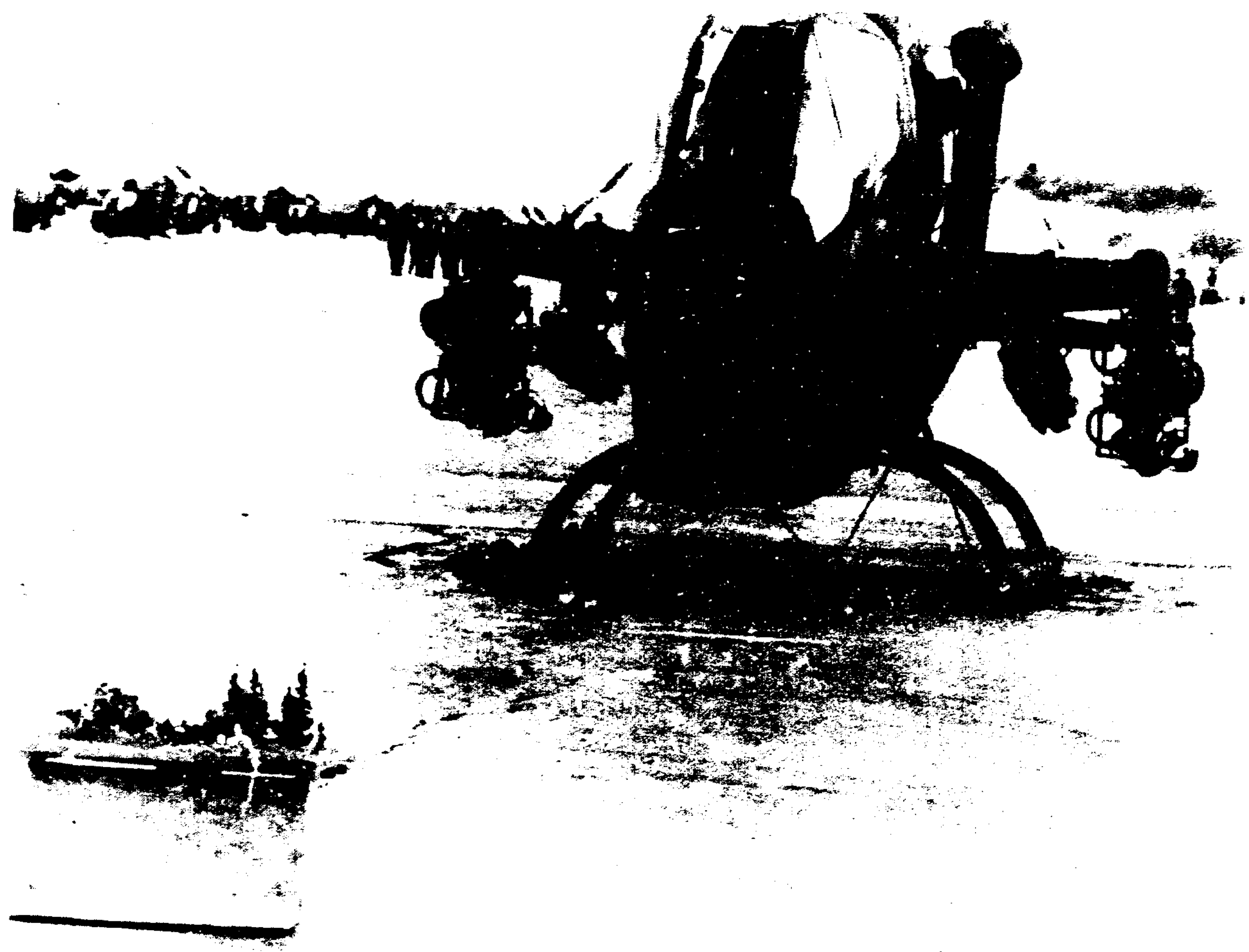

Figure 3-2. Compressed view of aircraft and terrain model locations.

Figure 3-3. Pilot/gunner observing through COBRA/TOW weapons sight.

Pretest. Fifty targets (all 10 vehicles in all 5 views) were presented to each observer. (See Appendix A for score sheets.) Targets were presented in blocks of five, each block containing five different views of the same vehicle. Orders of presentation were randomized for each block.

For the Pretest, vehicles were displayed on the same L-shaped platform used in Experiment 1. Table 3-17 shows the sequence of events as they occured during Pretest. No feedback concerning the correctness of response was given to the observers during Pretest.

Training. During Training, each observer received up to 100 presentations, with each vehicle being presented a maximum of 10 times, appearing in each of the five views twice. The vehicles were all displayed at the same place on the terrain model. Vehicles and views were randomized within each block of 10 trials. However, the presentation sequence was continuous, and the observer was unaware that the vehicles were presented in blocks. (See Appendix A for score sheets.) As in Experiment 1, the observer was given feedback after each presentation.

Training was discontinued when the observer correctly identified all of the targets in three successive blocks of 10 presentations. Few observers were able to attain this criterion.

Prior to the Posttest, a review of the vehicles was conducted. Vehicles were displayed on the L-shaped platform. The observer was allowed to view any vehicle or combination of vehicles. Main identifying features of each vehicle were pointed out and comparison views of vehicles most frequently confused by the observer were shown.

Posttest. This condition consisted of 50 target presentations. All five views of each vehicle were shown to the observer, but in a different order than in either the Pretest or Training phases. No feedback as to correctness of response was provided. Presentations were made in blocks of 10. If an observer correctly identified three successive blocks of 10, only the front views of the remaining vehicles in the randomized order were presented. Each observer was informed of his test scores and was allowed to re-view the models if he so desired.

Observers. The observers were 20 officers from the 6th ACCB, Fort Hood, Texas. All were qualified helicopter pilots, mostly in AHs, and all had received some formal training in target identification.

The terrain model. The model was approximately two feet square and was constructed by the same commercial firm which painted the tanks. The model was designed to depict Central European summer terrain. (See Figure 3-1.) The terrain was composed of wire and sand reinforced by a wooden frame. Trees and shrubbery were constructed of lichen and plastic. The model was designed to be easily portable so it could be rapidly set up and dismantled at the testing site.

Table 3-17. Sequence of Events During Pretest

1. Experimenter placed 1 of the 10 vehicles on the L-shaped platform showing 1 of the 5 different views.

2. Observer viewed vehicle then replied with 1 or more of the following responses:

   a. Friend/threat
   b. Type of vehicle (e.g., tank, scout car, assault gun)
   c. Commonly accepted name of vehicle (e.g., M60A1, Chieftain, etc.)
   d. Don't know, can't recognize or identify

3. Experimenter recorded reply.

4. Experimenter repositioned the same vehicle, now presenting a second view of the 4 remaining views possible.

5. Observer could respond with 1 or more of the responses in 2 above, or could indicate that his answer was the same as that previously stated.

6. The above procedures were followed until all 5 views of the same vehicle were shown and the observer gave his response to each of the 5 different views.

7. The vehicle was replaced with 1 of the 9 other possible modes and the same presentation/response sequence was followed.

8. This continued until all 10 vehicles had been presented to the observer.

The test site. As in Experiment 1, the test site was located at the Fort Hood Army Airfield. The stationary Cobra AH was emplaced with an unimpeded line-of-sight over the required distance. (See Figure 3-1.) Two target presentation points were set up along the line-of-sight corresponding to the required scaled distances. The observer looked (see Figure 3-3) toward a large hanger which effectively blocked the sunshine from the terrain model during the morning testing sessions. No light readings were obtained, as previous work under similar conditions had shown no relationship between illumination and vehicle recognition/identification. The L-shaped platform and terrain model were placed on a large box which was approximately 12 inches high. As in the previous study, a field telephone was set up to provide communications between the experimenters and observer.

Experimental Procedure

The data for this experiment were gathered during the month of February and the first week of March 1978. Two observers were tested each day, one at 0900 and the other at 1300. The procedures followed were basically those used in Experiment 1.

The experimenters first obtained background information from each observer, then the general instructions were read. (See Appendix B.) Following these instructions the Pretest was begun. The entire test required 2-3 hours, depending on the ability of the observer.

Results

The results of this experiment are presented in the same general fashion as those in Experiment 1. Recognition and identification scores were derived from the observers' responses by the same rules used in Experiment 1.

Pretest performance. Table 3-18 shows the overall percentage of correct responses for all Pretest presentations. Recognition and identification scores were computed separately for each target range (2500 and 3500 meters). However, no significant differences emerged in performance at the two ranges.

Recognition accuracy on this study was about the same as was found in the other studies. However, identification scores were lower in Experiment 2 than in Experiment 1.

Analysis of variance reveals reliable differences in accuracy of recognition of both vehicle types and views. However, the interaction between vehicle type and view was not significant. Differences in accuracy of identification of the vehicles was highly significant while

Table 3-18. Comparison of Recognition and Identification Performance on the Pretest, Experiment 2

	Recognition	Identification
Correct	80.4%	46.5%
Incorrect	15.4%	34.1%
Could not recognize	4.2%	
Could not identify		19.4%

significant differences were not observed for view. However, there was a significant interaction between viewing range and vehicle type. Table 3-19 gives the percentage of correct recognition and identification for all 10 vehicles in each view.

Misidentification and nonidentification. Tables 3-20 and 3-21 show the frequencies of the misidentification and nonidentification by vehicle view. In the Pretest no one particular view was more difficult than any other.

Misidentification error rates for the AMX-30 (42), the Marder (37), and Jagdpanzer (36) were the highest of the 10 vehicles in the target array. A consolidation of the misidentification and nonidentification errors appears in Table 3-22. This table indicates that observers were not extremely accurate in identifying friend and foe during the Pretest.

Table 3-23 is a confusion matrix of identification errors. It is interesting to note that the AMX-30 tank was frequently erroneously identified as a Soviet T-62 tank. Among friendly vehicles, the Leopard was frequently misidentified as a Chieftain.

Training performance. Both recognition and identification (Table 3-24) were improved by the Training. When compared to Pretest, recognition accuracy was increased by 10% and identification accuracy showed approximately a 32% increase. However, identification accuracy in this study did not approach the high levels achieved in Experiment 1. Analysis of variance was again used to assess the significance of differences in performance for vehicle type and view. For identification there were highly significant differences between vehicle type as well as view. There was too little variance in the recognition scores to permit an analysis. Table 3-25 summarizes the recognition and identification data for all 10 vehicles.

Performance, as shown in Table 3-26, tended to stabilize after 60 Training presentations. Little learning appears to be taking place after 60 presentations (each vehicle shown six times).

The rate of misidentification and nonidentification as shown in Tables 3-27 and 3-28 clearly establishes the difficulty of identifying vehicles viewed from the front. After Training, the AMX-30 remained the most difficult vehicle to identify. Training reduced the error rates for the other vehicles from those in the Pretest.

Table 3-29 consolidates the data of misidentification and nonidentification. Table 3-30 presents a confusion matrix based on error data obtained during Training. The T-54/55 and T-62 tanks were often confused with each other. The AMX-30 tank was called a Soviet T-62 27 times. This level of confusion indicates that these three vehicles create more learning problems than any other of the vehicles used in the target array.

Table 3-19. Percent Correct for the 10 Vehicles in Pretest

Vehicle	Identification	Recognition
M60	78.8	86.2
Chieftain	68.8	100.0
Leopard	43.8	93.8
AMX	32.5	48.8
Flakpanzer	35.0	76.2
Jagdpanzer	30.0	68.8
Marder	18.8	75.0
Scorpion	33.8	80.0
T-54/55	72.5	91.2
T-62	51.2	83.7

Table 3-20. Misidentifications During Pretest by Vehicle View
(Experiment 2)

VEHICLE VIEW	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Right Side	1	3	7	10	8	8	8	6	2	6	59
Left Side	4	4	6	10	8	8	7	6	3	5	61
Right Oblique	1	4	6	6	5	6	6	6	2	5	47
Left Oblique	--	6	6	6	5	8	7	6	2	5	51
Front	--	2	8	10	6	6	9	7	2	5	55
TOTAL	6	19	33	42	32	36	37	31	11	26	273

Table 3-21. Nonidentification During Pretest by Vehicle View
(Experiment 2)

VEHICLE VIEW	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Right Side	2	1	3	1	3	4	4	5	2	2	27
Left Side	2	1	2	1	2	3	5	4	2	2	24
Right Oblique	1	2	2	4	5	4	7	4	2	2	33
Left Oblique	3	1	3	4	5	4	7	5	2	2	36
Front	3	1	2	2	5	5	5	4	3	5	35
TOTAL	11	6	12	12	20	20	28	22	11	13	155

Table 3-22. Comparison of Misidentification and Nonidentification Totals During Pretest by Vehicle View (Experiment 2)

	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Misidentification	6	19	33	42	32	36	37	31	11	26	273
Non-identification	11	6	12	12	20	20	28	22	11	13	155
TOTAL	17	25	45	44	52	56	65	53	22	39	428

Table 3-23. Misidentifications During Pretest for Each Vehicle

VEHICLE NAMED	VEHICLE PRESENTED: M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Friendly											
Centurion	--	14	7	--	--	--	--	--	--	--	21
Gepard (FLAK)	--	--	--	--	--	1	2	--	--	--	3
German Tank Cannon	--	--	--	--	--	2	--	--	--	--	2
British MECH INF VH	--	--	--	--	--	--	3	--	--	--	3
British SCT VH	--	--	--	--	--	--	--	15	--	--	15
German AD/AA WPN	--	--	--	--	16	--	1	--	--	--	17
Leopard	--	--	--	4	1	1	--	1	--	--	7
AMX-30	--	5	--	--	4	2	--	--	--	--	11
ADA (AMX-30)	--	--	--	--	1	--	--	--	--	--	1
Roland	--	--	--	--	--	--	10	--	--	--	10
AMX-13	--	--	--	--	--	--	--	5	--	--	5
Swedish "S" Tank	--	--	--	--	--	8	--	--	--	--	8
M48 Tank	3	--	--	--	--	--	--	--	--	--	3
French 30	--	--	--	--	1	--	--	--	--	--	1
French 432 APC	--	--	--	--	--	--	2	--	--	--	2
Chieftain	--	--	26	--	1	--	--	--	--	--	27
M114 Recon SCT VH	--	--	--	--	--	--	1	--	--	--	1
M113 APC	--	--	--	--	--	--	1	1	--	--	2
Ferret/Fox Recon VH	--	--	--	--	--	--	--	1	--	--	1
M60 Tank	--	--	--	4	--	--	--	--	4	--	8
Saracen SCT VH	--	--	--	--	--	--	--	4	--	--	4
German APC	--	--	--	--	--	--	4	--	--	--	4
Swedish ASLT GN	--	--	--	--	--	4	--	--	--	--	4
Threat											
BTR-60	--	--	--	--	--	1	1	--	--	--	2
BMP	--	--	--	--	--	1	4	--	--	--	5
ZSU 57/2 ADS	3	--	--	--	1	--	--	--	1	--	5

Threat (cont'd)	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
USSR ASU AT	--	--	--	2	--	--	--	--	--	--	2
T54/55	--	--	--	1	--	--	--	--	--	26	27
ASU-85	--	--	--	--	--	8	--	--	--	--	8
T-62	--	--	--	22	--	--	--	--	4	--	26
ASU-122	--	--	--	--	--	4	--	--	--	--	4
Assault Gun	--	--	--	--	--	4	--	--	--	--	4
ZSU 23/4	--	--	--	--	7	--	--	--	--	--	7
BRDM	--	--	--	--	--	--	8	--	--	--	8
T-10	--	--	--	5	--	--	--	--	2	--	7
Warsaw Pact APC	--	--	--	--	--	--	--	4	--	--	4
T-72	--	--	--	4	--	--	--	--	--	--	4
TOTAL	6	19	33	42	32	36	37	31	11	26	273

Table 3-24. Recognition and Identification (Percent Correct) for Training, Experiment 2

	Recognition	Identification
Correct	90.4	77.8
Incorrect	9.6	22.2

Table 3-25. Percent Correct Recognition and (Identification) for the 10 Vehicles During Training

View	M60	CHIEF	LEO	AMX	FLAK	JAGD	MDR	SLD	T-54/55	T-62
Side Right	87.5 (81.2)	100.0 (75.0)	93.8 (37.5)	50.0 (31.2)	75.0 (31.5)	75.0 (25.0)	81.2 (25.0)	81.2 (31.2)	93.8 (75.0)	87.5 (50.0)
Side Left	75.0 (62.5)	100.0 (68.8)	93.8 (50.0)	50.0 (31.2)	75.0 (37.5)	68.8 (31.2)	81.2 (25.0)	81.2 (37.5)	87.5 (68.8)	75.0 (56.2)
Oblique Right	93.8 (87.5)	100.0 (62.5)	100.0 (50.0)	56.2 (37.5)	75.0 (37.5)	75.0 (37.5)	75.0 (18.8)	81.2 (37.5)	93.8 (75.0)	87.5 (56.2)
Oblique Left	87.5 (81.2)	100.0 (56.2)	87.5 (43.8)	50.0 (37.5)	75.0 (37.5)	62.5 (25.0)	75.0 (12.5)	81.2 (31.2)	93.8 (75.0)	87.5 (56.2)
Front	87.5 (81.2)	100.0 (81.2)	93.8 (37.5)	37.5 (25.0)	81.2 (31.2)	62.5 (31.2)	62.5 (12.5)	75.0 (31.2)	87.5 (68.8)	81.2 (37.5)
TOTAL	86.2 (78.8)	100.0 (68.8)	93.8 (43.8)	48.8 (32.5)	76.2 (35.0)	68.8 (30.0)	75.0 (18.8)	80.0 (33.8)	91.2 (72.5)	83.7 (51.2)

3-37

Table 3-26. Average Number of Mistakes Made During Training
(Each block represents 10 presentations)

Training Blocks (100 total presentations)	Mean Error Scores
1	5.2
2	3.3
3	2.6
4	2.1
5	1.9
6	1.8
7	1.5
8	1.2
9	1.5
10	1.1

Table 3-27. Total Number of Misidentifications During Training by Vehicle View

VEHICLE VIEW	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Right Side	1	3	5	10	5	2	2	1	2	6	37
Left Side	5	3	6	6	3	3	5	2	2	9	44
Right Oblique	1	4	8	9	7	4	4	3	7	7	54
Left Oblique	1	--	3	9	1	--	7	4	6	8	39
Front	5	13	15	17	2	3	10	3	17	15	100
TOTAL	13	23	37	51	18	12	28	13	34	45	274

Table 3-28. Total Number of Nonidentifications During Training by Vehicle View

VEHICLE VIEW	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Right Side	1	--	1	2	--	3	3	2	1	--	13
Left Side	4	--	1	1	3	3	--	--	--	--	12
Right Oblique	1	--	2	3	2	1	3	--	--	1	15
Left Oblique	4	--	1	1	1	2	4	1	--	1	15
Front	3	4	3	2	1	4	3	4	2	1	27
TOTAL	13	4	8	9	7	13	13	7	3	3	80

Table 3-29. Comparison of Misidentifications and Nonidentifications During Training by Vehicle View

	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Misidentification	13	23	37	51	18	12	28	13	34	45	274
Non-identification	13	4	8	9	7	13	13	7	3	3	80
TOTAL	26	27	35	60	25	25	41	20	37	48	354

Table 3-30. Number of Misidentifications by Name During Training for Each Vehicle

VEHICLE NAMED	M60 TANK	CHIEF TANK	LEO TANK	AMX TANK	FLAK AD WPN	JAGD ASLT GN	MDR APC	SLD SCT VH	T54/55 TANK	T-62 TANK	TOTAL
Friendly											
Chieftain	1	--	14	1	1	--	1	--	--	--	18
AMX-30	4	2	3	--	1	--	4	--	6	20	40
Saladin	2	--	--	1	2	1	2	--	--	--	8
Leopard	2	8	--	3	6	--	4	--	1	--	24
M60 Tank	--	3	8	6	--	--	--	--	5	5	27
Marder	--	--	1	3	2	--	--	--	--	1	7
British Recon SCT VH	--	--	--	--	--	--	--	8	--	--	8
Saracen SCT VH	--	--	--	--	--	--	--	1	--	--	1
AMX-13	--	--	--	--	--	--	--	1	--	--	1
Gepard (FLAK)	--	--	5	--	--	--	4	--	--	--	9
Centurion	--	1	2	--	--	--	--	--	--	--	3
German AD/AA GN WPN	--	--	--	--	6	--	3	--	--	--	9
Jagdpanzer	--	1	--	--	--	--	2	--	--	--	3
Roland	--	--	--	--	--	--	4	--	--	--	4
Swedish ASLT GN	--	--	--	--	--	1	--	--	--	--	1
German ASLT GN	--	--	--	--	--	6	--	--	--	--	6
Swedish "S" Tank	--	--	--	--	--	1	--	--	--	--	1
German SCT VH	--	--	--	--	--	--	1	--	--	--	1
German APC	--	--	--	--	--	--	1	--	--	--	1
Threat											
T-62	--	6	2	27	--	--	--	--	22	--	57
T54/55	2	2	1	8	--	--	--	1	--	19	33
ZSU 57/2 ADS	2	--	1	--	--	--	--	--	--	--	3
T-10	--	--	--	2	--	--	--	--	--	--	2
BMP	--	--	--	--	--	--	1	2	--	--	3
BRDM	--	--	--	--	--	--	1	--	--	--	1
ASU-85	--	--	--	--	--	2	--	--	--	--	2
Assault Gun	--	--	--	--	--	1	--	--	--	--	1
TOTAL	13	23	37	51	18	12	28	13	34	45	274

Posttest performance. Performance in both recognition and identification continued to improve during the Posttest (Table 3-31).

Table 3-31. Comparison of Recognition and Identification

	Recognition	Identification
Pretest	80.4	46.5
Training	90.4	78.8
Posttest	96.1	88.8

Although the identification performance in this study was poorer than in previous studies, it must be remembered that both the viewing conditions (camouflaged vehicles against a terrain background) and the number of vehicles was greater. Most of the misidentification were a result of confusions between the tanks. For example, the T-62 was confused eight times with the AMX-30, and six times with the T-54. The Saladin was misidentified only twice. The front view remained the most difficult.

Chapter 4

SUMMARY AND DISCUSSION OF RESULTS

The two experiments conducted in this study show that camouflaged armored vehicles can be identified at ranges of up to 4000 meters using a 13X optic. The major qualification of these findings is that the two experiments were conducted under almost ideal viewing conditions using tank models in a reduced-scale simulation. Thus, the degrading effects of atmospheric conditions did not operate in these studies. Further, the effects of sun angle and shadow were not controlled. Some of the interactions obtained in the data analyses may have been due to differences in lighting. Whether similar results would be obtained under actual field conditions remains to be determined. It remains for further research to explore the effects on target identification capability of such degrading factors as partial obscuration and different camouflage patterns.

The training methodology employed in both studies caused a marked improvement in the observers' recognition and identification abilities. Comments were made by all participants favoring this type of training over their current method of training. Existing training programs do not prepare the pilots for identifying armored vehicles which are presented in three dimensions at extended ranges. Current training emphasis is on pictorial (two-dimensional) representations. Models are used only to teach particular vehicle features and characteristics. Brigade training personnel responsible for threat training observed the studies and subsequently requested aid in converting their standard recognition and identification training program to a format similar to that used in these studies for *all* Brigade personnel.

Effectiveness of Current Training

These studies were not intended to evaluate current training programs or compare them to the experimental training. The Pretest in each experiment was intended to provide some indication of how well the observers could initially recognize and identify the target array vehicles. The Pretest also provided a baseline against which performance attained during Training and Posttest could be measured.

Prior to Training, 46% of the target vehicles were identified correctly. Recognition scores were much higher. The average Pretest score was 86% in Experiment 1 and 80% in Experiment 2. Proper evaluation of these results requires answers to a number of questions; i.e., is recognition (friend or foe) acceptable for job performance, or must the individual be able to correctly identify each vehicle he observes.

Although the training was demonstrated to be effective, it should be noted that only 5 or 10 target vehicles were used. An operational training program should involve a much larger vehicle array, and it could be expected that training on this larger array would take longer.

Even so, with careful development the training methods used in these studies should be quite effective in operational training programs. A cooperative research effort is planned between the 6th ACCB and the research staff to explore the feasibility of reduced-scale training techniques in an operational training program.

Factors Which Influence Recognition and Identification Performance

A major finding of these two experiments is that factors, such as camouflage, range, and terrain background, which were expected to affect recognition and identification performance apparently do not. For example, it might be supposed that performance would be poorer due to the addition of a camouflage pattern or that at longer ranges performance would suffer. The data did not support either of the suppositions.

Misidentifications

There was wide variation in rate of misidentification among the target vehicles. The high Pretest misidentification rates for some vehicles, such as the ZSU 57/2, Marder, Jagdpanzer, and Saladin, probably indicate that observers had had little exposure to these vehicles.

It was also apparent that unique vehicles were learned the quickest. Vehicles which were similar to other vehicles in the array were obviously the most difficult to learn. An example of this can be seen in the misidentification data for the French AMX-30 and Soviet T-62 tanks.

During the Pretest and early Training, foreign vehicles such as the Jagdpanzer or Flakpanzer, were especially hard to name. Once a unique vehicle was learned, however, it was rarely confused with any other vehicle.

The data indicate that early in the development of an operational training program, all candidate vehicles should be screened for uniqueness or commonality to other vehicles in the target array. Initial training emphasis should be on the unique vehicles, as these will be learned the quickest. Additional training should then concentrate on the vehicles with confusable characteristics.

Future research should be conducted using reduced-scale simulation, especially in the development of various camouflage patterns. Additional work is also required to study the effects of obscuration and its effect on recognition and identification performance. However, the results of reduced-scale studies should, wherever possible, be validated in a well controlled field experiment.

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APPENDIX A

Score Sheet Examples

Experiment 1, Pretest

Subject: ____________________
MOS/Job: ____________________
Unit: ____________________
Date: ____________________
Time of Day: ____________________

Weather: ____________________
Visual Acuity: ____________________
Glasses: Yes ______ No ______
Prior Recognition/Identification Experience ____________________

Run - 3000 m Range

Trial	Target	Response
1	M60-OL	______
2	ZSU57-OR	______
3	CH-SL	______
4	M113-SR	______
5	T54-F	______
6	ZSU57-SL	______
7	CH-SR	______
8	M113-F	______
9	T54-OL	______
10	M60-OR	______
11	CH-F	______
12	M113-OL	______
13	T54-OR	______
14	M60-SL	______
15	ZSU57-SR	______

4000 m Range

Trial	Target	Response
16	M113-OR	______
17	T54-SL	______
18	M60-SR	______
19	ZSU57-F	______
20	CH-OL	______
21	T54-SR	______
22	M60-F	______
23	ZSU57-OL	______
24	CH-OR	______
25	M113-SL	______

Experiment 1, Training

Trial	Target	Response	Trial	Target	Response
1	ZSU57-SL	______	26	T54-F	______
2	CH-SR	______	27	M113-SL	______
3	M113-F	______	28	CH-SR	______
4	T54-OL	______	29	ZSU57-OL	______
5	M60-OR	______	30	M60-OR	______
6	CH-F	______	31	M113-SR	______
7	M113-OL	______	32	CH-OL	______
8	T54-OR	______	33	ZSU57-OR	______
9	M60-OL	______	34	M60-F	______
10	ZSU57-SR	______	35	T54-SL	______
11	M113-OR	______	36	CH-OR	______
12	T54-SL	______	37	ZSU57-F	______
13	M60-SR	______	38	M60-SL	______
14	ZSU57-F	______	39	T54-SR	______
15	CH-OL	______	40	M113-OL	______
16	T54-SR	______	41	ZSU57-SL	______
17	M60-F	______	42	M60-SR	______
18	ZSU57-OL	______	43	T54-OL	______
19	CH-OR	______	44	M113-OR	______
20	M113-SL	______	45	CH-F	______
21	M60-OL	______	46	M60-OL	______
22	ZSU57-OR	______	47	T54-OR	______
23	CH-SL	______	48	M113-F	______
24	M113-SR	______	49	CH-SL	______
25	T54-F	______	50	ZSU57-SR	______

Experiment 1, Posttest

Trial	Target	Response
1	M113-SR	______
2	ZSU57-SL	______
3	M60-F	______
4	CH-OL	______
5	T54-OR	______
6	M60-OL	______
7	M113-F	______
8	CH-OR	______
9	T54-SL	______
10	ZSU57-SR	______
11	CH-SL	______
12	M60-OR	______
13	T54-SR	______
14	ZSU57-F	______
15	M113-OL	______
16	T54-F	______
17	CH-SR	______
18	ZSU57-OL	______
19	M113-OR	______
20	M60-SL	______
21	ZSU57-OR	______
22	T54-OL	______
23	M113-SL	______
24	M60-SR	______
25	CH-F	______
26	ZSU57-OL	______
27	M113-F	______
28	PT76-SR	______
29	AMX-OL	______
30	CH-OR	______
31	T54-SL	______
32	M60-SR	______

Experiment 2, Pretest

Subject:
Name & Rank: ____________
MOS/Job: ____________
Unit: ____________
Date: ____________
Time of Day: ____________

Weather: ____________
Glasses: Yes ___ No ___
Prior tng in recognition & identification (hours): ____________
Dominant Eye: R ___ L ___

Range: 2500 meters ___ 3500 meters ___

Trial	Target	Presentation View	
1	Chieftain	OL	______
		OR	______
		SL	______
		SR	______
		F	______
2	Jagdpanzer	SL	______
		SR	______
		F	______
		OL	______
		OR	______

Trial	Target	Presentation View	
3	Marder	F	______
		OL	______
		OR	______
		SL	______
		SR	______
4	T54/55	OR	______
		SL	______
		SR	______
		F	______
		OL	______

Pretest

Trial	Target	Presentation View		Trial	Target	Presentation View	
5	Leopard	SR	______	8	Flakpanzer	OR	______
		F	______			SL	______
		OL	______			SR	______
		OR	______			F	______
		SL	______			OL	______
6	M60A1	SL	______	9	AMX-30	SR	______
		SR	______			F	______
		F	______			OL	______
		OL	______			OR	______
		OR	______			SL	______
7	Saladin	F	______	10	Sheridan	OL	______
		OL	______			OR	______
		OR	______			SL	______
		SL	______			SR	______
		SR	______			F	______

Experiment 2, Training Sequence #1

Trial	Target	Response	Trial	Target	Response
1	AMX-SL		26	M551-OR	
2	CH-SR		27	JAGD-F	
3	LEO-F		28	FLAK-SL	
4	T54-OL		29	MDR-SR	
5	M60-OR		30	SLD-OL	
6	MDR-F		31	JAGD-SL	
7	SLD-SL		32	FLAK-SR	
8	M551-SR		33	MDR-OL	
9	JAGD-OL		34	SLD-OR	
10	FLAK-OR		35	M551-F	
11	SLD-SR		36	T54-SR	
12	M551-OL		37	M60-F	
13	JAGD-OR		38	AMX-OL	
14	FLAK-F		39	CH-OR	
15	MDR-SL		40	LEO-SL	
16	CH-F		41	M60-OL	
17	LEO-OL		42	AMX-OR	
18	T54-OR		43	CH-SL	
19	M60-SL		44	LEO-SR	
20	AMX-SR		45	T54-F	
21	LEO-OR		46	FLAK-OL	
22	T54-SL		47	MDR-OR	
23	M60-SR		48	SLD-F	
24	AMX-F		49	M551-SL	
25	CH-OL		50	JAGD-SR	

Experiment 2, Training Sequence #2

Trial	Target	Response	Trial	Target	Response
1	FLAK-OL	____	26	T54-SR	____
2	MDR-OR	____	27	M60-F	____
3	SLD-F	____	28	AMX-OL	____
4	M551-SL	____	29	CH-OR	____
5	JAGD-SR	____	30	LEO-SL	____
6	CH-F	____	31	M60-OL	____
7	LEO-OL	____	32	AMX-OR	____
8	T54-OR	____	33	CH-SL	____
9	M60-SL	____	34	LEO-SR	____
10	AMX-SR	____	35	T54-F	____
11	LEO-OR	____	36	M551-OR	____
12	T54-SL	____	37	JAGD-F	____
13	M60-SR	____	38	FLAK-SL	____
14	AMX-F	____	39	MDR-SR	____
15	CH-OL	____	40	SLD-OL	____
16	MDR-F	____	41	JAGD-SL	____
17	SLD-SL	____	42	FLAK-SR	____
18	M551-SR	____	43	MDR-OL	____
19	JAGD-OL	____	44	SLD-OR	____
20	FLAK-OR	____	45	M551-F	____
21	SLD-SR	____	46	AMX-SL	____
22	M551-OL	____	47	CH-SR	____
23	JAGD-OR	____	48	LEO-F	____
24	FLAK-F	____	49	T54-OL	____
25	MDR-SL	____	50	M60-OR	____

Experiment 2, Posttest Sequence #1

Trial	Target	Response	Trial	Target	Response
1	SLD-OR	____	26	FLAK-OL	____
2	MDR-SL	____	27	JAGD-OR	____
3	FLAK-SR	____	28	M551-SL	____
4	JAGD-F	____	29	SLD-SR	____
5	M551-OL	____	30	MDR-F	____
6	CH-F	____	31	JAGD-SL	____
7	LEO-OL	____	32	M551-SR	____
8	T54-OR	____	33	SLD-F	____
9	M60-SL	____	34	MDR-OL	____
10	AMX-SR	____	35	FLAK-OR	____
11	MDR-SR	____	36	M60-OL	____
12	FLAK-SR	____	37	AMX-OR	____
13	JAGD-OL	____	38	CH-SL	____
14	M551-OR	____	39	LEO-SR	____
15	SLD-SL	____	40	T54-F	____
16	LEO-OR	____	41	AMX-SL	____
17	T54-SL	____	42	CH-SR	____
18	M60-SR	____	43	LEO-F	____
19	AMX-F	____	44	T54-OL	____
20	CH-OL	____	45	M60-OR	____
21	T54-SR	____	46	M551-F	____
22	M60-F	____	47	SLD-OL	____
23	AMX-OL	____	48	MDR-OR	____
24	CH-OR	____	49	FLAK-SL	____
25	LEO-SL	____	50	JAGD-SR	____

APPENDIX B

Instructions to Subjects

Experiment 1

This morning's (afternoon's) testing will be conducted in three phases. During the first phase, I will show you a variety of vehicular targets at a simulated range of 3000 (or 4000) meters. Each target will be defined by a particular type of vehicle and by 1 of 5 orientation (front, side left, side right, oblique left, and oblique right view). There will be a total of 5 vehicles presented. Thus, with 5 vehicles and 5 views per vehicle, you will be shown 25 targets. After each target is presented, you should indicate if the target is a threat or a friendly vehicle. Next, you should indicate the name of the vehicle. Since in this phase of the testing I am interested in how well you can identify targets, I will not tell you if your answere are right or wrong. After all targets have been presented, this phase of the testing will be ended and there will be a short rest break.

During Phase II of the testing I will again present you with a variety of targets. These will be the same targets that you saw in Phase I of the testing. After each target presentation, you should, as before, first indicate if it is a threat or friendly target and then name it. If you cannot tell me if it is a threat or friendly vehicle, or if you cannot name the target, I will give you the correct information. Also, if you incorrectly recognize or identify the target, I will give you the correct information. In addition, you will be given an opportunity to study the targets that you did not correctly identify. You will continue this procedure for 50 trials or until you can correctly recognize and identify all of the targets in 2 successive groups of 5 targets. After this task has been completed, you will be given a 2-minute rest. Following this rest period we will begin the third phase of the testing.

During Phase III of the testing you will again be shown a variety of potential targets. There will also be 25 targets shown to you in this phase of testing. These will be the same as those you saw during the previous phase. In addition, at various times, some targets you have not seen previously may be shown to you to further test your knowledge of armored vehicles. Each target will be presented for, at most, 5 seconds. Immediately after a target has been presented, you should tell me if it is a threat or a friendly target and what its name is. After you give me your answers, we will proceed directly to the next target in the series. Since in this phase of the testing I am interested in how well you can identify targets, I will not tell you if your answers are correct or incorrect. Also, if you cannot recognize or identify a given target, you should tell me, "I don't know."

After all testing has been completed, I will tell you what percentage of targets that you correctly recognized and identified for each phase of the testing. This will provide you with an index of your target identification ability for the targets you have seen during the testing. Also, if you are interested, I will tell you which targets you missed so that you can study these at your Threat Center. One more thing. It is important that you do the best you can during the testing. While the results of this testing will be employed only for research purposes, the training that this testing will give you may be very important to you if you are ever in combat. As a consequence, by doing your best, you will benefit not only the Army in its threat recognition/ identification research, but you will also benefit yourself. Now, are there any questions about what we are going to do?

As I indicated in my introductory remarks, you will first be shown 25 targets at 1 of the 2 simulated ranges. You will view these targets through the XM65 gunsight. The physical distance at which the targets are located will simulate a 3000 (or 4000) meter range when viewed through the gunsight.

We will now begin the first phase of testing. I will present the first target. It and each additional target will be presented for, at most, 15 seconds, or until you make your response. If, after 15 seconds, you cannot correctly identify the target, I will show you the next target. This procedure will be repeated until all 25 targets have been presented. Now, do you have any questions? OK, we will now start.

Instructions to Subjects

Experiment 2

You are participating in a study designed to investigate how well air-crew personnel are able to recognize and identify camouflaged armored vehicles embedded in a terrain model while using the TSU in the 13X mode.

No attempt will be made to hide the vehicles--they will be placed in an open area and will be backgrounded against the terrain model. You will be shown both friendly (to include NATO vehicles) and threat vehicles. Five vehicle views will be shown: front, right side, right oblique, left side, and left oblique. Vehicles and views will be shown randomly. The vehicles are pattern painted in the MERDC 4-color European verdant pattern.

You will first be given a Pretest. This is designed to give us some idea of what your previous Army training has contributed to your ability to recognize and identify armored vehicles. I will not be able to tell you whether you are right or wrong during the Pretest. Next will be a Training phase, in which you will be shown all the vehicles in all their 5 different views, and you will be given as much feedback and reinforcement as possible on whether you are right or wrong. The final part of the study is a Posttest. In this phase, we will attempt to ascertain whether you have retained the ability to recognize and identify the target array. I will not be able to tell you whether you are right or wrong during the Posttest. I will allow you to examine the vehicles after the experiment is finished.

You will be able to communicate to me using field phones. After being shown each vehicle view for 10 seconds, I will ask you to first tell me whether it is a friendly or threat vehicle, then to specify what type of vehicle it is.

Before each section of the experiment is begun, I will place a model of the M113 APC on whichever background we are using so you can check the focus of your optics.

Are there any questions? If not, set up the TSU for operation and focus in on the model of the M113, which is in position on the green background.

Signal me on the field phone when you are ready.

APPENDIX C

Summary Tables of Analyses of Variance

Table C-1. Analysis of Variance of Pretest Recognition Scores

	SS	df	MS	F
SS (total)	38.947	296		
SS (groups)	.014	1	.014	.035
SS (between)	3.987	11		
SS (between error)	3.973	10	.397	
SS (within groups)	34.906	288		
SS (veh. type)	.514	4	.129	.535
SS (view)	1.780	4	.445	4.837**
SS (type x group)	.819	4	.205	.851
SS (view x group)	.286	4	.072	.783
SS (view x type)	3.486	16	.218	2.675**
SS (view x type x group)	1.715	16	.107	1.313
SS (error within)	26.360	240		
SS (error type)	9.627	40	.241	
SS (error view)	3.694	40	.092	
SS (error: view x type)	13.039	160	.082	

**$p < .01$

Table C-2. Analysis of Variance of Pretest Identification Scores

	SS	df	MS	F
SS (total)	70.680	299		
SS (groups)	1.080	1	1.080	.725
SS (between)	15.960	11		
SS (between error)	14.880	10	1.490	
SS (within groups)	54.720	288		
SS (veh. type)	4.380	4	1.095	2.951*
SS (view)	.847	4	.212	1.696
SS (type x group)	1.087	4	.272	.733
SS (view x group)	.086	4	.022	.176
SS (view x type)	4.953	16	.310	2.441**
SS (view x type x group)	3.247	16	.203	1.598
SS (error within)	40.120	240		
SS (error type)	14.853	40	.371	
SS (error view)	4.987	40	.125	
SS (error: view x type)	20.280	160	.127	

*$p < .05$
**$p < .01$

Table C-3. Analyis of Variance of Identification Scores by Vehicle (Training)

Source	SS	df	MS	F
Vehicle	5.1	4	1.275	3.03*
Error	18.5	44	.421	

*$p < .05$

Table C-4. Analysis of Variance of the Identification Scores by View (Training)

Source	SS	df	MS	F
View	11.9	4	2.975	6.26***
Error	20.9	44	.475	

***$p < .001$

Table C-5. Analysis of Variance of Pretest Recognition Scores (Experiment 2)

	SS	df	MS	F
SS (total)	126.795	799		
SS (groups)	.020	1	.020	.018
SS (between)	15.715	15		
SS (between error)	15.713	14	1.122	
SS (within groups)	111.080	784		
SS (veh. type)	17.345	9	1.927	21.222***
SS (view)	.370	4	.093	1.824
SS (type x group)	2.630	9	.292	3.216**
SS (view x group)	.055	4	.014	.272
SS (view x type)	1.330	36	.037	.829
SS (view x type x group)	1.795	36	.050	1.121
SS (error within)	87.550	686		
SS (error type)	62.287	126	.091	
SS (error view)	2.837	56	.051	
SS (error: view x type)	22.426	504	.045	

**$p < .01$
***$p < .001$

Table C-6. Analysis of Variance of Pretest Identification Scores (Experiment 2)

	SS	df	MS	F
SS (total)	199.020	799		
SS (groups)	.180	1	.180	.063
SS (between)	39.980	15		
SS (between error)	39.800	14	2.843	
SS (within groups)	159.040	784		
SS (veh. type)	30.995	9	3.444	4.785***
SS (view)	.433	4	.108	2.660*
SS (type x group)	7.745	9	.861	1.196
SS (view x group)	.132	4	.033	.813
SS (view x type)	2.217	36	.062	1.390
SS (view x type x group)	2.068	36	.057	1.278
SS (error within)	115.450	686		
SS (error type)	90.070	126	.720	
SS (error view)	2.275	56	.041	
SS (error: view x type)	22.475	504	.045	

*p < .05
***p < .001

Table C-7. Analysis of Variance of Identification Scores by Vehicle (Training, Experiment 2)

Source	SS	df	MS	F
Vehicle	92.757	9	10.306	6.00***
Error	231.743	135	1.717	

***$p < .001$

Table C-8. Analysis of Variance of Identification Scores by View (Training, Experiment 2)

Source	SS	df	MS	F
View	245.925	4	61.481	23.637***
Error	156.075	60	2.601	

***$p < .001$