Technical Report 583

LEARNING AND RECOGNITION OF U. S., SOVIET, AND PICTOGRAPHIC MILITARY SYMBOLOGY

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U. S. Army

Research Institute for the Behavioral and Social Sciences

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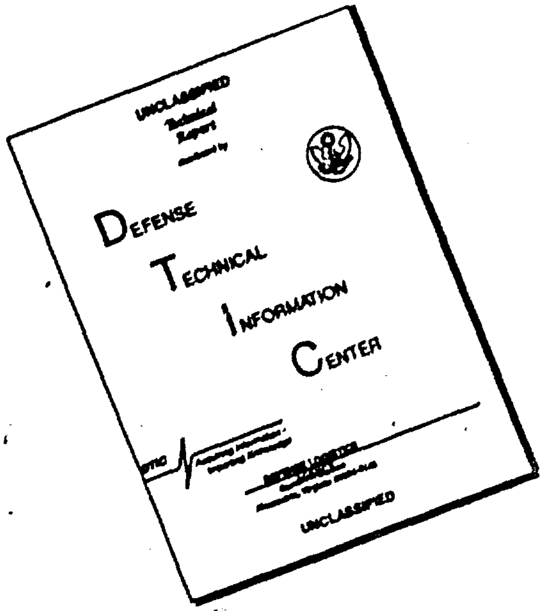

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Ability to detect and recognize military symbols under different levels of military symbol code, symbol density and trial duration was measured in terms of reaction time and accuracy. Each of 27 officer and enlisted interpreters performed three tasks designed to learn, rate the meaningfulness, and decode 19 military concepts coded into one of three military codes: U.S., Soviet, or a pictographic code developed by the Army Research Institute (ARI).

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The interpreters were divided into three groups of nine each. Each group was assigned to one of the military codes. Interpreters were first given a paired-associate learning task in which they learned the symbol-name associations for the 19 concepts. They then rated the symbols for meaningfulness along an 11-point scale. The symbol material for the decoding task was put on projector slides. A set of slides was made up for each military code. Each set was comprised of three subsets according to the number of symbols arranged randomly on a slide; either 25, 50, or 75 per slide. Twenty percent of the symbols on each slide were copies of one type called a target symbol. Each symbol in the code appeared as a target symbol on a slide. Prior to testing each group was further subdivided into three subgroups of three interpreters each. Each subgroup was assigned a trial duration for the test trials, either short, medium or long. A trial consisted of projecting a slide into a simulated CRT display presenting a randomly distributed array of different types of symbols. The decoding task was to search the display and detect and identify all target symbols present during the time interval the slide was displayed. Results indicated that symbol learning was significantly faster on the pictographic code than on either the U.S. or Soviet codes. On the decoding task overall performance was significantly better under the pictographic code, under the long and medium trial durations, and under the low symbol density level. Comparisons within codes showed that decoding performance within the U.S. and Soviet codes differed significantly as a function of the symbol being decoded; no such difference was observed under the pictographic code. Comparisons between codes showed that decoding performance under the U.S. code was significantly poorer on seven symbols than their respective counterparts in the Soviet and pictographic codes.

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LEARNING AND RECOGNITION OF U. S., SOVIET, AND PICTOGRAPHIC MILITARY SYMBOLOGY

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Battlefield Information Systems

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FOREWORD

This research is concerned with future battlefield demands for increasing the man-machine capability of acquiring, transmitting, processing, disseminating, and utilizing information. It focuses on the problems of interfacing and interacting within command and control centers.

Of special interest are human factors problems related to developing and validating new ADP compatible symbology concepts for efficient display of tactically significant information. The present research compares the relative effectiveness of conventional U.S. and Soviet codes with an experimental pictographic code developed by the Army Research Institute for the Behavioral and Social Sciences (ARI). The effort provides a fundamental part of the technology base required for assessing conventional military symbology.

Research in the area of tactical symbology is conducted as an in-house effort augmented with additional support from contracting organizations which are selected for their unique contributions to this area. This research is responsive to requirements of Army Project 2Q162717A790 and related to special requirements for the Combined Arms Combat Development Activity, Fort Leavenworth, Kansas. Special Requirements are contained in Human Resource Need 80-307, Optimizing Display of Topographic and Dynamic Battlefield Information, and 81-57 Strategy for Design and Improvement of Communications. This specific effort was conducted in cooperation with the TRADOC Combined Arms Test Activity (TCATA) test program FM 271-Tactical Operations System Applications and Software Experimentation which is managed by the Battlefield Automation Test Directorate.

JOSEPH ZEIDNER
Technical Director

LEARNING AND RECOGNITION OF U.S., SOVIET, AND PICTOGRAPHIC MILITARY SYMBOLOGY

BRIEF

REQUIREMENT:

The military intelligence community has become aware of the need to develop an improved code of military symbology for use with the new technology of automated tactical information processing systems being introduced into the Army. The purpose of this research was to collect a body of empirical data that will increase the technical information base on military symbology. The primary objective was to obtain measures of the learning and decoding characteristics of commonly used symbol elements from current U.S. and Soviet codes and from an experimental pictographic code developed by the Army Research Institute for the Behavioral and Social Sciences (ARI).

PROCEDURE:

Twenty-seven military personnel, participated as interpreters. The experiment consisted of four phases. First, all interpreters received a brief session of familiarity training on the 19 military concepts used as the code list in the study. Second, the interpreters were divided into three groups of nine each and assigned to one of the codes. They were then given a paired-associate learning task where they learned the associations between the symbols and their concept names. Test trials were alternated with study trials and performance data was recorded to determine if learning performance was related to decoding performance. Third, the interpreters rated the 19 symbols along an eleven point scale of meaningfulness (0 to 10). Fourth, the symbol decoding task was administered using three sets of projector slides (one set for each code). Each set was comprised of three subsets according to the total number of symbols arranged randomly on a slide, i.e., 25, 50, or 75 per slide. Twenty percent of the symbols on each slide were copies of one type of symbol called a target symbol. Each symbol in the code appeared as a target symbol on a slide.

Each group of nine subjects was divided into three subgroups of three each. Each subgroup was assigned to one of three trial duration conditions which were long, medium, or short trial durations. A trial was started by the experimenter announcing the name of one of the 19 symbols thereby designating it as the target symbol to search for. Then a slide was projected. The decoding task was to search the projected slide (simulated CRT symbology displays) and detect and report all target symbols present on the slide during the time interval the slide was displayed. The trials were presented in continuous succession. They were organized into three blocks of 40 trials each. Each symbol appeared twice as a target symbol in each block. Each block presented slides from one of the three subsets of slides displaying either 25, 50, or 75 symbols per slide.

FINDINGS:

In the paired-associate learning task learning was significantly faster on the ARI experimental pictographic code than on either the U.S. or Soviet codes. There was no significant difference in learning rates between the U. S. and Soviet codes. There was little variation in rate of learning among the individual symbols in the pictographic code. In contrast, there was significant variation in learning rates among the individual symbols in the U. S. and Soviet codes.

Results from the symbol recognition task indicated that overall decoding performance was significantly superior under the pictographic code than under either the U. S. or Soviet codes. There was no difference between the U. S. and Soviet codes. Decoding performance was also significantly better under the long and medium trial times compared to the short trial time, and under the low symbol density level (25 symbols per slide) in comparison to the medium (50 symbols) and high (75 symbols) densities.

None of the correlations between performance measures for the three experimental tasks were statistically significant. These results indicate that symbol learning difficulty, meaningfulness ratings, and decoding proficiency may be independent functions. Neither symbol learning difficulty nor meaningfulness level show promise as predictor variables for symbol decoding performance.

UTILIZATION:

This study has produced a substantial amount of empirical data describing the learning and decoding characteristics of a number of frequently used symbol-concept elements comprising contemporary military symbol codes. The findings provide a source of basic information for developers in graphic display technology interested in investigating and improving contemporary systems of military symbology.

LEARNING AND RECOGNITION OF U.S., SOVIET, AND

PICTOGRAPHIC MILITARY SYMBOLOGY

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INTRODUCTION

The military intelligence community has become aware that a need exists to develop an improved code of military symbology, i.e., a set of symbols used to represent military concepts, for use with tactical displays. Some users of the conventional symbology, documented in Army Field Manual FM 21-30 (1970), criticize it on the grounds that it fails to convey many essential variables of tactical information needed by the commander for making tactical decisions. Others find fault with it because it is difficult to adapt for use with electronic graphic displays which are coming into use with the new computerized command and control systems being currently deployed in the Army. These problems have led to dissatisfaction with the conventional code and a desire to replace it with alternate codes featuring more relevant symbols which are adaptable to computer graphics generation. Unfortunately, there has been very little research done on military symbology. The information transfer capacities and limitations of the conventional symbology are poorly understood. It is not known how effective the code is in terms of absolute criteria or in comparison with other military codes. There is a lack of empirical evidence available for making decisions concerning development of new codes or for retaining the present one.

BACKGROUND

Davis (1968) relates that many investigators in the area of coding research agree that the primary criterion for measuring the effectiveness of a code is how readily it can be interpreted. The amount of ease or difficulty involved in concept identification or recognition is the important factor. Howell and Fuchs (1961) specify that the most important measures of coding effectiveness are the speed and accuracy of information transmission. Speed is limited by the communication medium and coding system used and by the reaction time of the human interpreter to recognize the symbols. Accuracy is limited by the interpreter's ability to discriminate between symbols and to identify the symbol-concept associations. Both reaction time and accuracy are dependent upon a number of stimulus variables such as sensory mode, task induced stress, and number of elements in the code. However, under a given set of stimulus conditions, both reaction time and accuracy can be improved by improving the coding system. That is, if symbols contain certain characteristics that facilitate recognition performance, information can be transmitted more rapidly and accurately using them rather than other symbols which do not have these characteristics.

Although the literature contains many reports of studies that have used military symbology as stimulus material, few of them have been concerned with investigating concept recognition characteristics. A literature search disclosed only five studies that have used conventional military symbology as stimulus material for symbol interpretation tasks, and of these only four were primarily concerned with investigating basic symbols. One study dealt with using highly representative pictograms which contain much of the meaning of the concept in the graphic as compared with more abstract military symbols whose meaning must be learned by association. Two studies tested various methods of using color for coding military symbols. The last study compared the effects of conventional military and alphanumeric symbology on decision making behavior.

Howell and Fuchs (1961) conducted a series of experiments involved in developing and evaluating pictographic symbols that have high association value with population stereotypes of the concepts they represent. In one experiment ten pictographic symbols were compared with ten conventional military symbols. The comparisons included five weapon symbols, three installation symbols, and two radar symbols. The conventional symbols were taken from Field Manual FM 21-30-AFM 51-3 (1951). In order to increase the number of concepts in each code, 14 nonsense symbols were paired with concepts that appeared in only one code and were treated as a control condition. The symbols in each set were tested for concept identification under tachistoscope exposures of a single symbol for durations ranging from .015 to .21 second. The results from 20 interpreters showed that the pictographic symbols were learned significantly faster than the conventional symbols, but there were no significant differences in the capability to decode them.

Sidorsky (1977) conducted a study testing the use of color as a basic dimension of information in conventional military symbols using a simulated 19 inch CRT display. His interest was to determine if the effectiveness of color varies as a function of the order in which the information encoded by the color dimension must be decoded from the symbols. The military symbols were coded along three dimensions: unit type, size, and status; with four alternatives on each dimension. The decoding task consisted of an ordered sequence of three steps.

The first step required each of 40 interpreters to determine unit type, the second unit size, and the third unit status. Color was found to enhance decoding performance significantly only if it was used to represent the information extracted at the first level of decoding, in this case unit type where color was used in place of branch symbol. When used in this manner, latency rates were reduced by a third while accuracy was increased by seven percent. However, the results also indicated that color did not enhance decoding performance when used to encode information at either the second or third levels of decoding. It was no better than conventional military symbology or alphanumeric coding.

In a similar study, Hemingway and Kubala (1979) compared the effects of conventional military symbology with geometric symbology, coded redundantly with color, on the ability of 32 interpreters to detect changes in an updated display of a tactical situation. The geometric symbol set used the following double-cue codes to represent four types of tactical units: infantry - yellow circle, mechanized infantry - green diamond, armor - blue square, and artillery - red arrow. The conventional symbol set used the standard branch symbols for these unit types. A temporal sequence of four slides were presented depicting a changing tactical situation. The experimental task was to detect and identify changes in the presence and location of all units displayed as they occurred between updated slides. Performance measures taken were response accuracy and duration as measured from the end of the information input question to the end of the answer to the question. The results showed that differences between symbologies had no effect on accuracy performance; however, response duration was significantly faster with the double-cue, color-coded geometric symbols than with the conventional military symbology. Also, a sex difference was detected. Females were both significantly faster and less variable than males in responding to both symbol sets.

Finally, Vicino and Ringel (1965) compared decision making performance made from updated information presented either in graphic form using conventional military symbology or in alphanumeric form using a tabular format. Standard military symbols were used to represent infantry, artillery, tank, and motorized rifle units of different sizes. A temporal sequence of either 7 or 14 slides were presented depicting two rates of updating of a changing tactical situation. The experimental task was to determine in which of three sections the enemy was forming fastest for attack and which showed the most appropriate deployment of forces. The results were inconclusive. No differences in decision-making performance were found between 37 interpreters using either the military or alphanumeric symbology, nor as a function of updating rate.

Two points emerge from an assessment of the cited studies. The first is a concern with the number of code elements used in the experiments. In three of the studies only four symbols were used in the codes which were compared. The findings from these studies are, therefore, limited strictly to situations using a small symbol vocabulary. Furthermore, the small number of code elements raises doubts as to the adequacy of the task used in making the comparisons. Studies of verbal learning have established that the immediate memory capacity or span of apprehension of most people ranges from about three to seven items. Decoding tasks involving just four symbol-concept elements should be fairly easy to perform for most interpreters regardless of any differences in task difficulty c[illegible]sed by differences in the decoding quality of the codes. Real diff[illegible]s between codes could be readily obscured because the light ta[illegible]g frees the interpreter to concentrate his unused mental capacit[illegible]ating for these differences.

There is another problem stemming from using a short code list. The sample codes may not be representative of the actual codes which, in the case of FM 21-30, consists of well over a hundred basic symbols and several auxiliary symbols. The studies did use the four branch symbols that are most frequently used in tactical displays. But they did not include examples from other types of elements such as weapons, communications, or installations that are also used frequently in conjunction with branch symbols. These shortcomings were not as great in the study by Howell and Fuchs (1961) who used a total of 10 military symbols in their code lists.

The second point is that the studies indicate that color was the only stimulus variable tested which appears to enhance decoding performance over the conventional military code. Neither the pictographic, geometric, nor numeric codes seem to have improved performance under the conditions in which they were tested. Color was most potent when used in place of the basic symbol element; it enhanced both speed and accuracy of decoding when used in this mode. Its potential as an alternative coding dimension for the basic symbol element may be limited, however, since the human capacity for accurate (95 percent or better) discrimination among hues is limited; estimates range from eight to eleven (Halsey and Chapanis, 1951; Barmack and Sinaiko, 1966). Therefore, color will be used, most likely, as a supplemental code to the basic code. For example, it might be used to aggregate different types of elements belonging to the same class such as combat units versus combat support units; much in the same manner as color has been used traditionally on manual tactical displays where all friendly units are rendered in blue and enemy units in red regardless of type or other basic characteristics.

The review reveals that previous research has neglected the study of the decoding characteristics of individual basic symbol elements which comprise the vocabulary of military symbology codes. The subject is a primary consideration for study because it is a fundamental variable contributing to many of the qualities that constitute a code's functional effectiveness. It is necessary to elucidate the decoding characteristics of individual symbol elements in order to obtain an adequate functional description of the code and to create a data base from which further development can begin. The present study was undertaken in response to this need.

PURPOSE AND OBJECTIVES

The purpose of this research was to investigate the decoding characteristics of the basic symbol elements of contemporary and experimental military symbology. The effort was directed toward collecting a body of empirical data that would contribute to the technical information base on military symbology.

There were three specific objectives. One was to obtain empirical measures of the learning and decoding characterictics of individual basic symbols from conventionaal and pictographic military symbologies. A second was to elicit the measures within the context of computer-generated graphic display systems under optimal and degraded viewing conditions. A third was to compare these measures within and between symbologies. To meet these objectives, an approach was adopted that simulated some of the basic stimulus and task conditions common to computerized graphic displays.

Approach. A combination of three basic criteria define the operational utility of a set of symbols. The first is learning difficulty which determines training requirements and affects cost as well as flexibility of a language. The other two are speed of identification and accuracy of identification. They set the limits for effective communication. Learning difficulty is measured in terms of the number of trials required to achieve given standards of accuracy for individual symbols and for the set of symbols. Speed of identification is defined by measures of response latency (the interval between the onset of the stimulus and the beginning of the response). Accuracy of identification is defined in terms of frequency and type of error occurrence. The types of error possible under the conditions of this experiment are detection error: failure to detect the presence of a symbol, and confusion error: associating the wrong symbol with the designated symbol-concept element. These performance measures were used as the dependent variables in the research.

The set of symbols that was used in the study was based on selecting a sample which was representative of those used most frequently by the staff users of a specified echelon of command. It was decided to begin this line of research by using samples representative of the lowest echelon that has staff organizations dedicated to performing information transfer functions using military symbology. This occurs at the battalion level. Presumably, battalion tactical situation displays specify details down to the level of individual vehicles and crew-served weapons. The types of symbols chosen for the sample, therefore, represented combat units, and tactical weapons and vehicles.

Three other stimulus variables were tested. One was symbol codes which included two widely used conventional symbologies, FM 21-30 (1970), and the Soviet Armed Forces military symbols (1970), and one experimental pictographic symbology developed by ARI specifically for this study. These symbols were produced on the basis of composing figures featuring the unique or distinguishing characteristics of the military concept being represented. Information load and stress were the two other stimulus variables tested. They are factors affecting the quality of display conditions. Both are usually present as situational variables in military decoding operations and are known to influence interpreter performance (Howell and Fuchs, 1961). One objective of the study was to evaluate the capability of the codes to convey information under a wide range of viewing conditions, since a truly adequate code is one that is effective under all operational conditions. Information load was defined as the number of symbols displayed for decoding while time allotted for performing the decoding task was used to regulate stress level.

The experimental task required interpreters to recognize the individual members of a random distribution of a specific type of symbol when presented in displays with distributions of several other types of symbols. Measures were taken of symbol-concept learning performance and the speed and accuracy of decoding performance.

METHOD

Interpreters

Twenty-seven military personnel (22 males and 5 females) stationed at Fort Hood, Texas served as interpreters. Twenty-four were members of the 504th Military Intelligence Group (Corps), and the remaining three were from the Training and Doctrine Command Combined Arms Test Activity. Only individuals having corrected near visual acuity who were able to perceive the symbology clearly, as determined by examining the test stimuli, were permitted to serve as interpreters.

Nine demographic characteristics were obtained from each interpreter. They were sex, age, grade, Military Occupational Specialty (MOS)/Specialty Skill (SS), Time in MOS/SS, education, general technical (GT) score, symbol knowledge, and experience with military symbology.

Age. Age was defined as the interpreter's chronological age at the beginning of the experiment as measured from his last birthday. The mean age for all interpreters was 26.37 years, and the standard deviation was 6.42 years.

Grade. Grade was defined as the current military rank held by the interpreter. The group consisted of 18 enlisted personnel whose mean rank was between grades E-4 and E-5 (4.44), two warrant officers, and seven commissioned officers ranging from Second Lieutenant to Lieutenant Colonel.

MOS/SS. MOS/SS was defined as the primary MOS/SS assigned to the interpreter. Twenty-four interpreters had specialties in the area of military intelligence (MOS Series 96 and SS Series 35 and 37). Two enlisted personnel and one officer had specialties in other areas not associated with military intelligence.

Time in MOS/SS. Time in MOS/SS was defined as the time spent in the assigned primary MOS/SS up to the beginning of the experiment rounded off to the nearest month. The distribution of values for all interpreters was positively skewed producing a mean of 46.7 months, a median of 24.0 months, and a standard deviation of 55.77 months.

Education. Education was defined as the total number of years of civilian education completed. The mean for all interpreters was 13.7 years and the standard deviation was 1.91 years.

GT Score. GT score was defined as the score from the Army Classification Battery which is used as a measure of scholastic achievement. The scores are based on a normalized scale with a mean of 100 and a standard deviation of 20. The mean for all the interpreters was 119 and the standard deviation was 14.17.

Symbol Knowledge. Symbol knowledge was defined as the total number of U.S. military symbols the interpreter reported he knew the meaning of at the beginning of the experiment. The mean for all the subjects was 15.7 symbols and the standard deviation was 9.3 symbols.

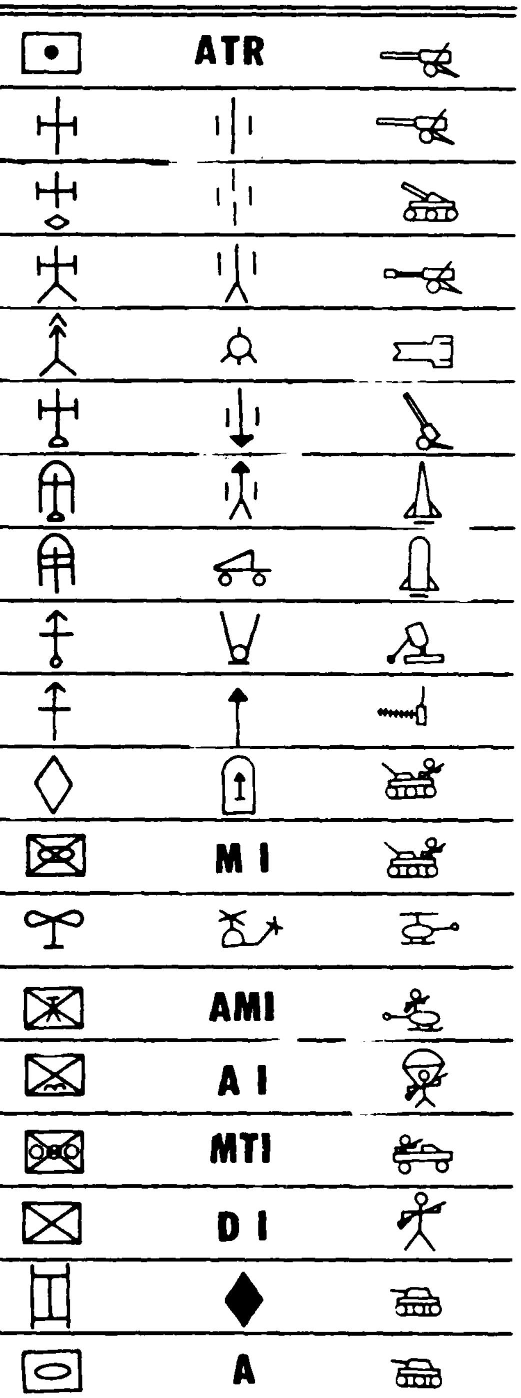
Experience with Military Symbology. Experience with military symbology was defined as the total amount of time spent in job assignments which required working with military symbology in performing task duties. The distribution of values was positively skewed. The mean for all interpreters was 20.3 months, the median was 12.0 months, and the standard deviation was 25.4 months.

Stimuli

Symbol Codes. Nineteen military concepts selected from three categories of elements were used as the code list in the experiment. The list included ten types of weapons, six types of combat units, and three types of tactical vehicles. Each concept was associated with three different symbols which represented it in three codes. One code paired the concepts with the appropriate U.S. military symbols and was called the U.S. symbol code. A second code paired the concepts with the appropriate Soviet military symbols and was called the Soviet symbol code. A third code which paired the concepts with pictographic symbols and was referred to as the ARI pictographic symbol code.

The symbols used for the U.S. and Soviet codes were based on examples from official publications (FM 21-30, 1970; U.S. Department of Defense Intelligence Agency, 1970). The pictographic symbols were developed expressly for the experiment and were designed to emphasize the main physical or functional features of the units or equipment they represented. The concepts and codes are shown in Figure 1.

A number of modifications were made to the symbol names for all codes and to the symbol elements in the Soviet code. In addition, the pictographic code included redundancy on three pairs of symbols. The official U.S. concept names for three weapon symbols were changed to obtain greater uniformity and functional description among the names in an attempt to reduce learning difficulty. Air defense gun was changed to anti-aircraft gun (the obsolete term), while surface-to-surface missile and surface-to-air missile were changed to artillery missile and anti-aircraft missile, respectively. Thus the nature of all defensive weapons in the code was indicated by the prefix "anti" and the function



CONCEPT		SYMBOL CODE		
Name	Abbreviation	US Code	Soviet Code	Pictographic Code
Artillery Unit	(Arty)		ATR	
Artillery Gun	(FA-Gun)			
Self Propelled Gun	(SP-Gun)			
Anti-Tank Gun	(AT-Gun)			
Anti-Tank Rocket	(AT-Rkt)			
Anti-Aircraft Gun	(AA-Gun)			
Anti-Aircraft Missile	(AA-MSL)			
Artillery Missile	(FA-MSL)			
Mortar	(None)			
Machine Gun	(MG)			
Armored Personnel Carrier	(APC)			
Mechanized Inf. Unit	(Mech Inf)		M I	
Helicopter	(Heli)			
Airmobile Inf. Unit	(Airmo Inf)		AMI	
Airborne Inf. Unit	(Airbrn Inf)		A I	
Motorized Inf. Unit	(Motor Inf)		MTI	
Infantry Unit	(Inf)		D I	
Tank	(None)			
Armor Unit	(Armor)		A	

FIGURE 1. The three 19-item symbol codes used in the experiment.

of each missile was described more precisely. In retrospect, these changes should not have been made since they reduced to some extent the validity of the experimental results with respect to the conventional codes. But at the time decisions had to be made for developing symbol-concept associations without prior knowledge of the amount of difficulty interpreters would encounter in learning the code. The overriding concern was that the 19-symbol code might prove too difficult for interpreters to learn and any unnecessary complications that contributed to difficulty ought to be eliminated. As it turned out, the interpreters were able to learn the codes fairly easily and the modifications were not required after all.

The alphabetical symbols used in the Soviet code were changed from Russian letters to English, but there was no change in the type of letters used. An error was made in the graphic production of the Soviet symbol for a tank. It was rendered as a solid diamond when it should have been an outlined diamond identical to the U.S. symbol for armored personnel carrier.

In the pictographic code, identical symbol figures were used for three pairs of concepts which consisted of a unit type concept paired with the characteristic weapon concept associated with it. Thus the same element was used to represent an artillery unit and a field gun. Likewise, identical figures were used for the combinations of mechanized infantry unit and armored personnel carrier, and for armor unit and tank. In the U.S. coding method, unit symbols are distinguised from other categories by placing them inside a rectangle. This practice could have been followed for distinguishing between the pictographic symbols. However, no distinction was made. The same basic symbol element served double-duty representing both unit type and associated weapon.

Slides. Projector slides were made up to present the symbol material. The slide format used a 3x4 aspect ratio for projection on a display surface similar to the proportions of a 19-inch CRT display. Projected dimensions for individual symbol images were 9/16 inch horizontally and 6/16 inch vertically. They were viewed from a distance of about 20 inches giving a visual angle of 1.6`. The slide contrast mode showed dark figures on a light background with a contrast ratio of 1:4.8. Display luminance was 831 cd/m^2. Each symbol was labeled with an identification number located near its bottoom right corner.

A set of slides was made up for each symbol code. Each set was divided into three subsets which differed in terms of the total number of symbols appearing on a slide; either 25, 50, or 75 per slide. The intent was to produce density levels of substantial difference in information load. Figure 2 presents examples of the three types of slides.

Slide A

Slide B

Slide C

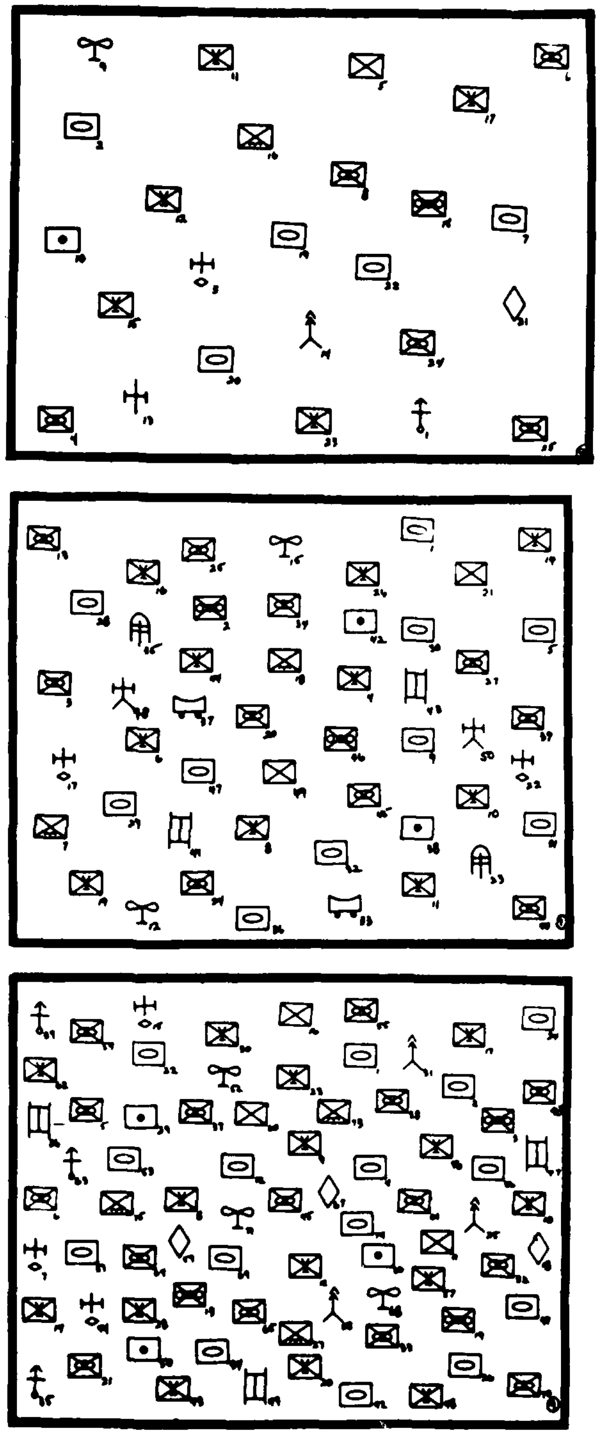


FIGURE 2. Examples of Slides with the Three Symbol Density Levels Used in the Experiment: Slide A 25 Symbols, Slide B 50 Symbols, and Slide C 75 Symbols.

Each slide contained several copies of three symbols from the code, called target symbols. They were mixed in with a few copies of a variety of other symbols from the code and parent symbology, called context symbols. Each of the three target symbols, by itself, accounted for 20 percent of the total number of symbols on the slide. Thus there were 5, 10 and 15 copies of each target symbol (or 15, 30, and 45 copies of all three target symbols) on the slides containing 25, 50, and 75 symbols respectively.

To control for the effects of learning the positions of target symbols during repeated exposures of a slide, the slides were produced in pairs; the slides in each pair differed with respect to the position location of the three types of target symbols. Each of the subsets consisted of seven pairs of slides. Six pairs contained symbol combinations for three target symbols each of which accounted for 18 of the 19 symbols comprising the code. The seventh pair of slides contained the requisite numbers of copies for the last target symbol and two other context symbols. The two slides in each pair were identical except that the symbol locations of the target symbols were exchanged with one another. During testing only one symbol was designated a target symbol on each trial. Therefore, the other two target symbols served as the main context symbols for their companion. The symbols were combined on the basis of which ones in the code were most likely to appear together on tactical displays. The aim was to devise symbol contexts that were fairly representative for each target symbol. Table 1 presents the combinations of target symbols appearing together on the same pair of slides. The approach was to group symbols according to combinations of combined arms presumed as likely to comprise contemporary tactical organizations. Thus slide pair 1 grouped the manuever elements found in armor and mechanized infantry divisions; slide pair 2 grouped types of light infantry units, and so forth. Thus each set of slides consisted of three subsets each containing seven pairs of slides. Each of the nineteen symbols of the symbol code appeared as a target symbol on two of the slides comprising a pair.

TABLE 1

Combinations of Three Target Symbols Presented
Together on One Pair of Slides

	Target Symbols		
Slide Pair	1	2	3
1	Mech Inf	Armor	Airmo Inf
2	Inf	Motor Inf	Airbrn Inf
3	Arty	Tank	APC
4	AT-Gun	FA-Gun	SP-Gun
5	AT Rkt	Mortar	MG
6	FA-MSL	AA-MSL	AA-Gun
7	Heli	-	-

Equipment

A Kodak Ektagraphic RA-960 random access slide projector was used to rear project the slide imagery onto a simulated 19-inch CRT display screen made from the cabinet of a table model commercial television set. A projection screen was built into the display window of the cabinet to register the imagery. Two devices were used to record performance events. An Esterline Angus Model A620X event recorder was used to record the time at which the experimental task was performed. The recorder had two controls; a hand-held thumb switch operated by the interpreter, and a push-button switch mounted in a control box operated by the experimenter. A Panasonic cassette audio tape recorder, Model Number RQ-413AS, was used to record verbal reports in executing the experimental task. Figure 3 shows the equipment arranged in the configuration that was used for testing with the person on the left sitting at the interpreter's station and the one on the right sitting at the experimenter's station.

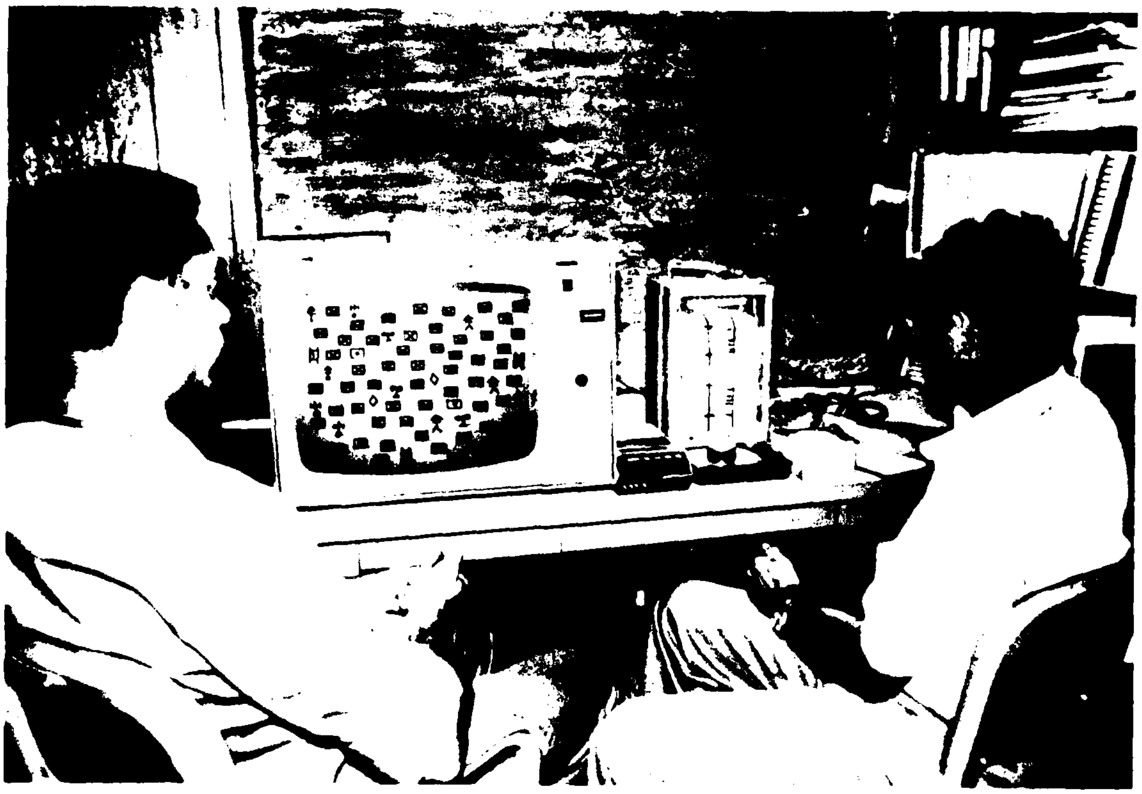


FIGURE 3. View of the Experimental Equipment Arranged for Testing

Experimental Design

Four different experimental tasks were used in this experiment. They are described in the order in which they were administered.

Concept Familiarity Task. All interpreters were given a brief session of familiarity training on the 19 military concepts comprising the code. They were shown photographs or drawings of each type of unit and weapon on the code list. The function or mission of each element was explained and its distinctive characteristics were described. The training ensured that the interpreters had an elementary knowledge of the basic characteristics and functions of the actual elements the concepts represented.

Paired-associate Learning Task. The interpreters first had to learn the associations between the symbols and their concept names to prepare them to perform the decoding task. This task also provided data for assessing the relative difficulty of learning the codes and for determining if learning performance was related in any way to decoding performance. In the learning task interpreters were given a series of trials in which test trials were alternated with learning trials. The task started with a test trial which was given without prior training. Data from this trial provided information of the interpreter's current knowledge of the code, especially with respect to the U.S. symbol code. Interpreters were instructed to guess the name of the symbols if they did not already know them from previous experience. They were shown each symbol, printed on an index card, for about two seconds and told to respond with its name within the next few seconds. Immediately following his response the interpreter was told if it was correct or incorrect. The procedure was repeated for all 19 symbols in the code list.

The first learning trial immediately followed the end of the first test trial. The interpreter was provided with two sets of cards. One set had the symbol and its name printed on the same side while the second set had the symbol on one side and its name on the back side. The interpreters were given two minutes to study the cards in any way they chose and were then tested again on the total list. On test trials the symbol cards were presented in random order. Before each learning trial began interpreters were given an accounting of all the symbols they named whether correctly or incorrectly on the test trial just completed. This helped them to use their learning time more efficiently. Testing and learning trials were repeated until the interpreter had named all 19 symbols correctly on three consecutive test trials.

Rating Task. A rating task was included to obtain estimates of the inherent meaning the symbols possessed with respect to their concept names. The data would provide measures of the relative meaningfulness of the symbols in the three codes and a means of deciding if symbol characteristics influence code learning and decoding performance.

In the rating task interpreters were required to rate the 19 symbols along a scale of meaningfulness. They were given a score sheet which contained an 11-point scale ranging from 0 to 10. Three numbers, 0, 5, and 10, were labelled with descriptive terms. The label for 0 read: No meaning (like a circle or square). The label for 5 read: Partial meaning. The label for 10 read: Exact meaning (like a photo of a thing). Located below the scale was the list of symbol names. The interpreters were given the cards with the military symbols on one side and their names on the other to use for the task. They compared each name on the score sheet with the appropriate symbol on the cards, referred to the rating scale, selected a scale value and entered it next to the name on the score sheet. They repeated the procedure for the 19 names on the list.

Symbol Recognition Task. The stimulus slides were used as the display material for the symbol recognition task. A trial was started by the experimenter reading aloud the name of one of the 19 symbols thereby designating it as the target symbol to search for during the trial. About a second later he presented one of the two slides showing several copies of the target symbol. The interpreter's task was to attempt to recognize and report all the target symbols present on the slide during the time interval the slide was displayed. When an interpreter detected a target symbol he responded by first depressing the hand-held thumb switch to indicate the time of detection. He then called out the symbol identification number to designate the particular symbol he had recognized. The interpreter then continued the search for other target symbols and repeated the response procedure every time he detected one. He continued to search for target symbols until he was sure he had detected all of them or until the trial time had expired, which was signified by the slide disappearing from view. The trials were presented in continuous succession separated by an intertrial interval of about five seconds.

The test trials were organized into three blocks of 40 trials each. Each symbol appeared twice as a target symbol in each block; once with each slide in the slide pair. The first two trials in each block were used as practice trials. Presentation of target symbols was ordered semi-randomly with each symbol occurring once during trials 3 to 22 and once during trials 23 to 40. Each block of trials presented slides from one of the three subsets of slides displaying either 25, 50, or 75 symbols per slide.

Test Conditions. The interpreters were semi-randomly divided into three groups on the basis of maintaining equivalence between groups in sex proportions, GT scores, and number of officers. Each group was assigned one of the three military symbol codes for learning and testing. Each group was further divided into three subgroups and assigned one of three trial durations for the decoding task. They were presented with all three levels of symbol density on the stimulus slides. Thus there were five independent variables: symbol codes at three levels, trial durations at three levels, symbol density at three levels, concept at 19 levels, and trial replication at two levels. The experimental design was a 3x3x3x19x2 factorial with repeated measures on the last three factors with three interpreters serving in each of the nine between-subjects treatment conditons. A block diagram of the experimental conditions is presented in Table 2.

TABLE 2

Experimental Conditions

Symbol Code	Trial Duration	Interpreter Number	Symbol density (Symbols per slide) 25 Symbols 1-19	50 Symbols 1-19	75 Symbols 1-19
U.S.	Long	1 2 3	38 Trials 38 Trials 38 Trials	38 Trials 38 Trials 38 Trials	38 Trials 38 Trials 38 Trials
	Medium	4 5 6			
	Short	7 8 9			
Soviet	Long	10 11 12			
	Medium	13 14 15			
	Short	16 17 18			
Pictographic	Long	19 20 21			
	Medium	22 23 24			
	Short	25 26 27			

Trial duration was varied relative to the symbol density levels to make available a constant proportion of time for processing the information load. For example, the long trial duration for the low, medium, and high symbol density levels was 8, 15, and 23 seconds respectively. In order to process all the symbols presented under the three conditions, interpreters had to perform the recognition task at a minimum rate of about three symbols per second. Likewise, the intervals for the medium trial durations were 6.5, 12.5 and 19 seconds requiring a recognition rate of four symbols per second; while the intervals for the short trial durations were 5, 10, and 15 seconds requiring a recognition rate of five symbols per second.

Task Order. All interpreters were tested individually, and one order of tasking was used for testing. The interpreters began their participation in the study by first providing demographic data requested on a demographic data questionnaire. It required about five minutes to fill out. They were then given the concept familiarity task which took about 15 minutes. Immediately afterward they were given the paired-associated learning task followed by the rating task. The former required about a half-hour to administer while the latter took from about five to ten minutes. Following completion of the rating task interpreters were given the symbol recognition task which required about an hour to complete. For all, it took about two hours to run each interpreter through all the experimental tasks.

RESULTS AND DISCUSSION

Paired-Associate Learning Task

The learning data were analyzed using a two-factor analysis of variance with symbol codes and concept as the main effects with repeated measures on the concept factor.[1] The results of the analysis indicated that code, $F(2,24) = 10.94$, $p<.001$, concept $F(18,432) = 7.71$, $p<.001$, and code x concept interaction, $F(36,432) = 2.33$, $p<.01$, to be significant. The Scheffe Multiple Comparisons Test (S) (Winer, 1971) was used to make tests of comparisons among the set of means related to each significant effect. Comparisons between the means for the code factor revealed that the mean for the pictographic code was significantly smaller than the means for the U.S. and Soviet codes. The results are presented in Table 3. The learning curves for the three code groups are plotted in Figure 4. The curves describe the learning process in terms of the mean number of trials required by each group to learn the correct symbol-concept association for a successive criteria (number) of symbols. The curves show graphically that learning occured more rapidly on the pictographic code than on the U.S. and Soviet codes. This finding is in agreement with those of Howell and Fuchs (1961).

[1] The major statistical analyses reported in this study were performed by means of computer programs from: Dixon (ED.), W. J. BMDP-77 Biomedical Computer Programs P-Series. University of California Press, Berkeley, 1977.

TABLE 3

Code Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Learning Task

	Symbol Code		
	Pictographic	U.S.	Soviet
Mean Trials	1.64	2.69	2.95

1. S.01 =0.99. This statistic specifies that the Scheffe critical value required for a significant difference between any two means must equal or exceed 0.99 at the .01 level of confidence.

2. Any two treatment means not underscored by the same line are significantly different, $p<.01$.

An important factor that contributed strongly to the difference in learning rates between codes was the ability of respondents to correctly determine the name (concept) of many pictographic symbols before they had experienced any paired-associate training on them. Table 4 (a) presents a frequency tabulation of the correct number of responses made to the symbols under each code on the first test trial in the learning session which preceded the first learning trial. Two chi-square test were conducted to determine significant differences in frequency rates between code groups. The results indicated that there were significantly more correct responses made to the pictographic symbols than to either the U.S. ($X^2 = 19.64$, $p < .001$) or the Soviet symbols ($X^2 = 55.17$, $p < .001$).

The apparent difference between the U.S. and Soviet codes was due to the interpreters' familiarity with four U.S. symbols: Artillery, Infantry, Mechanized Infantry, and Armor. This inference of familiarity is made on the basis that the majority of correct responses to the U.S. code, 60 percent, were concentrated on these symbols. When the data from the four symbols were removed from the comparison, Table 4 (b), the difference is virtually eliminated. In contrast, it is interesting to note the distribution of correct responses to the pictographic symbols. Over half, 57%, the responses to the pictographic figures on the first test trial were correct. They were distributed unevenly across the symbol set ranging from 0 to 9. This evidence seems to indicate that inherent symbol meaningfulness varied among the symbols in the code.

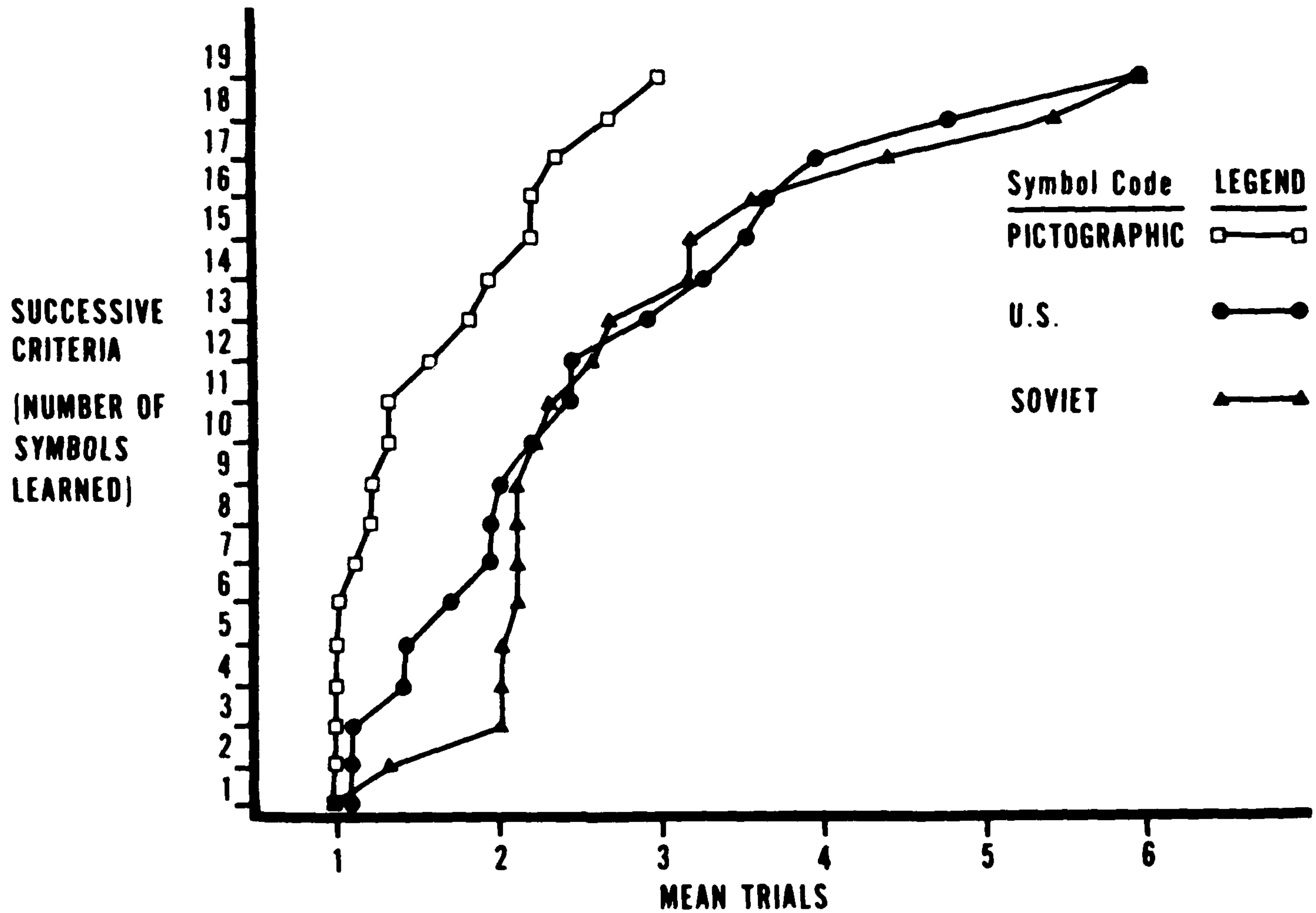


Figure 4. Learning Curves For The Three Symbol Code Groups.

The results of the comparisons between the means for the concept effect are presented in Table 5. They show that the Helicopter symbol type was learned more rapidly than the symbols for FA-Gun, AT-Gun, AA-Gun, and FA-MSL.

The means for the code x concept interaction are plotted in Figure 5. They are ordered along a scale indicating the mean number of trials required to learn the correct symbol-concept association for each concept The plots show clearly that there was little variation in rate of learning among the symbols in the pictographic code in comparison with the U.S. and Soviet codes. All the symbols in the former code were learned rather quickly. Multiple comparisons tests for differences between means among all pairs of pictographic symbols revealed no significant differences. In contrast, there was significant variation in learning rates for symbol-concepts in the U.S. and Soviet codes. The results of tests for differences between all pairs of means within these codes are presented in Table 6 and 7. They indicated a total of 36 significant differences between the means in the U.S. code and 45 in the Soviet code.

TABLE 4

Frequencies of Correct Responses to Individual Concept Types on the First Test Trial of the Learning Session (which preceded the first learning trial)

Concept		U.S.	Soviet	Pictographic
Arty		8	2	4
FA-Gun		2	3	4
SP-Gun		2	0	5
AT-Gun		0	0	4
AT-Rkt		0	0	0
AA-Gun		0	0	3
AA-Msl		0	0	7
FA-Msl		0	0	5
Mortar		1	1	5
MG		0	1	3
APC		0	1	4
Mech Inf		6	0	4
Heli		4	6	8
Airmo Inf		3	0	5
Airbrn Inf		4	1	9
Motor Inf		4	0	5
Inf		8	0	8
Tank		1	1	8
Armor		5	2	7
(a) All symbols in the code	Frequency	45	18	98
	Percent	26%	11%	57%
(b) Less Arty, Inf, Mech Inf and Armor symbols	Frequency	18	14	75
	Percent	13%	10%	56%

TABLE 5

Concept Main Effect. Results of the Multiple Comparisons Test
Between Treatment Means on the Learning Task

Concept	Mean	Heli 1.33	Inf 1.48	Tank 1.81	Armor 1.96	Arty 2.04	Mech Inf 2.11	APC 2.15	Mortar 2.19	SP-Gun 2.26	MG 2.33	Motor Inf 2.37	Airbrn Inf 2.41	Airmo Inf 2.44	AA-MSL 3.00	AT-RKT 3.11	FA-Gun 3.22	AT-Gun 3.22	AA-Gun 3.33	FA-MSL 3.33
Heli	1.33																X	X	X	X
Inf	1.48																			
Tank	1.81																			
Armor	1.96																			
Arty	2.04																			
Mech Inf	2.11																			
APC	2.15																			
Mortar	2.19																			
SP-Gun	2.26																			
MG	2.33																			
Motor Inf	2.37																			
Airbrn Inf	2.41																			
Airmo Inf	2.44																			
AA-MSL	3.00																			
AT-RKT	3.11																			
FA-Gun	3.22																			
AT-Gun	3.22																			
AA-Gun	3.33																			
FA-MSL	3.33																			

1. S .01 = 1.87
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

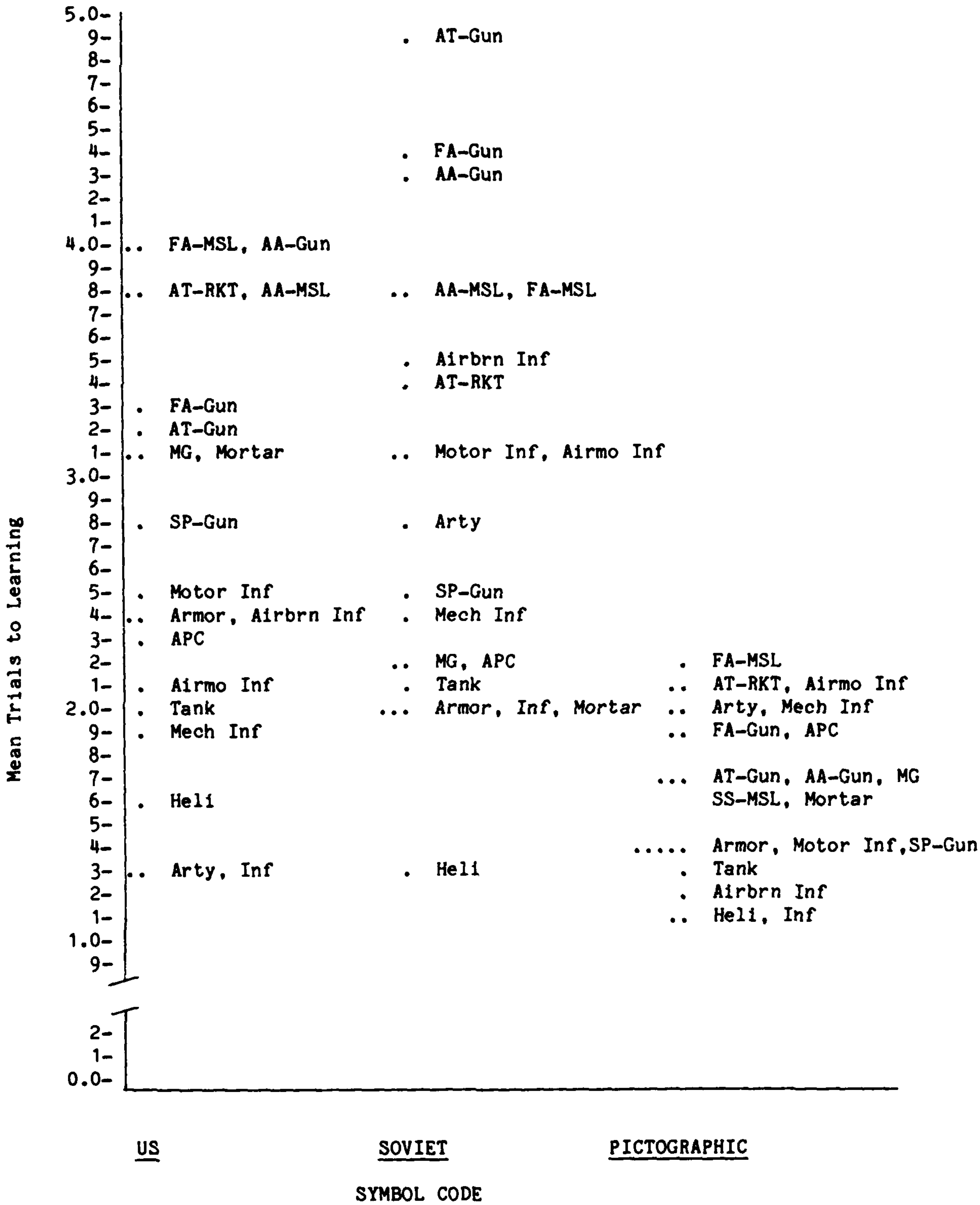


Figure 5. Mean Trials to Learn Individual Symbol Types In the Three Symbol Codes.

TABLE 6

Code x Concept Interaction: US Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Learning Task

Concept	Mean	Arty 1.33	Inf 1.33	Heli 1.56	Mech Inf 1.89	Tank 2.00	Airmo Inf 2.11	APC 2.33	Armor 2.44	Airbrn Inf 2.44	Motor Inf 2.55	SP-Gun 2.78	MG 3.11	Mortar 3.11	AT-Gun 3.22	FA-Gun 3.33	AT-RKT 3.78	AA-MSL 3.78	FA-MSL 4.00	AA-Gun 4.00
Arty	1.33												X	X	X	X	X	X	X	X
Inf	1.33												X	X	X	X	X	X	X	X
Heli	1.56														X	X	X	X	X	X
Mech Inf	1.89																X	X	X	X
Tank	2.00																X	X	X	X
Airmo Inf	2.11																X	X	X	X
APC	2.33																		X	X
Armor	2.44																			
Airbrn Inf	2.44																			
Motor Inf	2.55																			
SP-Gun	2.78																			
MG	3.11																			
Mortar	3.11																			
AT-Gun	3.22																			
FA-Gun	3.33																			
AT-RKT	3.78																			
AA-MSL	3.78																			
FA-MSL	4.00																			
AA-Gun	4.00																			

1. S .01 = 1.65
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 7

Code x Concept Interaction: Soviet Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Learning Task

Concept	Mean	Heli 1.33	Armor 2.00	Inf 2.00	Mortar 2.00	Tank 2.11	MG 2.22	APC 2.22	Mech Inf 2.44	SP-Gun 2.55	Arty 2.78	Motor Inf 3.11	Airmo Inf 3.11	AT-RKT 3.44	Airbrn Inf 3.55	AA-MSL 3.77	FA-MSL 3.77	AA-Gun 4.33	FA-Gun 4.44	AT-Gun 4.78
Heli	1.33											X[2]	X	X	X	X	X	X	X	X
Armor	2.00															X	X	X	X	X
Inf	2.00															X	X	X	X	X
Mortar	2.00															X	X	X	X	X
Tank	2.11															X	X	X	X	X
MG	2.22																	X	X	X
APC	2.22																	X	X	X
Mech Inf	2.44																	X	X	X
SP-Gun	2.55																	X	X	X
Arty	2.78																		X	X
Motor Inf	3.11																			X
Airmo Inf	3.11																			X
AT-RKT	3.44																			
Airbrn Inf	3.55																			
AA-MSL	3.77																			
FA-MSL	3.77																			
AA-Gun	4.33																			
FA-Gun	4.44																			
AT-Gun	4.78																			

1. S .01 = 1.65
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

One other point concerning the means for the U.S. code requires clarification. It appears as though the symbols for artillery and infantry were learned quite rapidly. However, this is not a correct interpretation, because eight of the nine subjects were already familiar with them and correctly named them on the first test trial which preceded the first learning trial; see Table 4. Discounting performance on these two symbols eliminates much of the difference in the distribution of scores between the U.S. and Soviet codes.

The code x concept interaction was analyzed by conducting comparison tests of differences between pairs of means from the different codes on the same concept. The tests revealed there were significant differences between pictographic and U.S. codes on eight concepts, between pictographic and Soviet codes on seven concepts, and between U.S. and Soviet codes on two concepts. These differences are presented in Table 8. Examination of the mean differences in Table 8 revealed that learning was more rapid under the pictographic code on 10 concepts compared with the learning rates under either the U.S. or Soviet codes for these concepts.

TABLE 8

Code x Concept Interaction: Results of the Between-Code Multiple Comparisons Test Between Treatment Means on the Learning Task.

	Mean Trials to Learn		
Concept	Pictographic Code	U.S. Code	Soviet Code
AA-MSL	1.44	3.78	-[3]
Mortar	1.44	3.11	-
AT-Gun	1.67	-	4.78
AA-Gun	1.67	4.00	4.33
FA-Gun	1.89	-	4.44
AT-RKT	2.11	3.78	-
FA-MSL	2.22	4.00	-
Airbrn Inf	1.22	-	3.55
Motorized Inf	1.44	-	3.11
AA-MSL	1.44	3.77	3.77

1. S .01 = 1.65
2. Any two treatment means not underscored by the same line are significantly different, $p < .01$.
3. Cells in which no mean scores are entered indicate that the mean did not differ significantly from the other means in the row.

Rating Task

The rating data were analyzed with a two-factor analysis of variance with symbol code and concept as the main effects with repeated measures on the concept effect. Results of the analysis of variance revealed the effects of concept, $F(18, 432) = 9.59$, $p<.001$, and code x concept, $F(36, 432) = 1.71$, $p<.01$, to be significant.

The results of the comparisons between the means for the concept effect are presented in Table 9. They indicate that the mean rating for the helicopter symbol type was significantly higher than the mean ratings of the symbols for MG, AT-RKT, APC, and AT-Gun.

The code x concept interaction was analyzed for differences between symbols within each code and between codes on each symbol. The results of tests for differences between mean symbol ratings within codes are presented in Table 10, 11, and 12. Table 10 shows 39 significant differences between the means for the U.S. code. Table 11 shows 29 significant differences between the means for the Soviet code. Table 12 shows 43 significant differences between the means for the pictographic code.

Table 13 presents a summary of the results of comparisons between pairs of means from the three codes on the same concept. On six concepts the ratings for the pictographic code were significantly higher than their counterparts for the U.S. code. There were no significant differences in mean ratings between codes on the remaining 13 concepts.

TABLE 9

Concept Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Rating Task

Concept	Mean	MG 4.59	AT-RKT 4.70	APC 4.89	AT-Gun 5.15	Mortar 5.85	AA-Gun 5.89	FA-Gun 6.04	AA-MSL 6.15	SP-Gun 6.22	FA-MSL 6.26	Airmo Inf 6.74	Motor Inf 7.11	Mech Inf 7.15	Arty 7.19	Tank 7.22	Airbrn Inf 7.74	Inf 7.81	Armor 7.93	Heli 9.11
MG	4.59																			X[2]
AT-RKT	4.70																			X
APC	4.89																			X
AT-Gun	5.15																			X
Mortar	4.85																			
AA-Gun	5.89																			
FA-Gun	6.04																			
AA-MSL	6.15																			
SP-Gun	6.22																			
FA-MSL	6.26																			
Airmo Inf	6.74																			
Motor Inf	7.11																			
Mech Inf	7.15																			
Arty	7.19																			
Tank	7.22																			
Airbrn Inf	7.74																			
Inf	7.81																			
Armor	7.93																			
Heli	9.11																			

1. S .01 = 3.79
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 10

Code x Concept Interaction: US Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Rating Task

Concept	Mean	MG 2.89	APC 2.89	AT-Gun 3.67	Airmo Inf 3.67	Mortar 4.22	AA-Gun 4.44	AT-RKT 4.56	Motor Inf 4.89	AA-MSL 5.11	FA-Gun 5.33	FA-MSL 5.44	Tank 5.56	SP-Gun 5.56	Inf 5.78	Mech Inf 6.22	Airbrn Inf 6.22	Arty 7.33	Armor 7.44	Heli 7.55
MG	2.89											X	X	X	X	X	X	X	X	X
APC	2.89											X	X	X	X	X	X	X	X	X
AT-Gun	3.67															X	X	X	X	X
Airmo Inf	3.67															X	X	X	X	X
Mortar	4.22																	X	X	X
AA-Gun	4.44																	X	X	X
AT-RKT	4.56																	X	X	X
Motor Inf	4.89																		X	X
AA-MSL	5.11																			
FA-Gun	5.33																			
FA-MSL	5.44																			
Tank	5.56																			
SP-Gun	5.56																			
Inf	5.78																			
Mech Inf	6.22																			
Airbrn Inf	6.22																			
Arty	7.33																			
Armor	7.44																			
Heli	7.55																			

1. S .01 = 2.47
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 11

Code x Concept Interaction: Soviet Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Rating Task

Concept	Mean	AT-RKT 4.00	APC 4.78	SP-Gun 5.44	AA-MSL 5.89	AT-Gun 6.00	AA-Gun 6.00	MG 6.33	Mortar 6.44	FA-Gun 6.44	Tank 6.89	FA-MSL 7.00	Arty 7.22	Airbrn Inf 7.44	Mech Inf 7.67	Motor Inf 7.67	Airmo Inf 7.78	Armor 7.89	Inf 8.00	Heli 10.00
AT-RKT	4.00										X[2]	X	X	X	X	X	X	X	X	X
APC	4.78													X	X	X	X	X	X	X
SP-Gun	5.44																	X	X	X
AA-MSL	5.89																			X
AT-Gun	6.00																			X
AA-Gun	6.00																			X
MG	6.33																			X
Mortar	6.44																			X
FA-Gun	6.44																			X
Tank	6.89																			X
FA-MSL	7.00																			X
Arty	7.22																			X
Airbrn Inf	7.44																			X
Mech Inf	7.67																			
Motor Inf	7.67																			
Airmo Inf	7.78																			
Armor	7.89																			
Inf	8.00																			
Heli	10.00																			

1. S .01 = 2.47
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 12

Code x Concept Interaction: Pictographic Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Rating Task

Concept	Mean	MG 4.56	AT-RKT 5.56	AT-Gun 5.78	FA-MSL 6.33	FA-Gun 6.33	Mortar 6.89	APC 7.00	Arty 7.00	AA-Gun 7.22	AA-MSL 7.44	Mech Inf 7.56	SP-Gun 7.67	Armor 8.44	Motor Inf 8.78	Airmo Inf 8.78	Tank 9.22	Airbrn Inf 9.56	Inf 9.67	Heli 9.78
MG	4.56									X[2]	X	X	X	X	X	X	X	X	X	X
AT-RKT	5.56													X	X	X	X	X	X	X
AT-Gun	5.78													X	X	X	X	X	X	X
FA-MSL	6.33																X	X	X	X
FA-Gun	6.33																X	X	X	X
Mortar	6.89																	X	X	X
APC	7.00																	X	X	X
Arty	7.00																	X	X	X
AA-Gun	7.22																			X
AA-MSL	7.44																			
Mech Inf	7.56																			
SP-Gun	7.67																			
Armor	8.44																			
Motor Inf	8.78																			
Airmo Inf	8.78																			
Tank	9.22																			
Airbrn Inf	9.56																			
Inf	9.67																			
Heli	9.78																			

1. S .01 = 2.47
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 13

Code x Concept Interaction: Between Codes Comparison Results of the Mulitple Comparisons Test of Treatment Means on the Rating Task.

	MEAN RATING SCORES		
Symbol Type	Pictographic Code	U.S. Code	Mean Difference
APC	7.00	2.89	4.11 [2]
Airmobile Infantry	8.78	3.67	5.11
Airborne Infantry	9.56	6.22	3.34
Motorized Infantry	8.78	4.89	3.89
Infantry	9.67	5.78	3.89
Tank	9.22	5.56	3.66

1. S .01 = 2.91
2. The differences between the six pairs of means are all significantly different, P<.01.

Examination of the results in Table 10 shows there are nine U.S. symbols that are rated low in meaningfulness in comparison to the other symbols in the code. Three of these appear in Table 13 where they also are rated significantly lower in meaningfulness in comparison to their counterpart symbols from the pictographic code. Two of them are widely used symbols: APC, and Airmobile Infantry. These findings suggest there are a number of commonly used symbols in the U.S. code that, unfortunately, contain low capacities of meaningfulness. However, the findings also show that representation of the same concepts with pictographic symbols increases meaningfulness significantly; this indicates that the concepts themselves do possess potential meaningfulness that can be represented and communicated by appropriate symbols that depict the unique physical characteristics or mission functions that the concepts are identified with.

Recognition Task

The raw scores of response time and frequency were converted into a combined score of response rate and error which was used as the performance measure for the recognition task. The combined score was derived by the following method. A measure of mean response rate per second was calculated by dividing the number of responses per trial by the elapsed time from trial onset to occurrance of the last response. Next, a measure of recognition error was obtained by calculating the percentage of target symbols that were recognized on each trial. Finally, the combined score was derived by transforming the two measures into z-scores and summing each pair. The combined score gives equal weight to response speed and accuracy in performing the recognition task.

The combined scores were analyzed in an analysis of variance using a five-factor design with repeated measures on the last three factors. They were code, trial time, symbol density, concept, and trial replications.

Table 14 presents summarized results of the analysis. The table shows that six treatment factors were found to have significant effects on symbol recognition performance. They were code, trial time, symbol density, concept, code x concept interaction, and code x symbol density x concept interaction.

The significant effects were analyzed by means of the Scheffe multiple comparisons test (S). Comparisons of the means under the main effect of codes are presented in Table 15.

TABLE 14

Summary of the Results of the Analysis of Variance of the Effects of the Experimental Variables on the Composite Scores of Response Rate and Error

SOV	df	Mean Square	F
Between Subjects	26		
Codes (A)	2	42.402	4.806**
Trial Time (B)	2	46.586	5.279**
A x B	4	10.519	1.192
Error	18	8.824	
Within Subjects	3078		
Symbol Density (C)	2	29.843	12.273***
A x C	4	3.[illegible]38	1.414
B x C	4	2.058	0.846
A x B x C	8	1.407	0.579
Error	36	2.432	
Concept (D)	18	18.813	17.936***
A x D	36	6.339	6.044***
B x D	36	1.064	1.015
A x B x D	72	1.300	1.240
Error	324	1.049	
C x D	36	0.651	1.099
A x C x D	72	0.938	1.584**
B x C x D	72	0.510	0.860
A x B x C x D	144	0.610	1.030
Error	648	0.592	
Trial Replications (E)[1]			

[1]None of the effects containing the trial replications factor were significant (P<.05) and, therefore, were not included in the table.

** $p < 0.01$
*** $p < 0.001$

TABLE 15

Codes Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task.

	- Code -		
	U.S.	Soviet	Pictographic
Mean	0.2025	0.0065	-0.6122[2]

1. S .01 = 0.4544
2. Treatment means not underscored by the same line are significantly different, $p<.01$.

The comparisons show that total decoding performance was significantly superior under the pictographic code than under either the U.S. or Soviet codes. There was no significant difference in overall decoding performance between U.S. and Soviet codes.

The comparisons of the means on the main effect of trial time are presented in Table 16.

TABLE 16

Trial Time Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task.

	Trial Time		
	Long	Medium	Short
Mean	-0.3214	-0.4137	0.3464[2]

1. S .01 = 0.4544
2. Treatment means not underscored by the same line are significantly different, $p<.01$.

The comparisons show that total decoding performance was significantly poorer under the short trial time than under either the medium or long trial times. There were no significant differences under either the medium or long trial times.

The comparisons of the means for the symbol density factor are presented in Table 17.

TABLE 17

Symbol Density Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task.

	Number of Symbols per Display		
(Density)	25 (low)	50 (medium)	75 (high)
Mean	-0.1909[2]	0.0545	0.1370

1. $S_{.01} = 0.2231$
2. Treatment means not underscored by the same line are significantly different, $p<.01$.

The results reveal that overall decoding performance was significantly better under the low level of symbol density (25 symbols per display) than under the medium or high densities (50 and 75 symbols per display). There was no significant difference in performance under the medium and high density levels.

The comparisons of the means for the main effect of concept are presented in Table 18. The table shows there were significant differences between the comparisons of 33 different pairs of means. Examination of the pattern of differences showed that 15 different concepts were involved. The pattern of comparisons appears to show that decoding performance was definitely superior under four concepts: Armor, APC, Tank, and Inf. It was marginally superior under four other concepts: MG, Motorized Inf, Helicopter, and Airborne Inf. Conversly, performance was clearly inferior under four concepts: AA-Gun, FA-Gun, FA-MSL, and AT-Gun, and marginally inferior under three other concepts: SP-Gun, Mortar, and AA-MSL.

The code x concept interaction was analyzed in two ways. First, an analysis was made of the significant mean differences occuring between concepts within each code. Second, an analysis was made of mean differences between the three codes on the same concept. The analysis of within code differences begins with the U.S. code. Table 19 presents a matrix of results of multiple comparisons tests between the means of the concepts of the U.S. code. The table reveals that there were significant differences between 37 different pairs of means. Examination of the pattern of comparisons shows that decoding performance was superior under the five symbols with the lowest means as compared to the five symbols with the highest means. The five symbols with the lowest mean scores were: Tank, Armor Unit, APC, Arty Unit, and Helicopter. The five symbols with the highest mean scores were: AA-Gun, FA-Gun, Mortar, SP-Gun, and AT-RKT.

The analysis of mean differences between concepts within the Soviet code revealed five comparisons which were significant. The results indicated that decoding performance was superior under the three symbols with the lowest means as compared with the two symbols with the highest means. The three symbols with the lowest means were: Airmobile Inf, Armor Unit, and MG. The two symbols with the highest means were AT-Gun and Arty Unit. The matrix of results of the multiple comparisons tests of the symbol means in the Soviet code are presented in Table A1 in the Appendix.

TABLE 18

Concept Main Effect. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task

Concept	Mean	Armor -0.68	APC -0.67	Tank -0.66	Inf -0.56	MG -0.43	Motor Inf -0.42	Heli -0.40	Airbrn Inf -0.38	Armor Inf -0.23	Mech Inf -0.15	Arty -0.13	AT-RKT -0.11	AA-MSL 0.03	Mortar 0.06	SP-Gun 0.07	AT-Gun 0.15	FA-MSL 0.20	FA-Gun 0.40	AA-Gun 0.42
Armor	-0.68													X[2]	X	X	X	X	X	X
APC	-0.67													X	X	X	X	X	X	X
Tank	-0.66													X	X	X	X	X	X	X
Inf	-0.56																X	X	X	X
MG	-0.43																		X	X
Motor Inf	-0.42																		X	X
Heli	-0.40																		X	X
Airbrn Inf	-0.38																		X	X
Airmo Inf	-0.23																			
Mech Inf	-0.15																			
Arty	-0.13																			
AT-RKT	-0.11																			
AA-MSL	0.03																			
Mortar	0.06																			
SP-Gun	0.07																			
AT-Gun	0.15																			
FA-MSL	0.20																			
FA-Gun	0.40																			
AA-Gun	0.42																			

1. S .01 = 0.6725
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE 19

Code x Concept Interaction: US Code. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Test

Concept	Mean	Tank -0.72	Armor -0.65	APC -0.60	Arty -0.59	Heli -0.42	Motor Inf -0.37	Inf -0.36	Airbrn Inf -0.11	AT-Gun 0.01	Airmo Inf 0.13	MG 0.14	Mech Inf 0.38	FA-MSL 0.50	AA-MSL 0.56	AT-RKT 0.62	SP-Gun 0.75	Mortar 0.76	FA-Gun 1.18	AA-Gun 1.49
Tank	-0.72													X[2]	X	X	X	X	X	X
Armor	-0.65														X	X	X	X	X	X
APC	-0.60															X	X	X	X	X
Arty	-0.59															X	X	X	X	X
Heli	-0.42																X	X	X	X
Motor Inf	-0.37																		X	X
Inf	-0.36																		X	X
Airbrn Inf	-0.11																		X	X
AT-Gun	0.01																		X	X
Airmo Inf	0.13																			X
MG	0.14																			X
Mech Inf	0.38																			
FA-MSL	0.50																			
AA-MSL	0.56																			
AT-RKT	0.62																			
SP-Gun	0.75																			
Mortar	0.76																			
FA-Gun	1.18																			
AA-Gun	1.49																			

1. S .01 = 1.164
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

The analysis of mean differences between concepts within the pictographic code disclosed that none of the differences were statistically significant.

The results of the analysis of between-code differences across each concept are summarized in Table 20. The table shows that there were a total of 19 comparisons between pairs of means, spread across 10 concepts, that were significantly different. The U.S. Code was involved in all but two of them and the differences showed a consistent relation. On seven concepts decoding performance under the U.S. Code was significantly worse than under both the Soviet or pictographic codes. These concepts were: FA-Gun, SP-Gun, AT-RKT, AA-Gun, Mortar, MG, and Mech Inf. In addition performance under the U.S. Code was inferior to the pictographic code on the AA-MSL concept and inferior to the Soviet code on the Airmobile Inf concept. Overall, performance under the U.S. code was inferior to the Soviet code on eight concepts and to the pictographic code on eight concepts.

Comparing the results from the within-code analysis, Table 19, with those from the between-code analysis, Table 20, reveals consistent findings. The six symbols in the U.S. code with the highest mean scores are not only found to elicit inferior decoding performance in comparison to other symbols within the U.S. code, but also produce inferior performance in relation to the Soviet and pictographic codes. These U.S. symbols are: AA-Gun, FA-Gun, Mortar, SP-Gun, AT-RKT, and AA-MSL.

The results of the multiple comparisons analysis of the code x symbol density x concept interaction are summarized in Table 21. Examination of the table indicates that increasing the level of symbol density on the display tends to reduce the number of significant performance differences occurring between codes on some of the concepts, but not all. Considering the effect of this general trend on the U.S. code shows that performance under the low symbol density level was inferior to both the Soviet and pictographic codes on 10 concepts. However, under the medium and high density levels it was inferior on only six and five concepts respectively, culminating in a 50 percent reduction in performance differences.

TABLE 20

Code x Concept Interaction: Between-Codes Comparisons Across Each Concept. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task

Concept	Performance Differences
Arty	Soviet < US[1]
FA-Gun	US < Soviet, Pictographic
SP-Gun	US < Soviet, Pictographic
AT-Gun	---------
AT-RKT	US < Soviet, Pictographic
AA-Gun	US < Soviet < Pictographic
AA-MSL	US < Pictographic
FA-MSL	---------
Mortar	US < Soviet, Pictographic
MG	US < Soviet, Pictographic
APC	---------
Mech Inf	US < Soviet, Pictographic
Helicopter	---------
Airmobile Inf	US, Pictographic < Soviet
Airborne Inf	---------
Motorized Inf	---------
Infantry	---------
Tank	---------
Armor	---------

[1]This table displays codes by symbol interaction at the .01 significance level, e.g., the first entry indicates that performance under the Soviet code was significantly poorer (<.01) than that achieved under the US code. See Table A2 in the Appendix for a tabulation of mean scores and presentation of multiple comparisons test data.

TABLE 21

Code x Symbol Density x Concept Interaction: Results of the Multiple Comparisons Test Between Codes Across Each Concept Under Each Symbol Density Level on the Recognition Task

	Symbol Density Level		
Concept	Low	Medium	High
Arty	S < U[1]	P < U[2]	P < U, S
FA-Gun	U < S, P	-	U, S < P
SP-Gun	U < S, P	U, S < P	-
AT-Gun	-	-	-
AT-RKT	U < S, P	-	-
AA-Gun	U < S < P	U < P	U, S < P
AA-MSL	U < P	U, S < P	U, S < P
FA-MSL	-	U, S < P	U, S < P
Mortar	U < S, P	-	-
MG	U < S, P	U < S, P	U < S, P
APC	-	-	-
Mech Inf	U < P	U, S < P	-
Helicopter	-	-	-
Airmobile Inf	U < S	-	
Airborne Inf	-	-	
Motorized Inf	-	-	
Infantry	-	-	
Tank	-	-	-
Armor	-	-	-

[1]The table presents symbol types and symbol density levels under which significant ($p<.01$) mean performance differences occurred between codes, e.g., the first entry in the table, S < U, indicates that performance under the Soviet Code was inferior to that achieved under the U.S. Code. See Table A3 in Appendix for comparisons of mean scores.

[2]P = Pictographic Code
S = Soviet Code
U = U.S. Code

The code x symbol density x concept interaction does not seem to affect the coding of the symbols uniformly. Higher symbol density levels may greatly increase the difficulty of the decoding task. Some of the distinguishing characteristics of the otherwise more easily recognizable symbols may become more difficult to discern at higher density levels so that they become as difficult to decode as the previously more difficult symbols.

Task Correlations

Correlations among performance measures for the experimental tasks were computed using the symbol within each code as the basic unit for comparison. Overall comparisons were made between tasks for each code and separate comparisons were made for each symbol between tasks. The correlations were generally low on most comparisons. Table 22 presents the results of the overall comparisons. None of the mean correlations between the learning and rating tasks, learning and decoding tasks, and rating and decoding tasks were statistically significant at the .05 level of confidence.

The correlations for individual symbols among tasks did produce some significant associations, but they seemed to lack consistancy. In the comparisons of learning and rating measures there were nine out of 57 correlations among the three codes that were significant; between learning and recognition measures two of 57; and between rating and recogniton measures four of 57. On the basis of chance alone and using a five percent alpha level it could be expected that approximately three of the 57 correlations would be significant.

These results apparently indicate that learning difficulty, meaningfulness ratings, and decoding proficiency are independent functions since they are not highly correlated with each other. Neither symbol learning difficulty nor meaningfulness level show promise as predictor variables for symbol decoding performance. Prior to this study the relationship between learning difficulty and decoding performance had been studied. Green and Pew (1978) found a weak negative correlation ($r = -0.19$) between the two variables which are in accord with the present findings.

TABLE 22

Pearson Correlation Coefficients (r) Between the Military Symbol Codes and the Experimental Tasks

Symbol Code	Pairs of Tasks: Learning and Rating	Learning and Recognition	Rating and Recognition
U.S.	0.549	-0.300	0.186
Soviet	0.420	-0.157	0.559
Pictographic	-0.099	-0.084	0.298

r .05 (df,7) = 0.666

Demographic Variables

The seven demographic variables were analyzed by stepwise multiple regression analysis to identify any that might predict either learning or recognition performance. The analysis of learning data produced a significant multiple correlation coefficient value of $R = 0.67$, equivalent to $F(2,24) = 9.85$, $p < .005$. Two demographic variables were found to be significantly correlated with learning performance. They were symbol knowledge, which accounted for 26 percent of the variance in learning scores, and time in MOS, which accounted for 19 percent. In sum, the proportion of variance due to these two variables was 45 percent. The correlation between symbol knowledge and time in MOS was not significant, $r(25) = 0.16$, $p > .10$; the result indicates that both variables have a direct effect on learning performance.

The analysis of the data for recognition performance produced negative results. None of the demographic variables tested were found to be significantly associated with performance on the experimental task. None qualified as variables for predicting ability for decoding military symbology. The results from these two tests should be considered as indicative and not firmly determined since the sample size used, N = 27, was relatively small for the reliability requirements of regression analysis tests.

SUMMARY AND CONCLUSIONS

This study has produced a quantity of empirical data on the learning and decoding characteristics of a subset of frequently used basic symbol elements comprising contemporary military symbol codes. Five general findings regarding the codes have evolved from the data analysis. The first three, and most basic findings, are that large individual differences exist between the symbol elements of contemporary military codes in terms of learning difficulty, speed of decoding capability and accuracy of decoding capability. Some concepts are coded much more effectively than others. It appears that guns and missiles are two catagories that have not been coded as well as other catagories. Perhaps this indicates that these concepts are more difficult to represent in a code.

The fourth finding indicated by the research is that pictographic symbology is superior to standard military symbology, the latter of which consists of large proportions of geometric and alphabetic symbol elements. The findings strongly support those from an earlier study (Howell and Fuchs, 1961) showing that pictographic symbols are much easier to learn than standard military symbols. In addition, the present results indicate that pictographic symbols are easier to decode. Thus it seems that pictographic symbology shows considerable promise as being a more efficient alternative method for encoding military concepts. In the past, it has suffered one major obstacle to its adoption and that has been the inability of individuals untrained in graphic arts to draw complex pictographs in free hand that are legible and recognizable, especially under field conditions. Computerized graphic display technology reduces the problem by performing the function automatically as symbols are produced and reproduced electronically and with high fidelity.

Finally, the fifth finding is that no strong association exists between learning and recognizing individual symbols - a finding that confirms earlier work with pictographic symbols. Obviously, the absence of a dependent relationship between the learning and decoding functions must have some implications for the course of development in the area. It seems to allow for greater freedom in selecting symbols primarily on the basis of decoding criteria without having to give as much consideration to learning requirements, especially for tasks that deal with a limited number of symbols where learning and memory requirements are moderate. Other factors that were not investigated in this study but which may influence recognition of military symbols are recognition rate (discriminability), similarity, complexity, and familiarity. They seem to be likely variables for study in future work in this area.

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APPENDIX

TABLE A1

Code x Concept Interaction: Soviet Code. Results of the Within-Code Multiple Comparisons Test Between Treatment Means on the Recognition Task

Concept	Mean	Airmo Inf -0.78	Armor -0.72	MG -0.71	Tank -0.70	Inf -0.67	APC -0.64	Mortar -0.60	Heli -0.60	AT-RKT -0.47	Airbrn Inf -0.42	Motor Inf -0.23	Mech Inf -0.17	SP-Gun -0.05	AA-MSL 0.01	FA-MSL 0.07	Arty Gun 0.19	FA-Gun 0.32	Arty 0.39	AT-Gun 0.44
Airmo Inf	-0.78																		X[2]	X
Armor	-0.72																		X	X
MG	-0.71																			X
Tank	-0.70																			
Inf	-0.67																			
APC	-0.64																			
Mortar	-0.60																			
Heli	-0.60																			
AT-RKT	-0.47																			
Airbrn Inf	-0.42																			
Motor Inf	-0.23																			
Mech Inf	-0.17																			
SP-Gun	-0.05																			
AA-MSL	0.01																			
FA-MSL	0.07																			
Arty Gun	0.19																			
FA-Gun	0.32																			
Arty	0.39																			
AT-Gun	0.44																			

1. S .01 = 1.164
2. An X in a cell indicates that the difference between the pair of means is significantly different, $p < .01$.

TABLE A2

Code x Concept Interaction. Results of the Between-Codes Multiple Comparisons Test Between Treatment Means on the Recognition Task

	Code		
Concept	U.S.	Soviet	Pictographic
Arty	-0.594	0.393	-0.182
FA-Gun	1.185	0.194	-0.181
SP-Gun	0.752	-0.060	-0.468
AT-Gun	0.011	0.442	-0.001
AT-RKT	0.619	-0.471	-0.483
AA-Gun	1.487	0.319	-0.538
AA-MSL	0.561	0.001	-0.477
FA-MSL	0.496	0.072	-0.023
Mortar	0.760	-0.602	-0.357
MG	0.136	-0.705	-0.710
APC	-0.597	-0.643	-0.794
Mech Inf	0.381	-0.173	-0.671
Heli	-0.420	-0.600	-0.183
Airmo Inf	0.133	-0.781	-0.056
Airbrn Inf	-0.117	-0.417	-0.595
Motor Inf	-0.373	-0.231	-0.670
Inf	-0.368	-0.665	-0.659
Tank	-0.722	-0.701	-0.546
Armor	-0.654	-0.723	-0.668

1. S .01 = 0.598
2. Means underscored by the same line are not significantly different, p<.01.

TABLE A3

Code x Symbol Density x Concept Interaction. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task

Symbol Density Code Concept	U.S.	25 (Low) Soviet	Pictographic
Arty	-0.594	0.393	-0.182
FA-Gun	1.185	0.194	-0.181
SP-Gun	0.752	-0.060	-0.468
AT-Gun	0.022	0.442	-0.001
AT-RKT	0.619	-0.471	-0.483
AA-Gun	1.487	0.319	-0.538
AA-MSL	0.561	0.013	-0.477
FA-MSL	0.496	0.072	0.023
Mortar	0.760	-0.602	-0.357
MG	0.136	-0.705	-0.710
APC	-0.597	-0.643	-0.794
Mech Inf	0.381	-0.173	-0.671
Heli	-0.420	-0.600	-0.183
Airmo Inf	0.133	-0.781	-0.056
Airbrn Inf	-0.117	-0.417	-0.595
Motor Inf	-0.373	-0.231	-0.670
Inf	-0.368	-0.665	-1.318
Tank	-0.722	-0.701	-0.546
Armor	-0.654	-0.723	-0.668

1. S .01 = 0.779
2. Means underscored by the same line are not significantly different, $p<.01$.

TABLE A3 (cont'd)

Code x Symbol Density x Concept Interaction. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task

Symbol Density	50 (Medium)		
Code Concept	U.S.	Soviet	Pictographic
Arty	-0.508	-0.203	0.563
FA-Gun	1.111	0.873	0.433
SP-Gun	0.529	0.530	-0.480
AT-Gun	0.745	0.871	0.223
AT-RKT	0.285	0.007	-0.414
AA-Gun	0.959	0.843	0.168
AA-MSL	0.840	0.633	-0.146
FA-MSL	0.251	0.452	-0.688
Mortar	0.127	-0.111	0.257
MG	0.835	-0.292	-0.593
APC	-0.694	-0.525	-0.395
Mech Inf	0.375	0.356	-0.584
Heli	-0.019	-0.443	0.196
Airmo Inf	0.223	-0.330	-0.054
Airbrn Inf	0.342	0.378	-0.236
Motor Inf	-0.358	0.201	0.347
Inf	-0.399	-0.237	-0.449
Tank	-0.482	-0.584	-0.361
Armor	-0.573	-0.594	-0.392

TABLE A3 (cont'd)

Code x Symbol Density x Concept Interaction. Results of the Multiple Comparisons Test Between Treatment Means on the Recognition Task

Density		75 (High)	
Code	U.S.	Soviet	Pictographic
Concept			
Arty	-0.453	-0.192	0.608
FA-Gun	1.134	1.201	0.270
SP-Gun	0.540	0.657	-0.035
AT-Gun	0.644	1.017	0.337
AT-RKT	0.373	0.169	-0.385
AA-Gun	1.085	0.950	0.146
AA-MSL	0.600	0.642	-0.209
FA-MSL	0.193	0.541	-0.618
Mortar	0.370	0.196	0.027
MG	1.175	-0.350	-0.469
APC	-0.398	-0.508	-0.089
Mech Inf	0.572	0.179	-0.009
Heli	-0.175	-0.210	-0.042
Airmo Inf	0.319	-0.278	0.153
Airbrn Inf	0.234	0.129	-0.216
Motor Inf	-0.459	0.219	0.091
Inf	-0.255	-0.265	-0.208
Tank	0.027	-0.669	-0.008
Armor	-0.251	-0.086	-0.157