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Simplification of the Panel Layout on Standard Series Tank Radios

by

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Fort Knox, Kentucky

Under the Technical Supervision of

The George Washington University
HUMAN RESOURCES RESEARCH OFFICE
operating under contract with
THE DEPARTMENT OF THE ARMY

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by

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This study was conducted while Dr. T.R. Vallance was Director of Research at Human Research Unit Nr 1, CONARC (now the U.S. Army Armor Human Research Unit).

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SIMPLIFICATION OF THE PANEL LAYOUT ON STANDARD SERIES TANK RADIOS

SUMMARY AND CONCLUSIONS

THE MILITARY PROBLEM

According to a recent survey of Armor training, many personnel, especially replacements received in T/O&E units, are not sufficiently proficient in operating the tank radio. This study evaluates the effect on operator performance of modifying the tank radio, in certain minor ways. The selection of modifications employed in the study was limited to those which could be made by the using units.

THE RESEARCH PROBLEM

There is a complex array of controls on the front panel of the standard series tank radio. During routine use, however, the tank crewman needs to manipulate only a few of these controls; furthermore, training personnel have observed that the other controls cause confusion. The purpose of this study was to evaluate the hypothesis that increasing the distinctiveness of controls through coding will result in a reduction of errors made during radio operation.

RESEARCH METHOD

The experimental method employed in the study utilized three companies of Armor trainees, each divided into two equal groups. In each company, Group 1, an experimental group, received training on sets with the eight most important controls coded in one of three ways: (1) painted a single distinctive color, (2) painted three different colors according to their function, or (3) numbered according to their order of use. In each company, Group 2, a control group, was trained on standard sets. In each company, Groups 1 and 2 were equated on GT scores and on a motivation scale before radio training. After training, they were compared on mean performance and on the number of trainees who obtained a perfect score.

FINDINGS

The mean performances of the three-color group and the numeral group were higher than those of the corresponding control groups. Also, more men in these experimental groups than in the corresponding control groups obtained the perfect score necessary to establish radio communication.

CONCLUSION

For the kind of radios studied, coding radio controls either by function or by order of use results in improved performance.

RECOMMENDATION

It is recommended that the controls on the AN/GRC series of radios, now in use, be coded according to either function or order of use.[1]

[1] A copy of the draft report was forwarded to Chief Signal Officer by Hq CONARC (ATDEV-5 413.4) with two recommendations, that:

a. A standard method of color/numerical coding of controls be developed and applied to such communication and electronic equipment as is feasible.

b. A modification Work Order be issued to implement the standard and specific method developed for accomplishing the color/numerical coding of controls for standard equipment currently in the field.

DESCRIPTION OF THE RESEARCH

Introduction

Interviews with training personnel, tests of trainees, and observations made during large-scale maneuvers have shown, according to a recent survey of Armor training problems,[1] that many personnel responsible for operating the tank radio do not reach an adequate level of proficiency. This lack of skill in tank radio operation has been noted especially in replacements arriving in T/O&E units. As a result, these crewmen make simple errors in operation which cause difficulties in communication.

Training personnel have observed that the complicated radio panel is a source of confusion to personnel learning to operate the radio. Of the complex array of controls on the front panel of the standard series tank radio, only a relatively small number need be used by the tank crewman in the routine operation of the radio. In fact, any change of the other controls from a specified setting may interfere with the proper and efficient use of the set.

Human engineering, specifically control coding, seemed to offer a possible solution to this problem both during training and in later operation. Coding could serve to (1) reduce the perceptual area by giving the necessary controls such a distinctive appearance that they would be the only ones attended to, and (2) organize this area to reduce confusion and subsequent errors in operation.

In previous research on coding of controls,[2] five basic methods—coding by location, size, shape, color, and order—have proved effective, singly or in various combinations. Since the first three of these methods would require manufacturer modifications and this study is concerned with radios already in use, it was decided to utilize only methods of increasing control distinctiveness which could be carried out by the using units, that is, color and order.

[1] E.J. Green *et al.*, *A Survey of Training Problems in Armor*, Staff Memorandum, Human Research Unit Nr 1, Fort Knox, Ky., July 1954 (Revised, July 1956); H.C. Olson *et al.*, *A Technical Supplement to the Report on a Survey of Armor Training Problems*, Staff Memorandum, Human Research Unit Nr 1, Fort Knox, Ky., April 1955.

[2] A. Chapanis, W.R. Garner, and C.T. Morgan, *Applied Experimental Psychology*, John Wiley and Sons, New York, 1949, p. 308.

Research Procedures

Coding. This study represents an evaluation of three methods of coding:

(1) Using one color to point up the necessary controls.
(2) Using three colors to show the necessary controls and indicate their functions.
(3) Using numerals to indicate the necessary controls and their order of use.

The colors used were selected for their ability to retain their distinctiveness from most backgrounds, even under limited illumination.[1]

The eight most important controls were coded for this study. The four specific treatments of the training aids mockups and standard radio sets used in instruction and testing were as follows: (1) ATP, all controls painted standard Army olive drab; (2) One Color, eight most important controls painted violet; (3) Three Colors, eight most important controls painted different colors to indicate functions (violet for on-off power, green for volume, yellow for squelch); (4) Numerals, eight most important controls painted olive drab with large distinctive numerals located near each to indicate the sequence in which the controls are manipulated to put the set in operation.

Pilot Study. A short pilot study was run in which the essential portions of the ATP training in communications were abstracted and presented to two experimental companies by The Armor School. These portions consisted of periods 1, 4, 5, 6, 7, and half of 8, as described in Appendix A. Each company was divided into four equal groups, and all groups were trained on the same type of radio set. The controls of the sets used by each group were coded as described in the preceding paragraph.

The groups were tested with a preliminary form of the criterion test, immediately after training and again after seven weeks. In this exploratory study, no group did significantly better than the others either time the test was given. Among possible reasons for the inconclusive results were the small number of men in the training groups, and lack of control over trainee and instructor motivation. In order to limit the influence of these variables, experimental controls were incorporated in the design of the main experiment.

Population. The study utilized three companies who were in the 10-week Armor Branch Individual Training Program (ATP 17-600). Each company was divided into two equal groups on the basis of GT scores[2] and the results of a motivation questionnaire.

The matching was conducted as follows: First, the men in the company were ordered according to GT scores; the eight men with the highest GT scores were then reordered according to the results of the motivation questionnaire and placed in two groups, the odd-numbered

[1] *Ibid.*, p. 81.

[2] The General and Technical (GT) score, used as an indication of general intelligence level, is made up of scores from the Verbal Test and the Arithmetic Reasoning Test of the Army Classification Battery.

men in Group 1, the even-numbered men in Group 2. The next eight men were treated in the same way, except that the odd-numbered men were placed in Group 2, and the even-numbered men in Group 1. The matching proceeded in this way until all the men in the company had been assigned to Group 1 or Group 2.

In each of the three companies, Group 1 was used as an experimental group and Group 2 as its control group, whenever a subject from Group 1 was lost by not participating in the training, his match in Group 2 was not used either. Table B-1 (Appendix B) shows the number of men in each group in each company and the mean score for each group on the two tests which were used in the matching procedure.

The motivation questionnaire used in matching the groups was in three parts: an assessment of the individual's satisfaction with Army life, and tests of his knowledge of Armor and radio information.[1] These information sections were modeled after the Naval Knowledge Test[2] which had been used successfully in predicting naval officer candidate school grades; the assumption underlying the use of such a test was that possession of knowledge of the sort that could have been obtained only through study would indicate an interest in the subject matter.

Training and Testing. In every company, Group 1 (experimental) was trained and tested on a set coded by one of the methods already described. The Group 2 (control) of every company was trained on a standard (ATP) set. This procedure prevented between-company differences from affecting evaluation of the experimental methods.

In each company, Groups 1 and 2 were trained at the same time, except that Group 1 was taught radio operation while Group 2 was taught radio-telephone procedure; then the instructors and course content were switched. (Each experimental group received instruction on radio operation first, thus having a slightly longer delay before testing.) The training for all groups was distributed in the same manner as standard ATP (Appendix A) training; the only deviation was the addition of two hours for review.

The performance test utilized coded radio sets for the experimental groups and was given concurrently with other training. The three companies were therefore equal with respect to instruction, scheduling, and amount of training (see Appendix B, Table B-2).

The criterion used to evaluate the coding methods consisted of a 12-item performance test (Appendix C). The trainees were requested to put two AN/GRC-4 radios into operation according to stated specifications. Six control settings were necessary to prepare each set, and subjects were scored by experienced personnel on each setting. One subject was tested at a time. No time limit was set for the test; the tester ended the test when the subject completed it or when the tester

[1] The split half reliability, corrected by the Spearman-Brown formula, was .52. The average item correlation with the criterion was .12. Correlation with the performance test was .26, and with the GT score .27. The mean was 22.52 and the standard deviation, 3.47.

[2] Form AIR-OPRR-17. See A.S. Clickman, *The Naval Knowledge Test: Construction and Validation*, Technical Bulletin 54-7, Personnel Analysis Division, Bureau of Naval Personnel, Washington, 1954.

was sure that the subject could not complete it. The time required was usually about seven minutes.

Results

The mean score for each group and the result of the significance tests are listed in Table 1. The hypothesis that the experimental groups would not do better on the criterion than the control groups was evaluated by means of a t ratio for matched groups. As the table shows, the three-color group and the numeral group did do better than the corresponding control groups, and the differences reach the .05 level of significance.

Table 1

GROUP MEANS AND RESULTS OF SIGNIFICANCE TESTS

Item	Company 1, 1 Color		Company 2, 3 Colors		Company 3, Numerals	
	Group 1 Experim.	Group 2 Control	Group 1 Experim.	Group 2 Control	Group 1 Experim.	Group 2 Control
Mean	9.56	9.48	10.19	9.19	10.33	9.45
Standard Error of Difference	.76		.48		.57	
t Ratio	.20		2.08 ($p < .05$)		1.54 ($p < .05$)	

To actually establish communication, the trainee must perform each successive item of the criterion correctly. This fact makes it possible to evaluate the results independently of the analysis in Table 1, by comparing the number of men in each group who obtained a perfect score. These data are presented and evaluated in Table 2. In each company, Group 1 (experimental) had more trainees with a perfect score than Group 2. This fact represents an over-all advantage for the experimental groups which is significant beyond the .001 level. The largest portion of the aggregate χ^2 is contributed by the χ^2's of the three-color and numeral groups, which reach a significance level of .055 and .001 respectively.

Table 2

NUMBERS OF TRAINEES WHO PASSED AND FAILED THE CRITERION, AND RESULTS OF SIGNIFICANCE TESTS BETWEEN GROUPS

Group and Company	Communication Established: 12 Items Correct	Communication Not Established: 11 or Fewer Items Correct	Total	Test of Significance
One-Color Coding (Company 1)				
Group 1, Experimental	10	23	33	
Group 2, Control	7	26	33	
Total	17	49	66	χ^2, .71

Continued

Table 2 *(Continued)*

NUMBERS OF TRAINEES WHO PASSED AND FAILED THE CRITERION, AND RESULTS OF SIGNIFICANCE TESTS BETWEEN GROUPS

Group and Company	Communication Established: 12 Items Correct	Communication Not Established: 11 or Fewer Items Correct	Total	Test of Significance
	Three-Color Coding (Company 2)			
Group 1, Experimental	20	32	52	
Group 2, Control	11	41	52	
Total	31	73	104	χ^2, 3.72
	Coding by Numerals (Company 3)			
Group 1, Experimental	16	17	33	
Group 2, Control	2	31	33	
Total	18	48	66	χ^2, 14.97
			Aggregate	χ^2, 19.40

Conclusions

This study shows that the use of control coding as a means of simplifying the perceptual problem of radio operators will result in improved average performance, and will produce a greater number of trainees who can turn in an errorless performance when they are required to establish radio contact.

Although there are other methods of coding controls, some of these would be feasible only when the radio is being designed. Because the AN/GRC-3 radio, now being used as the basic tank radio, will become obsolete too soon to warrant major modifications, this study evaluated only those methods of coding controls which could be instituted by training centers and T/O&E units. The methods of coding controls by function, or by order of use, resulted in improved operator performance.

Appendix A

COMMUNICATIONS TRAINING PROGRAM, AS OUTLINED IN ATP SUBJECT SCHEDULE 17-600

Section II, Part 3: Communications Training—Radio-telephone Procedure, Standard Series Radio Sets, and Tank Interphone (14 hours)

25. Schedule Chart (P: period; H: hour)

P	H	Lesson	Text Reference	Area	Training Aids and Equipment
1	1	Introduction to the basic communications course	FM 24-17 ACP 125 (A); JANAP 133	Classroom	Blackboard, overhead projector w/slides, phonetic alphabet cards
2	1	Radio-telephone procedure	ACP 121 (B); ACP 122 (B); ACP 125 (A); AFSAG 1247	do	Blackboard, TF 11-2061, overhead projector w/slides, PA set
3	1	do	do	do	Blackboard, TF 11-2044, authentication charts, overhead projector w/slides
4	1	Introduction to standard series radio sets	TM 11-284	do	One AN/GRC-3 Radio, one AN/PRC-8 Radio, one AN/PRC-6 Radio, wooden model of AN/GRC-3 Radio, overhead projector w/slides, control group, blackboard
5	1	Radio Set AN/VRC-8 and Auxiliary Receiver R-108/GRC	TM 11-286; TM 11-284	do	Blackboard, one AN/VRC-8 Radio, Radio Set AN/GRC-3, wooden model of set number 1, wooden model R-108, overhead projector w/slides
6	1	Radio Set AN/VRC-7	TM 11-285	do	Blackboard, one AN/VRC-7 Radio, wooden model of AN/VRC-7, overhead projector with slides
7	1	Tank interphone system	TM 11-284; TM 11-704	do	One C-375, one wooden model C-375, overhead projector w/slides
8	3	Practical exercise on Radio Set AN/GRC-3 and -4, and tank interphone and radio-telephone procedure	do	Radio workroom and tanks	20 AN/GRC-3 and -4 Radios complete with interphone system; 25 tanks with AN/GRC-4 Radios
9	4	do	do	do	do

NOTE: T/O&E's 17-26, 17-27, 17-36, and 17-37 must be used for determination of present equipment.

Appendix B

MEANS ON THE MATCHING VARIABLES, AND TIME SCHEDULE, FOR ALL GROUPS

Table B-1

MEAN GT AND MOTIVATION SCORES OF EACH GROUP

Test	Company 1, 1 Color		Company 2, 3 Colors		Company 3, Numerals	
	Group 1 Experim. (N = 33)	Group 2 Control (N = 33)	Group 1 Experim. (N = 52)	Group 2 Control (N = 52)	Group 1 Experim. (N = 33)	Group 2 Control (N = 33)
GT Score	98.79	97.94	96.46	95.90	97.42	97.12
Motivation	22.76	23.21	22.69	22.67	21.78	21.86

Table B-2

TRAINING AND TESTING SCHEDULE FOR ALL GROUPS

Week	Day	Time	Lecture	Practical
1	Fri.	0730-1430	6 hours	
2	Tues.	0730-1130	1 hour	3 hours
3	Mon.	0730-1130	1 hour	3 hours
	Fri.	1430-1630		2 hours review
5	Thurs.	0730-1530		Test, 10 min. per man

Appendix C

THE PERFORMANCE TEST

One subject was tested at a time using an AN/GRC-4 Radio. The statements underlined below were read to the subject, and he was scored on the numbered statements. The statements in parentheses are for the tester's benefit. No time limit was set for the test; but the tester ended the test when the subject completed it or when the tester was sure that the subject could not complete it.

Do everything which you consider necessary to prepare Set 1 so that you can transmit on channel 23.7 MCS for a distance of at least 10 miles.

1. Main mount power switch to ON position
2. Operate switch on PP-112 to TRANS-RECEIVE position
3. Hig' -low transmission switch to HIGH position
4. Volume all the way clockwise
5. Squelch turned clockwise until "rushing noise" stops
6. Channel 23.7 selected

(Allow him to manipulate anything which doesn't preclude his transmitting on the set. Shut everything off when each subject finishes the test.)

Do everything which you consider necessary to prepare Set 2 so that you can transmit on channel 49.3 MCS.

7. Main mount power switch to ON position
8. Off-int-RT-70 switch to RT-70 position
9. Volume all the way clockwise
10. Calibrate (the subject needs only to indicate that calibration is necessary)
11. Squelch turned clockwise until "rushing noise" stops
12. Chanel 49.3 selected

(Shut everything off when each subject finishes the test.)