THE DEVELOPMENT OF GROUP SCORES
IN THE PREDICTION OF
GROUP PERFORMANCE

DISSERTATION

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CHAPTER I

INTRODUCTION

A. Group, as a Construct in Psychology

In terms of function, a group is an organism. As such it may be described in terms of its behavior, its structure, or in fact on any level which is found useful in describing organisms. In nature, group is to individual as metazoan is to cell. As cells combine to form more complex organisms, the individual member cells may relinquish certain capacities which were possessed as single-celled organisms and subsequently may become more efficient performers of some specialized task. The many-celled organism will in all probability be more capable in all of its essential functions than its one-celled predecessor. We may attribute purposiveness to this process or we may prefer to avoid any reference to purpose. We can agree at least, that the development was advantageous in terms of an increased facility for adjusting to external stimulus situations. We may view this increased facility as a quantitative extension of abilities already present in the one-celled organism, or we may prefer to postulate new qualities which have been produced through some complex interactional process.

A similar situation prevails in regard to a group of organisms. The existence of a group makes possible a facility in dealing with certain aspects of the environment which is not available to individuals acting as individuals. Also, in the group, individual members may "relinquish" certain behaviors and specialize in others. A permanent differentiation of role however, is not a necessary aspect of the

group; a group may operate as a group with all members performing apparently identical functions, as in a team tug-of-war. It should be noted in this respect that Stogdill¹ has proposed a distinction between group and organization on the basis of the presence or absence of differentiation of individual responsibilities for the task of goal achievement. This view of an organization as a special class of group appears quite useful at the present stage of research. There can be no question concerning the point that research on group behavior is conducted on two different fronts at the moment. However, at some point, the divergent approaches must accumulate a sufficient body of knowledge to make a rapprochement possible. At that time, it will be necessary to have dimensions available on which transitory and emergent roles as well as prescribed and permanent ones may be ranged. It would then be possible to place the tug-of-war team at some point on an organization continuum, and the distinction between group and organization would be of less value.

To complete the analogy (between the group and the multiple-celled organism), we may view the increased facility which the group demonstrates in its responses to its environment as either a quantitative or qualitative difference from the abilities possessed by individual members.

It is implicit in the foregoing discussion that any collection of individuals does not constitute a group. Much of the early research

¹Stogdill, R., Leadership, membership, and organization. Psych. Bull., 1950, 47, 1-14.

on "group effects" of which the studies of Dashiell² and Farnsworth³ are representative, consisted of individual performance in memorizing lists or adding numbers while in the company of others. There is neither group nor group behavior involved in such situations, as these terms are currently employed. As definition, we may take the statement of Krech and Crutchfield, that:

"The criteria for establishing whether or not a given set of individuals constitutes a psychological group are mainly two: (1) all the members must exist as a group in the psychological field of each individual, i.e. be perceived and reacted to as a group; (2) the various members must be in dynamic interaction with one another."⁴

and note that this definition would admit to an interest in both organized and informal groups, in relatively permanent as well as very temporary groups, and in groups which were external-task-oriented as well as those whose performances were essentially internal in referent. Much of the research on group behavior has operated within a more restricted definition of the psychological group.

A large segment of the research on groups follows the early work of Lewin.⁵ The work here has been concerned essentially with unstructured groups in which internal changes have been related to varied

²Dashiell, J.F., An experimental analysis of some group effects. J. Abn. and Soc. Psych., 1930, 25, 190-199.

³Farnsworth, P.R., Concerning so-called group facts. J. Genet. Psych., 1928, 587-594.

⁴Krech, D. and Crutchfield, R.S., Theory and problems in social psychology. New York: McGraw-Hill, 1948.

⁵see Lewin, K., Lippitt, R., and White, R.K., Patterns of aggressive behavior in experimentally created "social climates". J. Soc. Psych., 1939, 10, 271-299 for one of the early studies.

environmental conditions. Implicit in these studies and the continued effort of the Research Center for Group Dynamics⁶ is the assumption that in the group we find processes which are qualitatively different from those encountered in studying the individual organism. This is not simply a statement to the effect that there is interaction, but rather that this interaction is not predictable from knowledge of the characteristics of individuals. This is clearly consistent with the general notion of the Gestalt, a quality of wholes which is not available through analysis of the constituent parts. This is a perfectly legitimate view and one which may lead to the development of valuable additions to methodology. However, it is not the only permissible view, and the burden of proof of the efficacy of the view falls to the proponent. It must be demonstrated that more adequate predictions result from the use of internal, dynamic concepts, than can be attained by the psychometric operations based on measures of individuals.

B. The Prediction of Group Performance.

Two problems have been central in efforts to predict group performance. The first is the problem which has been uppermost throughout the entire history of the development of psychometric methods, namely, what is the criterion? While this is a central issue about which books are written, the particular area of group performance does not represent a unique problem. All of the types of criteria which can

⁶A recent book which serves as a status report on the work of the Center (though outside contributors are included) is Cartwright and Zander, (Editors), Group dynamics: Theory and research. Evanston, Ill.: Row-Peterson, 1953.

be obtained for an individual performance can be obtained for a group performance. While groups introduce additional sources of random error, it has not been demonstrated that criteria of group performance are inherently less reliable than those measuring individual performances of equivalent complexity.

The other problem is more unique to the problem of the group. It may be introduced by the following statement.

"In attempting to evaluate the performance of the crew as a whole, one immediately meets an interesting and important problem in Social or Group Psychology. The fundamental question is: Are the characteristics of a group of individuals, such as a combat crew, completely explained by summing up the individual characteristics of its members?"⁷

While it is clear enough that the question demands a negative reply, it is not at all clear as to what operations should substitute for the summing up. Haythorn⁸ has pointed out that "each individual probably makes some contribution to group behavior", but there is no implication that the contribution is equally distributed among the members.

A valuable contribution toward a solution of this problem is

⁷Psychological research on operational training in the continental air forces, AAF Aviation Psychology Program Research Report No.16, U.S. Gov't. Printing Office, 1947.

⁸Haythorn, W., The influence of individual members on the characteristics of small groups. J. Abn. and Soc. Psych., 1953, 48, 276-284.

Cattell's⁹ concept of three "panels of observation" for viewing groups. First there are population variables, which are simply statistical parameters of the measured characteristics of the component individuals. Second are structural variables which describe the group as a group. Third are syntality variables which represent the performance of the group.

"Structure and syntality variables are equally attributes of, and statements about the group while population measures have to do only with the people in the group."

"The primary relation to be expected is that the population measures, when properly combined with structural variables should enable one to predict the syntality."¹⁰

Most studies which have attempted to predict group performance have employed predictive variables which are structural in nature. Following Hemphill's¹¹ work on group dimensions, Rush¹² employed these dimensions in a predictive study of air crew performance. The relationships reported were generally low, partly as a function of criterion measures of doubtful relevance,¹³ and probably in part because there

⁹Cattell, R.B., Concepts and methods in the measurement of group syntality. Psych. Rev., 1948, 55, 48-63.

¹⁰Cattell, R.B., New concepts for measuring leadership in terms of group syntality. Human Relations, 1951, 4, 161-184.

¹¹Hemphill, J.K., Situational factors in leadership. Bureau of Educational Research Monographs, 1950, No. 32, Columbus, The Ohio State University.

¹²Rush, C.H., Group dimensions of aircrews. Ph. D. Dissertation, The Ohio State University, 1953.

¹³see Hemphill, J.K. and Sechrest, L.B., A comparison of three criteria of air crew effectiveness in combat over Korea. J. App. Psych., 1952, 36, 323-327.

was no clear basis for establishing crew scores. While means and variances were employed by Rush, and scores were computed for each position as well as for total crew, enlisted men, and officers, there were no bases for supposing that one combination would be more effective than another.

In a study of clerical worker groups, Gekoski¹⁴ demonstrated a relationship between certain population variables and a subjective evaluation of production. The two best predictors in this study were (1) difference in age between supervisor and workers, and (2) homogeneity of ages of workers. There was no specified reason to predict that these two would be most effective, although the fact of their presence indicates that the researcher thought that they might be important. It is probable that these measures were suggested by the knowledge which the investigator possessed about the job situation, either from formal job analysis data or from observational experience.

In the context of the practical problem of forming air crews, Roby¹⁵ has outlined some of the possibilities for determining crew scores. He notes that we might employ a homogeneous argument, in which the same measures were considered for all members; a cross-over argument, with different measures pertaining for different classifications,

¹⁴Gekoski, N., Predicting group productivity. Person. Psych., 1952, 5, 281-292.

¹⁵Roby, T.B., Problems of rational group assembly exemplified on the medium bomber crew. HRRC Research Bulletin, 53-18.

relational, or composite arguments. He also notes that additive, multiplicative, or curvilinear score-functions might be employed. It is evident that an investigation of all possibilities would be prohibitive.

C. Statement of the Problem.

The problem with which we are concerned exists in the following context. (1) We are given a number of individuals who function as members of a group. (2) The criterion performance (i.e. the performance on those tasks which constitute the reason for the group's existence) can be evaluated meaningfully only as a group performance. (3) The human characteristics which are presumably relevant to the criterion performance are possessed by individuals and become known to us as measure of individuals. (4) Using these measures of individuals' knowledge, skills, interests, etc., we wish to predict group performance.

Parenthetically, it may be noted that we could, of course, construct job sample tests which would give group performance scores as predictors. However, the use of such techniques would require that groups be formed before predictor information could be obtained. This would be of no value in the major practical problem of how to combine individuals into groups that will function with optimum effectiveness. In addition, it is difficult to see how a theory of group behavior is advanced through using group performance to predict group performance. What is clearly needed at the level of theory as well as at the level of practice, is knowledge concerning the manner in which individual abilities combine to produce group ability.

It is the thesis of this study that the needed knowledge is available as a series of inferences from job analysis¹⁶ data of the performances which are expected of the group.

Let us suppose that we have extensive job or activity analyses of a complex group performance. This performance might be the bombardment of enemy targets by an air crew, it might be the reconnaissance of a specified area by an infantry squad, it might be the determination of a remedial program for a given individual by a clinical team, it might be the assembly of a specified number and type of machine by a group of industrial workers; it might, in short, be any performance by any group. The activity analysis would include a description of this performance in terms of the critical requirements which were demanded of the performing group. This would be a psychological description; it would be in terms of human characteristics. A given activity might be described as requiring stamina, verbal intelligence, ability to make decisions rapidly, ability to operate without supervision, ability to coordinate individual efforts, or any combination of these and numerous other traits.¹⁷ The description would do more than list the critical traits. It would describe the context within which the trait was demonstrated; it would specify the amount of the quality needed; it would specify the

¹⁶In terms of accepted terminology, job analysis refers to the analysis of performance by individuals occupying similar positions. For this reason, the term activity analysis might be preferred in referring to job analysis operations applied to group performances in which several positions were represented by the group.

¹⁷Trait, as here employed, is synonymous with human characteristic as that term is used in the preceding discussion. As such, trait may refer to a measure of knowledge, skill, temperament, etc.

CHAPTER II

THE RESEARCH SETTING

A. Review of Project 20-H-1b.

In October, 1952, the Office Chief of Army Field Forces initiated sponsorship of a broad program of research aimed at surveying marksmanship training programs in all weapons areas. Sub-projects, each dealing with a particular class of weapon were awarded to three universities. Dr. John E. Horrocks of The Ohio State University supervised research dealing with antiaircraft artillery weapons under Contract Nonr 495 (01) between the Special Devices Center, ONR, and The Ohio State University Research Foundation. Following the survey phase of this research, the contract was amended to cover research designed to develop and test experimental training procedures. A complete account of the specific problems investigated and the progress made toward their solution is available in a series of reports published by the Special Devices Center, Port Washington, N. Y.^{1,2,3} While no attempt will be made to summarize these reports, certain aspects are germane in establishing the context within which the present investigation must be viewed.

Of primary importance is the concept of marksmanship which evolved

¹Horrocks, J.E., Krug, R.E., Bowlus, D.R., Training for anti-aircraft artillery gunnery. Human Engineering Report Spec DevCen, 495-01-1, 1952.

²Horrocks, J.E., Krug, R.E., Bowlus, D.R., Training 90-MM AA Gun crews. Human Engineering Report SpecDevCen 495-01-4, 1953

³Horrocks, J.E., Krug, R.E., Bowlus, D.R., Technical appendices 1, 2, 3, and 4, to Human Engineering Report SpecDevCen 495-01-4, 1953.

during early phases of the research. In regard to heavy antiaircraft artillery weapons, it became evident that marksmanship did not refer to "a man aiming a gun". Marksmanship actually involved a rather lengthy sequence of activities which were performed by gun crews. Some of these activities might appear to have little relationship to actual engagement procedures. For example, an activity such as orienting and synchronizing a gun and fire control system might be performed at a time when no imminent engagement is predicted. However, unless it is accomplished without error, accurate fire cannot be delivered later. The same relationship prevails for many "preparatory" activities; they are essential steps in the marksmanship schema for which no substitute exists. The consequence is that each activity in a specified sequence of activities is to be considered as a component of the ultimate criterion. In terms of a classification, selection, or training objective, it is obvious that crews must be competent in all aspects of the criterion; high ability on one activity does not compensate for low ability on another.

Having decided that several activities were of crucial importance, analyses of these activities were made. Extensive observations were made of gun crews in tactical defense positions. These crews were presumably representative of the final product of then current antiaircraft artillery training programs. Activities involving any seemingly complex, difficult, or critical behaviors were filmed, and the motion pictures were reviewed with the goal of abstracting from the total, the essential psychological characteristics of the performance. Several

summary statements may be made concerning the results of these analyses. (1) Most activities are essentially group performances. The behaviors of an individual must be integrated with the behaviors of one or more other members of the team if the performance is to be efficient. (2) The activities and the group are structured. All activities follow formal procedures with the individual's role being specified by virtue of his position in the group. (3) A special feature of this structuring is the specific role assigned the leader. The group has a permanent leader (Gun Section Leader) and sub-leader (Gunner). The leader's role is essentially supervisory. The sub-leader's role varies considerably with the activity, so that he may perform as the leader for one activity while functioning as a crew member for some other activity.

The next phase of the research consisted of the development and testing of various training methods. This development was based on the results of the activity analyses and on generally established principles of learning. After initial pilot studies, sixteen crews were trained on all activities, employing the methods which appeared most adequate. Further variations were tested for sub-samples of these sixteen crews. The terms of the contract specifically excluded classification and selection problems from the purview of the researchers. Consequently, no investigation was directed toward problems of crew composition. While variation in performance between crews was obviously noted, it was not treated as a problem for research. Training methods were accepted or rejected to the extent that they were associated with an increase or decrease in the level of performance of the

AGCT scores were gathered for trainees in two different batteries and comparisons were made between these groups and Samples A and B. Again, no statistically significant differences were found.

These men were assigned to Battery A for an eight week training program designated as Advanced Individual Training. Their prior Army training consisted of an eight week program of Basic Individual Training. The standard practice was to conduct both phases of training at the individual level; one innovation of the research project was to assign all trainees to crews at the outset of the Advanced Individual phase. These crews remained as permanent units throughout the training program. The crew assignments were made according to the following plan. Rosters were received several days prior to the arrival of the trainees. The thirty-two men in each sample who ranked highest on the AGCT were designated as leaders. In both samples, the top sixteen men were assigned in order as Gun Section Leaders of Crews 1 through 16. In Sample A, the trainees occupying ranks seventeen through thirty-two were assigned in reverse order as sub-leaders (Gunner) on Crews 1 through 16. In other words, a low leader (relative to other leaders) was paired with a high sub-leader (relative to other sub-leaders). In Sample B on the other hand, the pairing was high leader with high sub-leader, Crew 1 receiving the two men ranking first and seventeenth, Crew 16 receiving those standing sixteenth and thirty-second. In both samples, all other crew members were assigned by going down the alphabetized list and assigning one man to each crew in order until all men were assigned. Since the normal gun crew consists of eight men

(excluding ammunition handlers) each training crew had a full complement plus two or three alternates.

Although Samples A and B are analyzed independently in Chapters IV and V, it is assumed that relationships prevailing in one may be compared with those demonstrated in the other. It is necessary therefore, to consider any factors which might argue against the legitimacy of such a comparison.

First, the instructors responsible for the training are identical for the two samples. While the fact of instructing Sample A makes them more experienced instructors for Sample B, it is believed that this effect is minimal. The instructor group received intensive instruction from members of the research staff during a four week period prior to the pilot study. They were closely supervised during the eight week pilot study and deficiencies were remedied. During the sixteen weeks in which Samples A and B were trained, they were under constant observation by members of the staff. It is believed that the instructor factor is as nearly constant as such a factor can be.

Second, the operational equipment used was constant in quantity and as near constant in quality as the maintenance forces were capable of supplying. Parts of operational equipment subject to considerable wear due to heavy use in training were replaced or repaired frequently.

Training aids and instructional materials were identical for the two samples.

Climatic conditions, while highly variable, may have favored Sample A, since extremely high temperatures were more frequent in the case

CHAPTER III

PROCEDURES AND METHODS

A. Selection of Criterion Measures.

Four activities from the marksmanship sequence were selected as expressions of group performance. They were selected on the basis of three criteria. First, they represent essential activities in regard to the ultimate performance. Second, in terms of their essential nature, the activities differ. Together they include most of the types of requirement which are made of gun crews. Third, they are activities for which objective and seemingly relevant criterion measures are available. Descriptions of the activities and criterion measures follow.

1. Activity I. The activity is designed to transfer the weapon from a traveling to an emplaced position. The performance consists of a standardized sequence of behaviors, all of which require cooperative effort. The crew member must know what to do, when and how to do it, and must integrate his behavior with the behavior of one or more of his associates. The activity is supervised by the leader, who serves as a force for integration by (a) giving commands which call into play behaviors which have not occurred properly, and by (b) regulating the time of occurrence of certain behaviors, when the total situation cannot be gauged adequately by the participants.

The activity must be accomplished (a) without damage to personnel or equipment, (b) correctly, judged by the final

outcome, and (c) within these limits, as rapidly as possible. These requirements lead to two criterion measures. The total time required for each trial is available, as are scores from an error check list. A copy of the check list is included in Appendix A. Items were selected for the check list on the basis of frequent occurrence or because the step was of critical importance to the total task. The checklist was used by the instructor and an assistant instructor who checked all observed errors as they occurred.

Since each crew had eight trials on this activity, several expressions might be used to represent status on this criterion. It was decided to employ the following aspects as possible time criterion scores: (1) Mean time on all trials, (2) Mean time on the last three trials, (3) Time on best trial, (4) Reduction in time throughout the trials. The same four statements of error criterion score were also selected.

2. Activity II. The objective of the activity is to transfer the gun from an emplaced position to a traveling one. In essentials, the behavior required is identical with that of Activity I. The task requires greater exertion, which may make the coordination of individual performances more critical.

The criterion measures employed parallel those for Activity I. The error checklist for this activity is also included in Appendix A.

cooperative effort. The activity is supervised by both leader and sub-leader who may perform as information givers, instigators of behavior, and as demonstrators.

The criterion employed is a checklist, a copy of which is presented in Appendix A. This checklist gives two scores which reflect different aspects of the activity. In using the checklist, the instructor in charge interrogated each crew member independently, asking the question, "what did you do in this drill?" The instructor checked each item reported. The number of correctly reported items, summed for all members of a crew, forms the R score. The instructor also inspected the condition of each piece of equipment to which an item referred. (Some of this inspection could occur during the drill rather than after its completion.) Each item was checked as Satisfactory or Unsatisfactory, regardless of whether or not it had been reported as accomplished. The number of items found in satisfactory condition summed for the crew, becomes the S score. The R and S scores for the first trial would seem most relevant, since the first trial is the best measure of the outcome of prior training in maintenance activities.

B. Predictor Measures.

Two types of predictor are available. First, there is the Area I score on the Army General Classification Test. Second, is a 105 item Test of Nomenclature and Functioning, a copy of which is presented in Appendix A. This latter test is constructed from three shorter tests which were given as weekly tests for Samples A and B. It will be noted

that some items occur more than once in this test; this is a result of the practice of inserting some review items in these weekly tests. As it stands, the 105 item test consists entirely of items that were attempted by all members of both samples at identical stages of training. The reliability of this test for Sample A is .96, based on the Kuder-Richardson Formula 21. This may be considered as a lower bound for the reliability coefficient.

It is evident that these two predictive devices could be expected to account for only a limited portion of the variance in criterion performance. While the knowledge measured by the nomenclature and functioning test is directly relevant to all performances, the relationship between possessing knowledge and the ability to apply the knowledge is far from perfect. The criterion performances include behaviors where traits such as strength, motor coordination, mechanical ability and interest, and such personality variables as leadership, aggressiveness, motivation toward military service etc., are relevant. In other words, of many seemingly relevant trait measures, two are available for present purposes. These may be designated as (1) general ability (AGCT), and (2) specific knowledge of the job. The significance of this limited range of predictors for the present study is simply that the magnitude of the validity coefficients is likely to be low. In terms of the stated problem this limitation does not appear critical. The interest is in the relative predictive efficiency of various expressions of a group's score, and the available predictors would appear sufficient to provide an adequate test.

Two preliminary analyses were made on the 105 item test. Three subtests were formed by selecting sixteen items with high face validity for Activities I and II, nineteen items with face validity for Activity III, and thirty-one items with face validity for Activity IV. All subjects of Sample A were scored on these three subtests and the resulting scores were coded on a ten point scale. In the case of the first subtest, the range of scores was narrow and skewed toward the high end; in this case, the scores were dichotomized. Item-subtest correlations were then computed for all items. Table II presents the results of this analysis. All correlations with subtests II and III are biserial correlation coefficients, while those with subtest I are tetrachorics. Inspection of Table II indicates that the three subtests are not independent. There is a spurious element in all part-whole correlations, and when this is considered, it is even more evident that most items are positively related to all three subtests to approximately the same degree. While differential prediction on the basis of the subtests would therefore seem doubtful, it was decided tentatively to employ them as separate predictors on Sample A. On the basis of the item-subtest correlations, the three subtests were revised in an effort to make them as independent as possible. The original and revised item composition of each subtest is indicated in Table II. New keys were then built and all subjects of Sample A were again scored. The reliability of each subtest was estimated by the Kuder-Richardson Formula 21. The reliabilities as well as the intercorrelations between subtests are presented in Table III. The intercorrelations between the

TABLE II

Item-Subtest Correlations for
Test of Nomenclature and Functioning

Item	I	II	III	Item	I	II	III
1	* <u>.55</u>	.31	.54	41	.63	.64	* <u>.94</u>
2	* <u>.75</u>	.65	.90	42	.58	.55	* <u>.83</u>
3	* <u>.38</u>	.44	.57	43	.50	.38	* <u>.64</u>
4	* <u>.90</u>	.58	.64	44	.48	.45	* <u>.74</u>
5	* <u>.81</u>	.50	.78	45	.42	.59	* <u>.74</u>
6	* <u>.84</u>	.54	.62	46	.35	* <u>.41</u>	.35
7	* <u>.79</u>	.45	.77	47	.34	.43	.46
8	* <u>.78</u>	.54	.94	48	.12	* <u>.41</u>	.17
9	* <u>.84</u>	.55	.83	49	.18	* <u>.29</u>	.08
10	* <u>.77</u>	.56	.60	50	.31	.32	.21
11	* <u>.90</u>	.72	.83	51	.28	* <u>.47</u>	.41
12	* <u>.87</u>	.45	.65	52	.17	.26	.26
13	* <u>.95</u>	.44	.60	53	.16	* <u>.57</u>	.37
14	* <u>.94</u>	.49	.59	54	.07	* <u>.51</u>	.33
15	* <u>.84</u>	.68	.85	55	.26	* <u>.51</u>	.42
16	* <u>.88</u>	.65	.82	56	.42	* <u>.68</u>	.59
17	<u>.58</u>	.42	.45	57	.58	.65	.68
18	.29	.33	<u>.59</u>	58	.41	.41	.67
19	.71	.59	<u>.96</u>	59	.43	.57	* <u>.63</u>
20	.85	.59	1.00	60	.21	.22	* <u>.31</u>
21	.73	.48	<u>.91</u>	61	.00	.70	* <u>1.00</u>
22	.60	.53	<u>.98</u>	62	.31	.49	.67
23	.50	.36	<u>.44</u>	63	.47	.54	* <u>.82</u>
24	.43	.23	.26	64	.58	.60	* <u>.89</u>
25	.60	.40	* <u>.96</u>	65	.50	.63	* <u>.93</u>
26	.74	.49	* <u>.89</u>	66	.35	.59	* <u>.89</u>
27	.88	.55	* <u>1.00</u>	67	.43	* <u>.69</u>	.49
28	.67	.54	* <u>.83</u>	68	.48	* <u>.69</u>	.48
29	.67	.59	* <u>.89</u>	69	.51	* <u>.82</u>	.55
30	.55	.39	* <u>.73</u>	70	.48	* <u>.77</u>	.52
31	.40	.43	* <u>.65</u>	71	.48	<u>.43</u>	.48
32	.60	.51	* <u>.81</u>	72	.06	-.09	* <u>-.06</u>
33	.38	.30	* <u>.69</u>	73	.32	.31	* <u>.43</u>
34	.43	.41	* <u>.59</u>	74	.32	.47	* <u>.45</u>
35	.51	.48	* <u>.88</u>	75	.35	.37	* <u>.41</u>
36	.47	.56	<u>.53</u>	76	.50	* <u>.57</u>	.36
37	.31	.40	.27	77	.43	<u>.66</u>	* <u>.74</u>
38	.27	.15	.12	78	.26	.62	* <u>.61</u>
39	.60	.34	.37	79	.16	.56	* <u>.66</u>
40	.62	.52	.52	80	.50	.60	.68

Entries marked with asterisk indicate items in original subtests.

Entries underlined indicate items in final subtests.

TABLE II (Cont'd.)

Item	I	II	III	Item	I	II	III
81	.34	.36	* .40	94	.43	.43	.46
82	.34	.56	.51	95	.56	* .67	.38
83	.55	.69	.65	96	.62	* <u>.79</u>	.60
84	.67	.72	.62	97	.47	* <u>.59</u>	.62
85	.62	.76	.60	98	.55	.48	.49
86	.74	.80	.68	99	.49	.46	.48
87	.67	.67	.73	100	.57	.62	<u>.91</u>
88	.48	.61	.60	101	.57	.58	<u>.88</u>
89	.51	.58	.52	102	.60	.62	<u>.93</u>
90	.53	.58	.60	103	.49	* <u>.57</u>	<u>.66</u>
91	.63	.75	.76	104	.60	* <u>.65</u>	.79
92	.62	.68	.67	105	.08	* <u>.45</u>	.26
93	.48	.48	.42				

measure of a relevant trait for a number of individuals, how can we predict whether the necessary integration will take place? The answer advanced is that a measure of the homogeneity of the group on the trait in question will lead to such prediction. Consequently, we can compute the variance for the crew on a given measure, and use this score as the predictor of a performance which requires this type of integrated behavior. Inasmuch as the leaders ordinarily function somewhat outside of the group (as supervisors), it is probable that the variance should be based on the scores of the crew members excluding leaders. We will use both of these estimates (total crew and crew minus leaders) for our first analysis.

Since leadership was mentioned as a significant feature of the activities which we wish to predict, the score of the leaders on a relevant trait might, for certain activities, be taken as the best estimate of a crew's future performance. For the first analysis we can compute an absolute score (average of two leaders) and a relative score (leaders' score minus crew score).

A third kind of score is required by the presence of one criterion performance which consists essentially of summed individual performances. In this case, the amount of the relevant trait possessed by the crew would seem to provide the necessary kind of estimate. The mean score of the crew, or the mean score of the crew minus leaders will be employed.

It is evident that there are innumerable other scores which could be derived by employing other combinatorial methods. Any sequence of

mathematical operations could be applied to build group scores from a series of individual scores. The present study is not designed to investigate any significant proportion of the possible scores; the objective is to test the value of a rationale for the development of such scores.

D. Statement of Hypotheses.

The general hypothesis for this study is: The method of combining individual scores to form the optimum estimate of a group's future performance may be determined by logical deduction from the critical factors in the future performance, as these factors are revealed by job analysis. Application of this hypothesis to the particular situation under investigation leads to the following specific hypotheses.

1. A measure of homogeneity of a relevant trait¹ among members of a group will predict group performances characterized by a high degree of coordination between group members.

Performance on Activities I and II, in which coordination is a crucial factor, should be predicted by the Variance of the crew on a relevant measure. Activity III, while standing lower than Activities I and II in terms of its requirement for coordinative behavior, should also show a relationship with crew Variance, since a time criterion is employed. Time is lost through failure to integrate individual efforts, even though the criticalness of the integration may be minor in terms of ultimate outcome.

¹Relevant trait is employed in the sense indicated in Section B of this chapter. A trait is posited as relevant in terms of the critical factors isolated by job analysis.

- 1a. A measure of homogeneity of a relevant trait among members of a group will predict a time criterion of group performance to a greater degree than an error criterion.

Performance on Activity IV should show little relationship to the Variance of the crew.

- 1b. A measure of homogeneity of a relevant trait among members of a group will be a poor predictor of group performances characterized by a high degree of individual activity.
2. The amount of a relevant trait possessed by leaders of a group will predict group performance in activities where supervision is of primary importance.

Performance on Activity III should be related to leader score on a relevant trait.

Activity IV is a closely supervised task in which there is considerable individual activity. As such, group performance should be related to leader score as indicated in hypothesis 2 above. Since the leader can exercise more direct control over what the crew member does than over what the crew member remembers, the leader score will predict the S criterion better than the R criterion. However, this statement of the expected degree of relationship should not obscure the fact that both R and S measures derive from an activity where leadership is a major factor, and both should be somewhat related to the score of the leader on a relevant predictor.

Activities I and II are also supervised tasks, but the effect of supervision here is somewhat restricted by the nature of the task. The leader can instigate a behavior, he can interfere with or stop a

behavior, and to some extent he can facilitate the accomplishment of a behavior. However, in this latter case, the ability of the individual performer and the ability of several individuals to integrate their performance are limiting factors.

- 2a. In a complex, coordinated group performance, the amount of a relevant trait possessed by the leader will be a better estimate of an error criterion than of a time criterion.
3. The average amount of a relevant trait possessed by members of a group will estimate future performances which are characterized by a high degree of individual behavior.

The mean score of the crew on a relevant measure should predict performance on Activity IV, showing a higher relationship with the R score than with the S score. Performance on Activities I and II should show little relationship to an estimate of this type, unless the homogeneity of the groups were held constant.

- 3a. The average amount of a relevant trait possessed by members of a group will be a poor predictor of performances where the behaviors to which the trait refers must be coordinated in order to produce effective results.

Criterion measures which reflect individual behaviors should show some relationship to estimates based on level of trait possessed, even though the total performance is not one in which individual activity is central.

- 3b. The average amount of a relevant trait possessed by members of a group will be more highly related to an error criterion than

to a time criterion in complex, coordinated group performances.

The specific deductions made from these eight hypotheses will be tested in the following chapters.

CHAPTER IV

ANALYSIS OF SAMPLE A

A. Correlational Analysis.

From the five test scores available for each of the 170 subjects, thirty-three scores were computed for each of the sixteen groups. The list of these scores is presented in Table IV, which indicates the source of the score and the nature of the resulting group score.

From measures of crew performance on four activities, twenty-two criterion scores were computed for each of the sixteen groups. Table V lists these measures.

Since all intercorrelations between these fifty-five variables were desired, the crew scores were converted to ranks in order to facilitate the computations. On each variable, the rank of 1 was assigned to the extreme group at the "good" end of the scale. For example, the group with the highest average score on a test was assigned the first rank, while the group having the lowest variance was assigned first rank on the homogeneity measure. On the criterion side, low time and low error are both "good", while high R score, and high time reduction are "good". All rankings then are from presumably good to presumably bad rather than from high to low on raw score. The rank of each crew on each variable is indicated in Table XVIII.

Rank-difference coefficients of correlation (ρ) were then computed, resulting in 1485 coefficients. These are presented in Table XIX which, with Table XVIII is found in Appendix B.¹

¹These tables are placed in an Appendix because of their length. Relevant portions will be presented in context.

TABLE IV

List of Predictor Variables

No.	Source	Measure
1	Subtest I	Mean score of total crew
2	" "	Mean score of crew excluding leaders
3	" "	Variance of total crew
4	" "	Variance of crew excluding leaders
5	" "	Leader plus sub-leader minus mean of crew
6	Subtest II	Mean score of total crew
7	" "	Mean score of crew excluding leaders
8	" "	Variance of total crew
9	" "	Variance of crew excluding leaders
10	" "	Leader plus sub-leader
11	" "	Leader plus sub-leader minus mean of crew
12	Subtest III	Mean score of total crew
13	" "	Mean score of crew excluding leaders
14	" "	Variance of total crew
15	" "	Variance of crew excluding leader
16	" "	Leader plus sub-leader
17	" "	Leader plus sub-leader minus mean of crew
18	Total Test	Mean score of total crew
19	" "	Mean score of crew excluding leaders
20	" "	Variance of total crew
21	" "	Variance of crew excluding leaders
22	" "	Leader plus sub-leader
23	" "	Leader score
24	" "	Sub-leader score
25	" "	Leader plus sub-leader minus mean of crew
26	Army General Classification Test	Mean score of total crew
27	"	Mean score of crew excluding leaders
28	"	Variance of total crew
29	"	Variance of crew excluding leaders
30	"	Leader score
31	"	Leader plus sub-leader
32	"	Sub-leader
33	"	Leader plus sub-leader minus mean crew

The reduction of Table XIX according to these general principles results in a set of correlations which may be employed to test the hypotheses which were stated in Chapter III. Using all possible correlations for such tests would have the effect of magnifying any relationships which were present by adding a spurious component. The reduced table consists of measures which are at least as independent as the available measures allow.

Table VI presents the correlation coefficients (rho's) between the fifteen predictors and seven criteria which will be employed in the ensuing analysis.

Since certain tests require the addition, subtraction, multiplication, etc. of the tabled entries, the correlation coefficients of Table VI were transformed to z equivalents.² The resulting table of z 's appears in Table VII. The z 's will be employed in all subsequent tests, even though the rho's would suffice for many non-parametric tests.

B. Tests of Hypotheses.

The general procedure to be followed in this section will involve the application of non-parametric tests of significance as a matter of computational convenience. Where significance is demonstrated by such techniques, significance would always be demonstrated by application of parametric tests. Hence, no increase in the likelihood of Type I errors is introduced by using these statistical methods. Where the non-parametric test fails to give a clear statement of support or rejection of

²For table of r to z transformations, see McNemar, Q., Psychological statistics. New York: John Wiley and Sons, 1949.

TABLE VI

Rank-Difference Correlations For Selected Variables On Sample A

Predictors		Criteria						
		M _T I	M _E I	M _T II	M _E II	M _T III	R ^{IV}	S ^{IV}
		34	38	42	46	50	52	54
Mc	2	-.06	-.04	.15	.32	.44	.24	.00
Vc	4	.12	.06	.19	.23	.61	.52	.11
L	5	-.01	-.01	-.13	-.25	-.64	-.20	.12
Mc	7	.06	-.12	.30	.15	.11	.17	.06
Vc	9	.25	.50	-.13	-.10	-.35	-.29	-.08
L	10	.02	-.35	.19	.02	.03	.33	.55
L-Mc	11	-.07	-.25	-.14	-.06	-.03	.18	.40
Mc	13	-.02	-.08	.23	.30	.37	.31	.05
Vc	15	.24	.28	.51	.25	.50	.45	-.04
L	16	-.10	-.37	-.03	-.10	-.41	-.26	.17
L-Mc	17	-.11	-.32	-.15	-.16	-.49	-.43	-.06
Mc	27	-.24	.35	-.14	.04	.18	.24	-.06
Vc	29	.34	-.16	.19	-.07	-.21	-.09	.40
L	31	-.34	-.28	-.48	-.28	-.41	-.43	.34
L-Mc	33	.01	-.45	.05	.02	-.37	-.43	.16

TABLE VII

Transformation (rho to z) of Table VI

Predictors	Criteria						
	34	38	42	46	50	52	54
2	-.060	-.040	.151	.332	.472	.245	.000
4	.121	.060	.192	.234	.709	.577	.10
5	-.010	-.010	-.131	-.256	-.758	-.203	.121
7	.060	-.121	.309	.151	.110	.172	.060
9	.256	.549	-.131	-.100	-.366	-.299	.424
10	.020	-.366	.192	.020	.030	.343	.618
11	-.070	-.256	-.141	-.060	-.030	.181	.424
13	-.020	-.080	.234	.309	.389	.321	.050
15	.245	.288	.563	.256	.549	.485	-.040
16	-.100	-.389	-.030	-.100	-.436	-.266	.171
17	-.110	-.332	-.151	-.161	-.536	-.460	-.060
27	-.245	.366	-.141	.040	.181	.245	-.060
29	.354	-.161	.192	-.070	-.214	-.090	.424
31	-.354	-.288	-.523	-.288	-.436	-.460	.354
33	.010	-.485	.050	.020	-.389	-.460	.161

and consequently supports the hypothesis. With two tests available then, one supports the hypothesis while the other clearly refutes it.

Hypothesis 2a. If this hypothesis is true, the leader score should predict performance measured by the error criterion of Activities I and II to a greater extent than performance on the same activities as measured by a time criterion. There are fourteen pairs of correlations which may be employed in this test. Twenty-three of these twenty-eight correlations are negative, reflecting the generally negative status of the leader variables in this sample. Those coefficients which express a relationship with the error criterion are more negative than the ones relating to time. This difference (which is in the opposite direction from that predicted) is present in ten of fourteen pairs. This would be an expected occurrence in six samples out of one hundred. The hypothesis is rejected; further, the data suggests an opposite statement of relationship.

Hypothesis 3. A deduction from this hypothesis is that the mean score of a crew will predict the R score of Activity IV, and will show less relationship to the S score. Table IX presents the data for testing the significance of the difference between predictions of R and S.

TABLE IX

The Relation of Mean Score With R and S Scores

Criterion	M	s.d.	s.d. _M	s.d. _{MD}	t	p
R	.245	.052	.030	.032	7.62	>.01
S	.010	.024	.014			

The hypothesis is supported.

individual efforts performs well in all situations, regardless of the demand which the situation makes for coordinated activity.

2. The ability of the leaders on a presumably relevant trait is of little value in predicting the performance of a group on any of the tasks with which this study is concerned. The only exception to this generalization is an activity where the leader is exclusively engaged in supervising performances which are essentially individual, and where he is free to make a point-by-point investigation of what is happening.

CHAPTER V

ANALYSIS OF SAMPLE B

A. Correlational Analysis.

The testing of hypotheses in Sample A was accomplished using twenty-two variables which were selected from the original fifty-five. These consisted of fifteen predictors which were relatively independent, and seven measures which adequately represented the four criterion activities. For Sample B, these twenty-two variables form the basis for analysis. They are listed in Tables XI and XII.

The sixteen groups comprising Sample B were ranked on the twenty-two variables, with the result indicated in Table XIII. Finally, the rank-difference correlation coefficients were computed between predictors and criteria.¹ These correlations are presented in Table XIV. The transformed table of z's is presented in Table XV.

B. Testing of Hypotheses.

In every instance, the tests for this sample are identical with those of the preceding chapter. The results are presented below.

Hypothesis 1. The correlations between variance scores and performance on Activities I and II are generally negative. The hypothesis is refuted.

Hypothesis 1a. There is no consistent difference between time and error relationships to variance scores. The hypothesis is refuted.

¹The complete table of intercorrelations was not computed, since most of these relationships were not of interest. Specific inter-relationships which are essential will be presented and discussed at a later point.

TABLE XIII

Rank of Crews On Twenty-two Variables

Crew	Variable									
	1	2	3	4	5	6	7	8	9	10
1	1.5	8	14.5	1	6	4	12	8	12	8
2	6	3	12	15	7	2.5	1	7	2	1.5
3	15	14	1	12.5	3.5	2.5	4	9.5	15	8
4	8.5	7	8.5	16	15	5.5	2	9.5	11	5
5	4.5	1	16	5	5	13	13	1	1	14
6	12.5	16	3	8.5	10	1	3	11.5	14	1.5
7	8.5	12	8.5	7	13	8.5	8	4	10	8
8	4.5	5	11	3	11	8.5	11	2	5	15
9	16	10	3	12.5	3.5	5.5	6	16	6	8
10	8.5	6	8.5	14	16	13	5	11.5	7.5	12
11	11	11	5	4	8	13	14	14	7.5	12
12	8.5	9	8.5	11	9	13	10	6	4	16
13	3	4	13	2	2	13	15.5	3	3	3.5
14	12.5	13	3	10	1	8.5	7	15	13	12
15	14	15	6	6	12	8.5	9	13	16	3.5
16	1.5	2	14.5	8.5	14	16	15.5	5	9	8

Crew	Variable								
	11	12	13	14	15	16	17	18	19
1	8.5	5	9	1	3	8.5	13	13	15
2	4	15	2	2.5	1	6	1	11	3
3	7	14	1	4	2	16	14.5	9	9
4	5	7	12	2.5	4.5	7	14.5	3	8
5	15.5	2	15	5	10	1	16	12	12.5
6	1.5	3	4	7	11	8.5	5	5	4
7	12	12	10	6	4.5	11.5	8.5	1	7
8	15.5	13	11	10	7	4	7	2	1
9	1.5	16	5	8	6	11.5	11	8	11
10	8.5	9	3	10	9	13	2.5	6.5	2
11	13	1	13	12	15	10	2.5	4	5
12	14	11	8	10	8	2	10	15	14
13	10	4	6	13	14	5	8.5	14	12.5
14	6	6	14	14.5	13	14	4	16	6
15	3	8	16	14.5	12	3	6	6.5	10
16	11	10	7	16	16	15	12	10	16

Hypothesis 1b. The relationship between variance scores and performance characterized by a high degree of individual activity is low, as predicted. The mean value of the eight correlations is .05 which is not significantly different from zero. The hypothesis is supported.

Hypothesis 2. Again, two tests are available. The first tests the departure from zero (in a positive direction) of the seven correlations between leader scores and performance in Activity III. The mean z is .102 which is not significantly different from zero, though the departure is in the predicted direction.

The second test involves comparing the correlations between leader and S score of Activity IV with the correlations between leader and R score of the same activity. All seven differences are in the predicted direction, which is significant beyond the .01 level. As in Sample A, the first test refutes the hypothesis while the second confirms it.

Hypothesis 2a. The correlation between leader score and the error criterion of Activities I and II is greater than the mean of the correlations between leader score and time criterion in thirteen of fourteen cases. This difference ($t=3.2$) is significant at the .003 level. The hypothesis is accepted.

Hypothesis 3. There are four pairs of correlations between the mean score of the crew and the R and S scores of Activity IV. All four of the correlations with R are above the mean correlation with S. However, the significance level for this occurrence is only .125. The support for this hypothesis is very weak.

Hypothesis 3a. There are sixteen correlations between mean score and time and error scores for Activities I and II. The average z is .00 which is the degree of relationship predicted. The hypothesis is supported.

Hypothesis 3b. The above group of correlations consists of eight relationships with time and eight with error. Seven of the eight correlations with time are above the average correlation with error. This is opposite to the predicted effect. The hypothesis is rejected.

C. Summary.

Sample B shows a quite different pattern of relationships than does Sample A. In general, leader score predicts all activities, while the variance score shows only scattered relationships. This difference will be considered in some detail in the following chapter.

CHAPTER VI

DISCUSSION OF RESULTS

It may be helpful to restate the specific hypotheses advanced along with the outcomes of their testing in Samples A and B. Table XVI presents this summary.

Certain of these hypotheses (1a, 2, 2a, 3b) refer wholly or in part to the fact that the specific expression chosen to represent a criterion has an effect on the kinds of measures which will predict the criterion. These hypotheses are simply attempts to formalize this relationship. It is evident that certain of these are supported by the data. For example, given a performance which consists essentially of supervised individual performance (Activity IV), the degree to which the ability of the leader predicts this performance depends on the criterion measure chosen (the S score is predicted significantly better than R). It is also evident that in other examples, the logic applied is fallacious, and a contrary statement would more nearly describe the relationship found. For example, it was hypothesized that the average amount of a trait possessed by a group would show a higher relationship with an error measure than with a time measure of a highly coordinated performance, since errors are made by individuals while speed is a function of integrated teamwork. On the basis of the evidence reported in Chapters IV and V, it would seem that groups whose individual members are high on a relevant variable perform adequately in terms of speed, and that this is accomplished at the expense of smooth and errorless performance. However, this relationship is

TABLE XVI
SUMMARY OF RESULTS

Hypothesis	Outcome	
	Sample A	Sample B
1. A measure of homogeneity of a trait among members of a group will predict group performances characterized by a high degree of coordination between group members.	Supported	Rejected
1a. A measure of homogeneity of a trait among members of a group will predict a time criterion of group performance to a greater degree than an error criterion.	Rejected	Rejected
1b. A measure of homogeneity of a trait among members of a group will be a poor predictor of group performances characterized by a high degree of individual activity.	Rejected	Supported
2. The amount of a relevant trait possessed by leaders of a group will predict group performance in activities where supervision is of primary importance.	Some support	Some support
2a. In a complex, coordinated group performance, the amount of a relevant trait possessed by a leader will be a better estimate of an error criterion than of a time criterion.	Rejected	Supported
3. The average amount of a relevant trait possessed by members of a group will estimate future performances which are characterized by a high degree of individual behavior.	Supported	Some support

TABLE XVI (Cont'd.)

Hypothesis	Outcome	
	Sample A	Sample B
3a. Amount of a trait possessed by a group will be a poor predictor of performances where the behaviors to which the trait refers must be coordinated in order to produce effective results.	Supported	Supported
3b. Amount of a trait possessed by a group will be more highly related to an error criterion than to a time criterion in complex, coordinated group performances.	Rejected	Rejected

embedded in a more complex one which involves the nature of leadership and group homogeneity, and will be considered again in that light.

Hypotheses 1, 1b, 2, 3, and 3a are statements about the relationships which should prevail between population variables and syntality variables, as these terms are employed by Cattell.¹ They are attempts at deducing information about group structure from knowledge of task requirements. As such, they constitute the major interest of this study.

Hypotheses 3 and 3a refer to the predictive value of estimates based on summing individual's scores. In general, these hypotheses find support in the data.

Hypotheses 1 and 1b refer to measures of group homogeneity on a relevant trait (group variance), while hypothesis 2 refers to the predictive value of the leaders' score as an estimate of group performance. In general, the homogeneity of the group predicts most performances in Sample A, while the leader scores predict performances in Sample B. The result is that hypotheses which find support in one sample are refuted in the other. The analysis of this difference and its implications becomes a major requirement if we are to account for the data of this study.

It has been noted that the manner in which leaders were paired differed between the two samples. In Sample A, high leaders were assigned with low sub-leaders (on the basis of AGCT), while in Sample B,

¹Cattell, R.B., Concepts and methods in the measurement of group syntality, Psych. Rev., 1948, 55, 48-63.

high leaders were associated with high sub-leaders.

Viewed in terms of performance, we may say that leadership did not operate in Sample A. In one sense of course, it could be argued that leadership was involved, in that the good leader was one who allowed the inherent abilities of his group (as homogeneity) to operate. This argument however, does not void the charge that leadership potential was wasted, since the ability of the leader made no contribution to group performance. It might also be argued that possession of the measured traits was not relevant to leadership, but in this case we would be faced with difficulty in accounting for the positive correlations between leader score and group performance in Sample B.² There would seem to be evidence that leadership behavior was facilitated by the assignment of leaders who were somewhat near one another in ability. One test of this would be to compute the difference scores between leader and sub-leader and correlate this measure (ranked from low and high) with group performance. This was done for AGCT scores on Sample A, with results indicated in Table XVII. This measure is very nearly a constant for Sample B because of the way in which leaders were assigned. In a sense then, Sample B held this difference-between-leaders factor constant, and investigated the effect of variation in mean ability of leaders.

This line of reasoning about the data suggests that in the group of performances under consideration, the leadership role involves what

²It should be noted that in both samples, the correlation between leader score and mean crew score was low, while the relationship between leader score and crew homogeneity was low and negative.

TABLE XVII

Rank-Difference Correlations Between Leader-Difference
Score on AGCT and the Seven Criterion Measures

$M_{T I}$	$M_{E I}$	$M_{T II}$	$M_{E II}$	$M_{T III}$	R^{IV}	S^{IV}
.04	.36	.35	.39	.10	.58	.34

Gibb³ has called a harmonizing function. The leader serves as a force for integration in activities where this integration is essential to successful group performance. Where this function is absent, the "natural" integration of the crew is the major determiner of group performance. Possible support for this analysis comes from the correlational analysis of Sample B, reported in Table XVI. It may be noted in this table that the measures of homogeneity show higher correlations with the time measure of Activity I than do the leader scores, but that this relationship is reversed for Activity II. While no great reliance may be placed in this trend, it would at least be reasonable to expect that any leadership effect would require some time to develop, and that prior to its establishment, the performance of crews would be predicted by "built-in" crew features.

While the above discussion admittedly falls short of explaining all of the results of this study, more detailed statements of explanation are probably not warranted. It is true that the segments of behavior investigated are very limited relative to some other performances of military and like groups, and it is also true that for a

³Gibb, C. A., An experimental approach to the study of leadership. Occup. Psychol. 1951, 25, 233-248.

naturalistic study of groups, certain relevant factors were more under the control of the investigators than is usually the case. Nonetheless, any realistic appraisal of the study must recognize that (1) many possibly relevant factors were completely uncontrolled, such as transitory motivational attitudes, (2) the number of crews involved in each sample is very small, allowing chance factors to play determining roles at indeterminate points, (3) as noted earlier, the available predictors covered only a small portion of the traits which job analysis would indicate as relevant, and (4) at the current stage of research on group behavior, studies such as this one are of value primarily as they generate hypotheses concerning the relevant variables for future study. Consequently, the data will now be considered in terms of some tentative conclusions which have a bearing on research practices as well as some implication for group assembly procedures.

1. There seems to be sufficient support for the general hypothesis advanced in Chapter III to suggest that a similar rationale be applied as a device to select the measures which would comprise the original matrix in a larger study of group scores. As Roby⁴ has indicated, the number of predictive scores that are possible, given a number of individuals who are to form groups, is extremely large. We have a number of scores available for each person, and might be interested in various combinatorial functions of various trait scores for various individuals. The use of job analysis data on expected performances offers the

⁴Roby, T. B., Problems of rational group assembly exemplified in the medium bomber crew. HRRC Research Bulletin 53-18.

possibility of reducing the tremendous labor of analysis as well as making validation possible with less than an infinite number of groups.

2. The data warrants the conclusion that group performance can be predicted from population variables, even when the predictors employed cover only a very restricted segment of the behaviors involved in the performance. While group performance may not always be evident from summing individual measures, summing is after all, a rather simple operation, and one which hardly exhausts the possibilities. It is suggested that rather than postulating some new and not predictable quality, we look for a priori reasons for performing other operations on the individual scores as a means of establishing group scores. The present study has shown that in certain types of group performance, simple summing of individual scores will estimate the adequacy of performance. Continued effort is clearly needed to specify the conditions which determine what operations are necessary. Our current knowledge of group behavior seems insufficient to warrant the conclusion that fundamentally new problems are present.

3. No structural variables were involved in the present study. The nature of the structure of successful groups was inferred from activity analyses; actually, job analyses of group performances consist essentially of statements about the required structure. It is evident that group dimensions, such as those developed by Hemphill⁵ occupy an

⁵Hemphill, J. K., Situational factors in leadership. Bur. Ed. Res. Mon., 1950, No.32, Columbus, Ohio, The Ohio State University.

essential position in the predictive picture. Rush⁶ has demonstrated a relationship between certain of these dimensions and a rating-type criterion for a sample of combat crews. Rush observed that there was no reason for using a mean score to represent the crew's position on any dimension, but there was no basis for using some other type of score. The reasoning applied in the present study is equally applicable to the problem of how to determine a crew's score on a structural variable. In the total predictive sequence, the structure variable is analogous to what Thorndike⁷ has termed an intermediate criterion. Since our research will most often be concerned with groups whose assembly was beyond the researcher's control, we will find it most profitable to investigate relationships between dimensions and performance, which is to say, between structure and syntality. In subsequent assembly of groups, we will be concerned with using individual measures to predict the structure, since dimensional measures will exist at all stages of the group's development and at some stage will constitute a sufficiently adequate estimate of syntality to permit group selection to occur.

4. If a practical goal is to assemble groups so as to provide a number of outstanding crews (such as lead crews for Air Force squadrons) the obvious procedure seems to be the correct one. The procedure

⁶Rush, C. H., Group dimensions of aircrews. Ph. D. Dissertation, The Ohio State University, 1953.

⁷Thorndike, R. L., Personnel selection. New York: John Wiley and sons, 1949.

outlined in AAF Letter 50-117⁸ which directed the assembly of crews composed of those individuals possessing the highest scores (on relevant predictors) for each crew position, would apparently give the desired results.

5. If the practical problem was to make optimum use of all individuals available in the assembly of crews, the data of this study would suggest a somewhat different procedure. Two conclusions seem relevant: (a) the ability of the crew, and the ability of the leaders seem to occupy a compensatory relationship, (b) the relationship between positions of leadership within a group is not compensatory. It would therefore seem indicated to form groups by assigning crew members who were similar on relevant traits, and to then assign good leaders to poor groups and poorer leaders to better groups. However, the data of this study does not include instances where leaders are below crew average on a predictor; consequently the above suggestion is so restricted. It would be very surprising if this compensatory factor extended to cases where the crew members were superior to their leaders on variables relevant to the expected performance.

6. While no additional evidence is required, the current study demonstrates the degree to which our predictive efforts are bound by arbitrary choices of criterion measures. In terms of logical evaluation, both time and error measures are relevant measures for two of the activities considered. It is quite evident that these two expressions

⁸published in Psychological research on operational training in the continental air forces, AAF Aviation Psychology Research Report No.16, U.S.Gov't. Printing Office, 1947.

are quite different aspects of a total performance, which show quite different relationships with the predictors employed.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The general hypothesis for this study was that the method of combining individual scores to form the optimum estimate of a group's future performance might be determined by logical deduction from the critical factors in the future performance, as these factors are revealed by job analysis. On the basis of activity analyses of the expected group performances, eight specific hypotheses were advanced. These constituted specific predictions concerning the relationships which would prevail between the predictors and criteria employed.

Two samples of sixteen crews each comprised the sample for the investigation. Four group performances were selected on the basis of (1) their representativeness and (2) the availability of objective measures of performance. From these four activities, twenty-two expressions of performance were computed. Five test scores were available for each individual in the study. In terms of the hypotheses, various types of group score were computed from these individual scores; thirty-three group scores resulted.

The crews in the first sample were ranked on these fifty-five variables, and all intercorrelations were computed. The elimination of overlapping variables resulted in the selection of fifteen predictor variables and seven criteria. The correlations between these variables provided the data for testing each hypothesis.

The selected variables were then employed in a similar analysis for the second sample, and identical tests were made. Differences

between the results of the two samples were discussed, and tentative explanations were advanced.

The data permits the following conclusions.

1. Job analysis data provides information about the required group structure, and this information is useful in determining the nature of the scores taken as representing the group.
2. The score of the leader will be an adequate estimate of group performances characterized by a high degree of supervised individual activity.
3. The average amount of a relevant trait possessed by members of a group will estimate future performances characterized by a high degree of individual activity.
4. The average amount of a relevant trait possessed by members of a group will be a poor estimate of group performances in which the behaviors to which the trait refers must be coordinated with the behaviors of others in order to produce effective results.
5. In the absence of effective leadership, a measure of homogeneity of a trait among members of a group will predict performances characterized by a high degree of coordinated activity among group members.
6. Effective leadership serves as a force toward integration of behaviors among group members, compensating for the absence of trait homogeneity. In this sense, effective leadership is associated with a low difference between the scores of leader and

sub-leader.

While very tentative, certain implications for research and practice are noted.

1. The rationale employed in this study would appear equally applicable to studies investigating relationships between group structure and performance.
2. The relationship between population variables and structure seems analogous to the relationship between predictors and intermediate criteria, with syntality variables representing more distal criteria.
3. In view of the above, a rather traditional psychometric approach¹ to group performance should be feasible, since the problems involved seem to be familiar rather than unique.
4. For purposes of group assembly, the suggested relationships (i.e. leader and crew compensate for one another; leader and sub-leader do not) would seem worthy of additional investigation.

¹As here employed, traditional psychometric approach would describe most of the activities of the Personnel Research Board at the Ohio State University, of Cattell, and of the Human Resources Research Center of the U.S. Air Force. It is contrasted with work generally included under the term group dynamics.

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APPENDICES

APPENDIX A

Test of Nomenclature and Functioning¹

1. This is a picture of the:²

- a. mechanical leveling jack
- b. hydraulic jack
- c. jack ram
- d. leveling socket

2. Its purpose is to:

- a. raise the mount to permit removal of bogies
- b. level the top carriage
- c. center the gun tube
- d. support the shear pin

3. How many of these are on the gun?

- a. one
- b. two
- c. three
- d. four

Match the following with the illustration:

- 4. ____ jack stay
- 5. ____ by-pass valve
- 6. ____ jack ram
- 7. ____ jack handle
- 8. ____ filler cap
- 9. ____ T-handle wrench

¹Developed by the staff of Project 20-H-1b, and reported in Special Devices Center Technical Report 495-01-4.3.

²Items beginning with the stem, "This is a picture of ---", refer to drawings on Ozalid overlays which are projected on a screen at the front of the testing room.

10. This is a picture of:

- a. mechanical leveling jack
- b. hydraulic jack
- c. jack ram
- d. leveling socket

11. Its purpose is to:

- a. raise the mount to permit removal of the bogies
- b. level the top carriage
- c. change tires on the bogies
- d. remove the outrigger

Match the following with the illustration:

12. ____ level vial

13. ____ operating handle

14. ____ worm shaft clamp handle

15. ____ centering arrows

16. ____ scribe line

17. This is a picture of:

- a. front carriage
- b. rear carriage
- c. front bogie
- d. rear bogie

18. Its purpose is to:

- a. move the M-55 MG mount
- b. move the 90-MM gun
- c. brace the gun during firing
- d. support the trailer

Match the following with the illustration:

19. ____ swing bolts

20. ____ hand brake lever

21. ____ maneuvering bar

22. ____ wheel

23. This is a picture of:

- a. carriage
- b. leveling mechanism
- c. pedestal
- d. support mechanism

24. Its purpose is to:

- a. support the weight of the gun
- b. level the top carriage
- c. remove the bogies
- d. traverse the mount

Match the following with the illustration:

25. _____hydraulic jack

26. _____tool box

27. _____outrigger

28. _____base plate

29. _____leveling socket bearing

30. This is a picture of:

- a. recoil mechanism
- b. firing mechanism and breech block
- c. top carriage
- d. gun proper-exploded view

31. It corresponds to what part of a rifle?

- a. rifling
- b. bolt
- c. clip
- d. plunger cams

Match the following with the illustration:

32. _____firing mechanism

33. _____automatic cocking lever

34. _____sear

35. _____block

36. The correct name of the pin which secures the front bogie to the pedestal is:
- a. locking bolt assembly
 - b. front bogie securing pin
 - c. draft spindle pin
 - d. swing bolts
37. The purpose of the equilibrator is to:
- a. counter-balance the outriggers during emplacement
 - b. equalize the recoil pressure
 - c. stabilize the traversing mechanism
 - d. equalize the effort required to elevate and depress the tube
38. The cradle:
- a. supports the traversing parts of the gun
 - b. fires the round
 - c. supports the top carriage
 - d. supports all parts of the gun which move in elevation
39. The top carriage:
- a. supports the traversing parts of the gun
 - b. rests on the gun tube
 - c. supports all parts of the gun which move in elevation
 - d. supports the bogies
40. This is a picture of the:
- a. recoil mechanism
 - b. firing mechanism
 - c. exploded view of gun proper
 - d. fuze-setter-rammer rolls

Match the following with the illustration:

41. _____ gun tube
42. _____ gun rails
43. _____ breech ring
44. _____ tube support
45. The bogies have:
- a. electrical brakes only
 - b. mechanical brakes only
 - c. both electrical and mechanical brakes
 - d. no brakes

46. The top carriage is centered when:
- a. the scribe lines are even with the top of the jacks
 - b. the red arrows on the top carriage and pedestal are matched
 - c. the bubbles are centered in the four leveling jacks
 - d. the tube is at zero mils azimuth
47. When operating the hydraulic jacks, you should use:
- a. short, rapid strokes
 - b. one man at a time
 - c. long, even strokes
 - d. short, slow strokes
48. The leveling jacks are centered when:
- a. the outriggers touch the ground evenly
 - b. the tube is at zero mils elevation
 - c. the bubbles are centered in the four leveling vials
 - d. the scribe lines are even with the top of the jacks
49. The mount is rough leveled when:
- a. the outriggers touch the ground evenly
 - b. the tube is at zero mils elevation
 - c. the bubbles are centered in the four leveling vials
 - d. the scribe lines are even with the top of the jack
50. The inner and outer outrigger sections are held rigid when extended by the:
- a. outrigger locking pin
 - b. outrigger stay pin
 - c. outrigger latch
 - d. outrigger wedge key
51. This is a picture of the:
- a. orientation ratchet wheel
 - b. power control unit
 - c. indicator regulator
 - d. driving mechanism
52. It is a part of which of the following major components?
- a. recoil mechanism
 - b. remote control system
 - c. traversing mechanism
 - d. top carriage

53. The reading on the dials is:
- a. 6400 mils
 - b. 1740 mils
 - c. 1440 mils
 - d. 2140 mils
54. To adjust the dials on this instrument, use the:
- a. orientation ratchet wheel
 - b. transfer lever
 - c. throwout lever
 - d. hydraulic jack
55. How many of these components are on the gun?
- a. one
 - b. two
 - c. three
 - d. four
56. When the transfer levers of the power control units are in AUTOMATIC, the gun is positioned by the:
- a. elevation and azimuth hand cranks
 - b. hydraulic jacks
 - c. autometer
 - d. the radar
57. The purpose of the recoil mechanism is to:
- a. equalize the weight of the gun
 - b. position the gun automatically
 - c. absorb the "kick" of firing a round
 - d. absorb shock of bogies when traveling over rough ground
58. Which of the following is not a part of the recoil mechanism?
- a. floating piston cylinder
 - b. counter recoil buffer
 - c. gas cylinder
 - d. hydraulic check mechanism
59. The recoil mechanism uses:
- a. nitrogen gas
 - b. recoil oil
 - c. nitrogen gas and recoil oil
 - d. heavy duty coil springs and recoil oil

60. An indirect check of the recoil mechanism is performed by:

- a. jacking the gun out of battery with a ratchet wrench
- b. measuring gas pressure with a pressure gauge
- c. re-establishing reserve oil
- d. firing the gun

61. This is a picture of the:

- a. recoil mechanism
- b. firing mechanism and breech block
- c. top carriage
- d. gun proper-exploded view

62. It corresponds to what part of a rifle?

- a. rifling
- b. bolt
- c. clip
- d. plunger cams

Match the following with the illustration:

63. _____ firing mechanism

64. _____ automatic cocking lever

65. _____ sear

66. _____ block

67. This is a picture of:

- a. indicator regulator
- b. hydraulic plunger
- c. fuze-setter-rammer control unit
- d. power control unit

68. It is a part of:

- a. remote control system
- b. radar
- c. fuze-setter-rammer
- d. leveling mechanism

69. The handle (red in the picture) is the:

- a. fuze throwout lever
- b. hydraulic check index finger
- c. transfer lever
- d. hand crank

70. When the handle is in MANUAL:
- a. fuzes must be set by hand
 - b. the mount must be elevated or traversed by the handcranks
 - c. the mount is positioned by the radar
 - d. the mount is positioned by the remote control system
71. The fuze-setter-rammer:
- a. loads and fires a round of ammo
 - b. sets a fuze and fires a round
 - c. loads and extracts a round
 - d. sets a fuze and loads a round
72. If the fuze-setter-rammer drive shaft stalls, an adjustment should be made to the:
- a. throwout lever
 - b. throttling valve
 - c. hydraulic check
 - d. governor
73. When the fuze throwout lever is in the FUZE position, the rammer rolls are:
- a. turning at high speed
 - b. not turning
 - c. turning at low speed
 - d. retracted
74. The motor drive handwheel on the fuze-setter-rammer:
- a. adjusts the fuze dial
 - b. turns the motor drive off and on
 - c. adjusts the speed of the ramming rolls
 - d. turns the amplifier on
75. To operate the motor drive handwheel on the fuze-setter-rammer, the manual-automatic plunger must be:
- a. in the Automatic position
 - b. in the Manual or Automatic position
 - c. in the Manual position
 - d. completely disengaged
76. The gun receives power from the:
- a. 400 cycle generator
 - b. 60 cycle generator
 - c. FCS T-33
 - d. motor drive

77. The soldier in the picture is:
- a. firing the gun
 - b. placing the transfer lever in automatic
 - c. removing equilibrator stop pins
 - d. opening the breech
78. The red handle is the:
- a. firing lever
 - b. plunger shaft
 - c. breech opening lever
 - d. cocking lever
79. The correct gas pressure of the recoil gas cylinder is:
- a. 100 lbs. per square inch
 - b. 500 lbs. per square inch
 - c. 1,000 lbs. per square inch
 - d. 10,000 lbs. per square inch
80. The purpose of the counter recoil buffer is to:
- a. absorb the shock in traveling
 - b. balance the fuze-setter-rammer amplifier
 - c. ease the gun back into battery from recoil
 - d. ease the mount to the ground during emplacement
81. The counterrecoil buffer uses:
- a. nitrogen gas
 - b. recoil oil
 - c. nitrogen gas and recoil oil
 - d. heavy coil springs
82. The purpose of the remote control system is to:
- a. position the gun automatically in azimuth and elevation, and adjust for range
 - b. control the operation of the hydraulic jacks
 - c. provide a means of controlling gun from the prime mover
 - d. load and fire the gun from a protected area
83. The purpose of the pedestal is to:
- a. support the weight of the gun
 - b. level the top carriage
 - c. permit removal of the bogies
 - d. traverse the mount

84. The top carriage:

- a. supports all parts which move in elevation
- b. supports all traversing parts
- c. rests on the gun tube
- d. supports the bogies

85. The purpose of the leveling mechanism is to:

- a. level the ground where the gun is emplaced
- b. adjust top carriage so accurate fire can be delivered
- c. get the pedestal level
- d. level the outriggers

86. The component which actually fires the round is:

- a. fuze-setter-rammer
- b. top carriage
- c. gun proper
- d. recoil mechanism

87. The purpose of the recoil mechanism is to:

- a. equalize the weight of the tube
- b. position the gun automatically
- c. absorb the kick of firing a round
- d. absorb the shock of traveling

88. The cradle:

- a. supports the traversing parts of the gun
- b. fires the round
- c. supports the top carriage
- d. supports all parts which move in elevation

89. The equilibrator:

- a. counter balances the outriggers during emplacement
- b. equalizes the recoil pressure
- c. stabilizes the traversing mechanism
- d. equalizes the effort of elevating or depressing the tube

90. The fuze-setter-rammer:

- a. loads and fires a round
- b. sets a fuze and fires a round
- c. loads and extracts a round
- d. sets a fuze and loads a round

91. The purpose of the bogies is to:
- a. brace the gun during firing
 - b. support the trailer
 - c. enable the gun to be moved
 - d. center the gun tube
92. The remote control system:
- a. allows the crew to fire the gun from a safe distance
 - b. automatically positions the gun in azimuth and elevation
 - c. is used in steering the gun while moving
 - d. keeps the rate of fire at a safe level
93. The correct name of the pin which secures the front bogie to the pedestal is:
- a. locking bolt assembly
 - b. front bogie securing pin
 - c. draft spindle pin
 - d. swing bolt
94. This is a picture of:
- a. orientation ratchet wheel
 - b. power control unit
 - c. indicator regulator
 - d. driving mechanism
95. The leveling jacks are centered when:
- a. the outriggers evenly touch the ground
 - b. the tube is set at zero mils elevation
 - c. the bubbles in the four leveling vials are centered
 - d. the scribe lines are even with the top of the jack
96. The mount is rough leveled when:
- a. the outriggers evenly touch the ground
 - b. the tube is set at zero mils elevation
 - c. the bubbles in the four leveling vials are centered
 - d. the scribe lines are even with the top of the jack
97. The mount is fine leveled when:
- a. the bubbles in the four leveling vials are centered
 - b. the scribe lines are even with the top of the jacks
 - c. the bubble in the gunner's quadrant remains centered when the tube is traversed 6400 mils
 - d. the outriggers evenly touch the ground

98. To center the top carriage, you must:

- a. get the scribe lines even with the top of the jacks
- b. match up the red arrows on pedestal and top carriage
- c. center the bubbles in the four level vials
- d. place the tube at zero mils azimuth

Match the following with the illustration:

99. ____ level vial
100. ____ operating handle
101. ____ worm shaft clamp handle
102. ____ centering arrows
103. The reading on the dials is:
- a. 6400 mils
 - b. 3200 mils
 - c. 1600 mils
 - d. 4800 mils
104. The reading on the dials now is:
- a. 2400 mils
 - b. 4400 mils
 - c. 2200 mils
 - d. 1200 mils
105. The reading on the dials now is:
- a. 1240 mils
 - b. 1340 mils
 - c. 1220 mils
 - d. 1320 mils

Checklist for Activity I

Battery and Battalion _____ Instructor _____ Crew _____

TRIALS

1 2 3 4

CONDITIONS

TEMPERATURE

SAND

HOURL

TIME IN MINUTES AND SECONDS

A. PREPARATION:

Remove bump bars

Set hand brakes on rear bogie

Place brake cable in dummy socket

B. LOWER AND EXTEND SIDE OUTRIGGERS

Support O. R. removing stay pin

Remove O. R. wedge key

Unlatch O. R. sections

Stand clear of O. R. when lowering

Insert inner wedge key

Replace stay pin

Replace ropes

Close side shields before raising jacks

Check oil level in hyd. jacks

Remove equil. stop pins

Remove tube clamps

Report on jacks

TRIALS

1	2	3	4	
---	---	---	---	------

C. ROLL OUT FRONT BOGIE:

Raise carriage evenly

Turn draft spindle 90° to right

Remove draft spindle pin

Support O. R. when removing locking pin

Replace locking pin

Insert outer section key first

Elevate tube to max.

Split jack float blocks

D. ROLL OUT REAR BOGIE:

Unclamp swing bolts before raising carriage

Release hand brakes

Disconnect electric brake cable

Set hand brakes after bogie is rolled out

Support O. R. when removing locking pin

Replace locking pin

Close jack filler plugs

Hold up jack stay when lowering jacks

Support jacks when lowering

E. ROUGH LEVEL:

Loosen worm shaft clamps

Report on worm shaft clamps

Put selector switches in neutral

Level accurately

TRIALS

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>....</u>
Tighten worm shaft clamps					
Connect cable					
Total	<hr/>				

Checklist for Activity II

Battery and Battalion _____ Instructor _____ Crew _____

TRIALS

1 2 3 4

CONDITIONS

TEMPERATURE

SAND

HOURL

TIME IN MINUTES AND SECONDS

A. CENTER TOP CARRIAGE AND LEVEL JACKS:

Center top carriage

Remove bump bars and ropes

Loosen worm shaft clamps

Report on worm shaft clamps

Center jacks

Report on jacks being centered

Tighten worm shaft clamps

Report on clamps

B. ROLL IN REAR BOGIE:

Run jack ram down to max.

Report on jacks

Remove rear O. R. locking pin

Stand clear when raising O. R.

Lock locking pin

Raise carriage evenly

Roll bogie in straight

TRIALS

1	2	3	4	
---	---	---	---	------

Fold in and down on draw bar when
carriage is lowered

Plug in brake cable

Set hand brakes

Lock jack floats

Report on jacks

C. ROLL IN FRONT BOGIE:

Insert equil. stop pins

Raise carriage evenly

Remove inner O. R. pin first

Remove locking pin

Stand clear of O. R. when raising

Lock locking pin

Turn draft spindle 90° left

Roll bogie in straight

Close jack filler plug

Put jack cover on right

Replace foot rests, seats and cranks

D. PIN UP SIDE OUTRIGGERS

1. Elevation Side

Remove stay pin

Remove inner O. R. wedge key and lay on
platform

Stand clear when raising side O. R.

Hold O. R. when replacing stay pin

TRIALS

1	2	3	4	
---	---	---	---	------

Replace main O. R. wedge key in bracket

Latch O. R. section together

Make one complete turn on snub cyl. with rope

2. Azimuth Side

Remove stay pin

Remove inner O. R. wedge key and lay on platform

Stand clear when raising side O. R.

Holding O. R. when replacing stay pin

Replace main O. R. wedge key in bracket

Latch O. R. section together

Make one complete turn on snub cylinder with rope

E. HOOK TO PRIME MOVER:

Remove draw bar pins

Replace bump bars

Release hand brakes

Total _____

Checklist for Activity III

Battery and Battalion _____ Instructor _____ Crew _____

TRIALS

1 2 3 4

Time in Min. and Sec.

Orientation

A. Fine Level

1600 mils

3200 mils

4300 mils

6400 mils

B. Azimuth (error)

C. Elevation (error)

Synchronization

A. Azimuth error. (diff. between
computer and mech. dial)

B. Elevation error. (diff. between
computer and mech. dial)

C. Fuze error. (diff. between any
of 3 rounds and commuter.)

Checklist for Activity IV

Inspector asks crew member what he has done, checks the items reported (R), then checks to see if accomplished satisfactorily (S) or unsatisfactory (U). Then checks those items which were not reported but which should have been accomplished to see if they are satisfactory or unsatisfactory. Every item must be checked in either the S or the U column.

Trial	1	2	3
	R	S	R S

Gunner

Breech mechanism examined, cleaned and oiled
 Breechblock inspected; if necessary removed
 and cleaned
 Percussion mechanism removed, cleaned, oiled
 Hand cocking lever checked
 Firing lever checked
 Supervised cleaning of tube; if necessary

No. 1

Checks oil level in elevation remote control
 system
 Checks equilibrator chains, cleans and oils
 Elevates (at direction of 5 and 6) and cleans
 rack
 Depresses (at direction of 5 and 6) and
 checks if equal pressure
 Checks for backlash

No. 2

Checks operation of traversing mechanism,
 traverses 360° checking for obstructions
 Checks for backlash
 Checks oil line in azimuth remote system

No. 3

Opened ramming rolls
 Inspected F-S-R bore for brass filings
 Checked condition of fuze knives
 Checked oil level in transmission
 Lubricates F-S-R if necessary
 Assists in cleaning tube
 Checks M-13 Fuze setter (clean and oil)
 Checks rammer rolls for cleanliness and
 wear
 Closes rammer rolls

Trial	1	2	3			
	R	S	R	S	R	S

No. 4

Assists gunner with breechblock and firing
mech.
Assists in cleaning tube
Checks M-13 fuze setter (clean and oil)

Nos. 5 and 6

Drain and re-establish reserve oil
Perform indirect check at zero mils elev.
If necessary, performs direct check,
GLS Sup.
If necessary, charges gas cylinder to
1000 lbs.
Perform indirect check at maximum elev.
If necessary, performs direct check
Check oil supply in counter recoil
buffer at -10°
Assist in cleaning tube

Rate the overall condition of gun site excellent, satisfactory,
 unsatisfactory.

APPENDIX B

TABLE XVIII

Rank Of Crews In Sample A On Fifty-five Variables

Crew	Variable								
	1	2	3	4	5	6	7	8	9
1	16	16	15	13	1	7	11	14	3
2	4.5	4	6	7	13.5	4	5	5	7
3	6.5	5.5	8	8	15	8	7	4	9
4	12	13	16	16	7	14.5	12.5	9	8
5	15	15	13	14	3	2	2	7	11
6	14	10	9	9	16	10.5	14	10	10
7	2	2.5	7	6	10.5	14.5	10	13	13
8	6.5	7	2	2	10.5	9	8	3	4
9	8	9	10	10.5	5.5	1	1	6	6
10	11	12	12	12	3	13	15	16	14
11	3	2.5	3	3	13.5	5	4	15	15
12	9	8	5	5	10.5	10.5	9	2	2
13	13	14	11	10.5	5.5	16	16	8	5
14	1	1	1	1	8	3	3	12	16
15	10	11	14	15	3	12	12.5	1	1
16	4.5	5.5	4	4	10.5	6	6	11	12

Crew	Variable								
	10	11	12	13	14	15	16	17	18
1	2.5	1	8	10	15	14	3	3	12
2	9	12	6.5	8	8	8	3	4	3
3	15.5	16	4	4	5	5	14	13.5	4
4	11	7	16	16	16	16	10	2	15
5	6.5	13	5	7	9	9	3	5	6
6	4.5	3	10	6	12	13	15	15	13
7	13	9	3	3	14	15	6.5	10	7
8	12	10.5	1	1	1	1	5	16	1
9	1	8	13	15	13	11	1	1	5
10	4.5	2	14	13.5	11	12	12.5	7	11
11	2.5	5.5	2	2	2	3	10	12	2
12	6.5	5.5	6.5	5	7	7	12.5	11	8
13	9	4	15	13.5	6	6	16	13.5	16
14	14	15	9	9	4	4	6.5	7	9
15	15.5	14	11	11	10	10	10	9	14
16	9	10.5	12	12	3	2	8	7	10

TABLE XVIII (Cont'd.)

Crew	Variable										
	19	20	21	22	23	24	25	26	27	28	29
1	15	15	12	4.5	4	5.5	1	14	15	16	5
2	4	9	9	3	1	8.5	6	16	16	13	3
3	2	3	5	12	7	15	14	4	5	9	10
4	14	16	16	9.5	13	2.5	4	10	9	12	14
5	7	11	10	2	4	2.5	5	12	11.5	11	6
6	11	10	11	16	8	16	13	6	4	3	7
7	6	12	14	7.5	6	13	12	5	6	6	11.5
8	1	1	1	7.5	9.5	8.5	16	7	7	5	11.5
9	8	14	13	1	2	1	2	1	1	8	8
10	13	13	15	6	11.5	4	3	11	11.5	4	4
11	3	4	4	4.5	4	5.5	11	9	10	10	9
12	5	2	2	14	16	10	15	8	3	14	15
13	16	8	8	15	15	14	10	13	13	2	1
14	9.5	7	7	11	9.5	11	9	3	8	7	13
15	12	5	3	13	14	12	8	15	14	1	2
16	9.5	6	6	9.5	11.5	7	7	2	2	15	16

Crew	Variable								
	30	31	32	33	34	35	36	37	38
1	1	2.5	16	1	6	3	1	3.5	9.5
2	2	10.5	15	2	3	6	9	6	15
3	3	2.5	13	8	9	8	7	11	3.5
4	4	5	10	4	16	15	6	16	11
5	6.5	6.5	10	3	7	5	14	8	12.5
6	6.5	8.5	12	13.5	5	11	13	9	7.5
7	6.5	4	7	10.5	15	14	11	15	12.5
8	6.5	6.5	10	12	13	16	16	13	9.5
9	9	1	1	7	10.5	7	4	5	7.5
10	10.5	13	14	10.5	14	13	15	14	16
11	12	8.5	2	5	12	10	10	7	14
12	16	16	3	16	4	4	3	3.5	1.5
13	13	12	4.5	6	1	1	2	1	3.5
14	10.5	10.5	4.5	13.5	2	2	5	2	6
15	15	15	7	9	8	9	12	12	1.5
16	14	14	7	15	10.5	12	8	10	5

TABLE XVIII (Cont'd.)

Crew	Variable								
	39	40	41	42	43	44	45	46	47
1	11.5	13	5	15	15	3	12	14	15
2	6.5	9.5	13	3	7	10	13	5	9
3	5	6.5	9.5	9	3	2	5	8	4.5
4	15	9.5	9.5	16	16	14	16	12.5	6
5	13	15	9.5	2	5	9	4	7	13.5
6	6.5	13	5	13	10	13	8	15	13.5
7	8	9.5	1.5	12	12	11	7	2	2
8	14	9.5	16	10	11	15	14	12.5	10.5
9	9.5	3.5	13	11	9	7.5	10	11	12
10	16	16	1.5	6	13	12	9	10	7.5
11	9.5	13	5	1	1	5	2	1	1
12	1.5	1	9.5	5	8	16	6	3	7.5
13	4	3.5	5	7	2	1	1	6	10.5
14	11.5	3.5	15	14	14	7.5	15	16	16
15	3	6.5	13	8	4	4	11	9	4.5
16	1.5	3.5	5	4	6	6	3	4	3

Crew	Variable							
	48	49	50	51	52	53	54	55
1	14	6	15	2	15	14	2	8.5
2	5	15	5	4.5	11.5	8.5	10.5	11.5
3	7.5	2.5	8	12	13.5	8.5	10.5	13.5
4	9.5	10	12	6	16	1	16	15
5	7.5	16	9.5	10	6	4.5	13	7
6	14	1	1	14	4.5	7	4	3
7	2.5	10	13	8.5	11.5	10.5	10.5	13.5
8	14	4.5	9.5	11	8	15.5	7	16
9	11.5	10	15	16	9	15.5	1	10
10	11.5	10	11	15	7	13	5	1
11	2.5	10	3.5	8.5	2	2	3	5.5
12	2.5	10	3.5	7	1	3	14	5.5
13	2.5	14	6	1	4.5	12	8	4
14	16	10	2	4.5	3	6	6	2
15	9.5	4.5	15	3	13.5	10.5	10.5	11.5
16	6	2.5	7	13	10	4.5	15	8.5

TABLE XIX

Intercorrelations Between Predictors and Criteria For Sample A¹

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	96	80	78	-49	25	49	-07	-45	-37	-49	41	38	51	49	17	-13	56
2		85	83	-66	27	47	-06	-48	-32	-46	49	51	51	47	09	-25	58
3			99	-62	34	47	01	-36	-15	-30	54	59	77	75	05	-44	62
4				-60	28	41	-08	-35	-12	-22	54	60	75	71	04	-45	58
5					-04	-15	-10	27	18	20	-43	-57	-39	-33	32	55	-43
6						91	03	-21	31	-38	30	12	28	36	67	39	59
7							11	-28	11	-55	43	24	35	42	67	33	73
8								71	-40	-50	12	12	19	24	02	-18	17
9									-03	10	-10	-12	-18	-11	05	-01	-19
10										73	-14	-17	-23	-20	20	30	06
11											-31	-21	-39	-41	-24	01	-38
12												95	43	38	26	-42	80
13													46	38	00	-64	66
14														99	-14	-55	49
15															-05	-45	49
16																64	47
17																	-13

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	60	43	32	10	17	-16	-36	49	30	-04	-46	-17	-07	39	-35	-16	-19
2	66	48	35	00	22	-29	-48	51	36	-03	-46	-11	-06	33	-40	-06	-16
3	67	67	58	-07	08	-27	-61	51	41	-06	-50	-25	-21	37	-55	13	-04
4	62	63	54	-08	08	-29	-61	52	41	-09	-52	-21	-16	35	-54	12	-03
5	-61	-47	-28	30	-13	51	69	-38	-42	06	39	-09	00	-01	34	-01	27
6	41	06	16	60	69	41	26	26	13	-44	-09	16	25	12	18	23	33
7	61	16	21	60	62	39	08	40	27	-44	-32	09	29	33	11	06	22
8	35	49	54	-24	-21	-22	-36	-10	11	10	03	-10	-14	11	-10	26	12
9	-12	14	30	-19	-25	-08	-04	-41	-16	-02	26	00	-05	-06	15	25	21
10	-16	-39	-32	45	38	54	43	-04	06	-28	19	02	15	08	25	02	16
11	-49	-41	-40	-02	-11	18	22	-21	-07	-02	19	-02	-02	-07	08	-07	-03
12	83	52	49	23	44	-19	-56	08	04	-15	-19	24	24	-04	-01	-07	-10
13	78	62	54	-04	25	-40	-76	13	14	00	-22	13	11	-01	-20	-02	-15
14	55	86	81	-15	-13	-23	-56	22	13	03	-22	-38	-37	30	-35	22	08
15	52	83	81	-10	-10	-16	-48	25	17	-04	-24	-37	-33	33	-32	24	14
16	23	-30	-15	83	67	59	48	02	-10	-41	-03	-38	44	-03	38	-10	06
17	-34	-71	-58	62	35	74	90	-13	-19	-50	04	27	24	-08	49	-11	16

¹All entries are two-place rank-difference correlations, with decimal points omitted.

TABLE XIX (Cont'd.)

	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
1	-07	-06	-06	17	37	-18	16	10	-02	-04	36	44	24	06	27	-09	15
2	-10	-02	-04	23	32	-15	15	12	-08	-01	32	38	21	15	44	-14	24
3	-10	21	07	22	36	-21	28	17	-17	10	25	13	13	15	63	-17	54
4	-04	23	06	20	35	-13	19	10	-14	11	23	12	12	19	61	-14	52
5	16	10	-01	-34	-09	06	-13	-25	22	-16	-25	-28	-23	-25	-64	30	-20
6	06	42	-14	-09	04	-41	27	15	16	-05	-08	-34	-22	-08	14	-24	17
7	04	27	-12	-05	18	-45	30	19	07	00	15	-09	02	-18	11	-24	17
8	00	03	56	42	49	-65	12	34	-11	-12	04	-02	10	11	-05	11	-11
9	29	16	50	32	33	-33	-13	07	02	-19	-10	-15	01	15	-35	37	-29
10	15	35	-35	-19	-31	37	19	-04	-07	23	02	-25	-01	-13	03	-29	33
11	19	12	-25	-18	-34	59	-14	-28	-17	14	-06	-12	-01	-06	-03	-03	18
12	-33	-05	-19	00	-19	-12	27	22	-10	12	32	16	19	10	19	-04	16
13	-37	-08	-08	10	-16	-02	23	25	-19	20	30	19	20	22	37	-08	31
14	-15	24	22	25	31	-26	54	54	16	33	28	17	19	14	57	-04	51
15	-06	30	28	29	39	-33	51	53	21	31	25	11	15	15	50	-04	45
16	00	10	-37	-34	-08	-36	-03	-28	-05	-40	-10	-29	-22	-23	-41	00	26
17	32	06	-32	-32	-08	-14	-15	-41	02	-40	-16	-21	-18	-43	-49	07	-43
18	-29	-02	-33	-12	-06	-31	40	24	-15	04	32	15	14	-06	14	-36	17
19	-33	-12	-12	09	07	-32	40	32	-24	10	39	30	25	08	27	-33	20
20	-16	12	46	49	41	-31	44	57	04	29	32	29	25	33	48	03	41
21	-06	24	53	50	42	-41	42	56	13	22	26	18	18	31	38	17	35
22	-14	-03	-70	-52	-39	-05	24	-12	00	-14	12	-07	-03	-38	-41	-21	-19
23	-09	12	-56	-27	-38	-03	09	02	15	-07	02	-18	-08	-14	-11	-21	-12
24	00	-08	-50	-57	-26	-05	14	-26	-17	-20	-04	-08	-11	-33	-42	-22	-12
25	22	06	-37	-40	-29	08	-11	-32	22	-26	-25	-27	-27	-36	-54	05	-41
26	07	-06	25	09	42	-02	-24	-12	-12	10	-08	07	-15	43	17	-63	20
27	06	-10	35	25	46	02	-14	-04	-30	19	04	15	00	46	18	-67	24
28	-42	-20	14	-03	-03	02	-14	14	05	02	-22	-03	-17	16	-02	-07	19
29	-11	20	-16	-03	-34	12	19	29	43	09	-07	-24	-01	-23	-21	29	-09
30	-02	-18	-46	-45	-45	-02	-39	-38	-03	-41	-34	-27	-28	04	-21	01	-55
31	12	14	-28	-44	-24	-01	-48	-27	12	-20	-28	-18	-24	09	-41	-21	-43
32	28	33	38	31	61	-11	17	33	08	33	34	21	35	-12	16	00	54
33	18	11	-45	-34	-41	03	05	09	39	-08	02	-12	11	-42	-37	38	-43
34	44	84	44	46	36	-21	12	27	31	12	-11	-56	01	-15	52	48	39
35	65	91	37	30	36	-14	12	25	49	19	-02	-52	09	-34	24	52	31
36		66	45	32	60	01	-28	-06	40	03	-02	-19	16	-09	01	46	-06
37			32	31	41	-14	14	24	38	21	-02	-54	06	-26	40	39	50
38				70	78	-24	-15	29	30	17	-08	-03	03	45	11	21	08
39					65	08	31	60	32	50	49	34	53	29	29	17	11
40						-33	-05	21	17	08	15	09	24	13	17	20	14
41							12	03	14	57	37	36	39	11	01	-11	07
42								74	11	63	74	37	62	-29	30	-11	41
43									52	75	62	39	61	-03	27	03	28
44										40	11	06	14	10	-15	33	-20
45											68	37	68	-02	27	-17	42

TABLE XIX (Cont'd.)

	53	54	55
1	16	-05	-17
2	24	00	-09
3	15	07	09
4	11	11	10
5	-34	12	15
6	07	27	09
7	19	06	-12
8	-07	-38	-46
9	-35	-08	-38
10	-06	55	46
11	-15	40	41
12	04	07	-29
13	11	05	-17
14	15	-05	12
15	10	-04	07
16	-25	17	-33
17	03	-06	-09
18	-06	15	-31
19	12	-08	-37
20	15	-17	-05
21	12	-13	-07
22	-20	27	-19
23	-18	45	-16
24	05	07	-05
25	-16	16	11
26	06	09	-01
27	14	-06	-05
28	-41	30	17
29	-48	40	22
30	-21	14	-43
31	-28	34	-46
32	22	05	18
33	-09	16	-24
34	03	10	48
35	-01	18	47
36	06	05	10
37	-02	35	53
38	02	-20	01
39	17	-29	03
40	07	-24	-06
41	10	10	38
42	26	-20	22
43	17	-10	07
44	-18	25	09
45	21	-08	33

AUTOBIOGRAPHY

I, Robert Edward Krug, was born in Dayton, Ohio, September 12, 1925. My elementary and secondary education was received in the public schools of that city. Following military service, I enrolled in The Ohio State University and received the degree Bachelor of Science in Education in 1948. I was granted the degree Master of Arts in 1949 from the same institution. From 1949 to 1951 I was Assistant Professor of Psychology in Trinity University, San Antonio, Texas. From 1951 to 1953 I was Research Associate of The Ohio State University Research Foundation. While completing the requirements for the degree Doctor of Philosophy at The Ohio State University, I was Research Assistant during the year 1953-54, while during 1954-55 I was part-time Instructor in Psychology at Ohio Wesleyan University.