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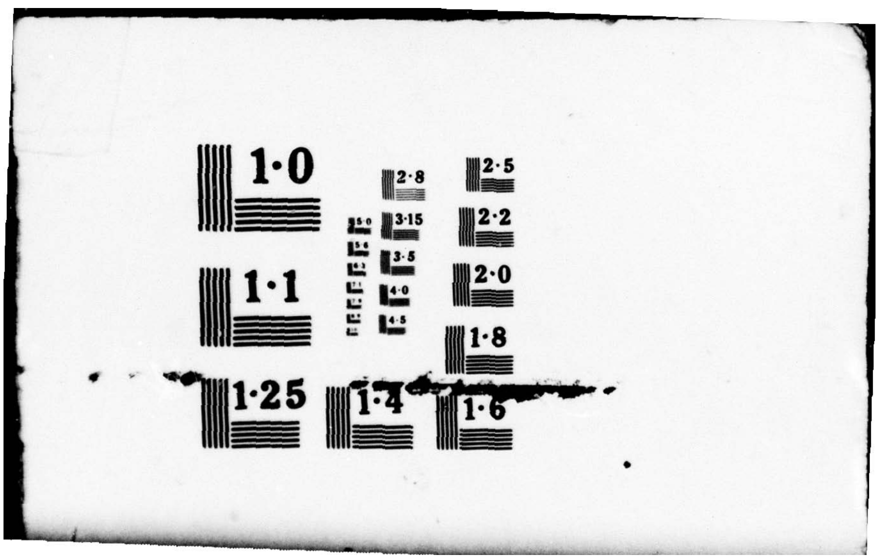
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U.S. Army Armor Human Research Unit
Fort Knox, Kentucky

Under the Technical Supervision of

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A report of work done in connection with Exploratory Studies, Armor Human Research Unit, "Command Decision-Making"

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Research under the technical supervision of
HUMAN RESOURCES RESEARCH OFFICE
The George Washington University
operating under contract with
The Department of the Army

INTRODUCTION

In a world of ever-increasing automation, some of man's functions are being restricted or curtailed while others are being extended. One of the most important of man's roles in any man-machine or automated system is that of information processer. He must receive information and act on it by abstracting, categorizing, and structuring the data so that it can be used or transmitted to other human or non-human system components. Man, as one of the system components, also makes decisions. He makes decisions each time he perceives, categorizes, or transmits information.

The importance to the military establishment of understanding individual decision processes is almost self-evident. While it may be possible to fully automate a weapons system, it is less likely that the decision to use or not to use the weapon, i.e., the commander's role as an ultimate decision-maker, can ever be replaced. With an increase in the complexity and speed of modern warfare, both administrative and tactical decisions must, necessarily, be made more rapidly and will take into account a wider range of specialized information. There is also good reason to believe that more important, life-and-death decisions will be made at lower echelons of organization or operation than was the case in previous wars.

Although research on decision processes has been relatively neglected in the past, there has been a considerable surge of interest within the last decade. A recent survey, for example, located over 100 active projects on individual decision processes (9). It was noted, however, that some crucial problems were being neglected. Although reasonably satisfactory progress is being made with respect to decision-making in operational games and other group situations, the survey team notes that inadequate attention is being given to sequential decision-making, i.e., the more realistic operational condition in which successive choices influence what future information becomes available and each choice contributes to the perception of a long-range, developing goal. Equally neglected are studies clarifying the conditions for efficiency of decision-making in different contexts of information scarcity and information overload, and the conditions of efficient selection or training of individuals for decision-making. Further, few definitive studies of decision-making under environmental or psychological stress are available; this neglect is perhaps the most glaring since the military commanders, in the most crucial of their activities, must perform their functions with precision and wisdom under the stresses imposed by combat--fear, fatigue, cold, hunger, and the like--as well as stresses imposed by command and administrative requirements--work overload, conflicting requirements, ambiguous information, life-and-death responsibilities, and the increased anxiety brought on by novel and complex environments.

To deal effectively with such problems, the commanders must be carefully trained. But trained in what? How should they be trained? Is it even possible to train a commander to deal more effectively with the unknown--to make better decisions and to make them faster? At this time, answers to such simple but basic questions are not available. If they are ever to be had, a systematic program of research is demanded. It is hardly necessary to add that no such program presently exists. Before such a program is undertaken, however, the present status of our working knowledge about command skills, duties and functions, i.e., command decision-making, should be care-determined.

Here, it is both relevant and of interest to note that most textbooks of management science include the topic of decision-making in their definition of management (11) (44). Many simply define management as "the art and science of decision-making and of leadership (11)." Thus, throughout these texts primary emphasis is placed upon the development of decision-making skills and proficiency in the use of the mathematical and economic concepts and techniques which will result in improved decision quality and predictive power. While there is still some disagreement as to whether the military commander is primarily a "manager" or something more--and thus qualitatively unique--there is little disagreement over the importance to both managers and commanders of decision-making skills.

Traditionally, within the Army, command decision-making has been treated under the rubric "estimation of the situation." The procedure normally employed is as follows:

1. <u>Mission</u>. A statement of the task and its purpose. If the mission is general in nature, determine by analysis what task must be performed to insure that the mission is accomplished. State multiple tasks in the sequence in which they are to be accomplished.

2. <u>The Situation and Courses of Action</u>.

a. Determine all facts or in the absence of facts logical assumptions which have a bearing on the situation and which contribute to or influence the ultimate choice or course of action. Analyze available facts and/or assumptions and arrive at deductions from these as to their favorable or adverse influence or effect on the accomplishment of the mission.

b. Determine and list significant difficulties or difficulty patterns which are anticipated and which could adversely affect the accomplishment of the mission.

c. Determine and list all feasible courses of action which will accomplish the mission if successful.

3. Analysis of Opposing Courses of Action. Determine through analysis the probable outcome of each course of action listed in paragraph 2 c when opposed by each significant difficulty enumerated in paragraph 2 b. This may be done in two steps:

a. Determine and state those anticipated difficulties or difficulty patterns which have an approximately equal effect on all courses of action.

b. Analyze each course of action against each significant difficulty or difficulty pattern (except those stated in paragraph 3, above) to determine strengths and weaknesses inherent in each course of action.

4. Comparison of Own Courses of Action. Compare courses of action in terms of significant advantages and disadvantages which emerged during analysis (paragraph 3, above). Decide which course of action promises to be most successful in accomplishing the mission.

5. Decision. Translate the course of action selected into a complete statement, showing who, what, when, where, how and why, as appropriate (15).

Following this excellent advice is, of course, easier said than done. Attempts are made in each of the service branch schools and at the Command and General Staff College at Fort Leavenworth to teach these principles and techniques and to provide the officer student with a considerable amount of practice in the form of both tactical and administrative practical exercises. To what extent this system is successful in producing skilled tactical and administrative decision-makers is unknown. It can be safely concluded, however, that all of the graduates of this rather unsystematic program can improve. There is also good reason to believe that in actual practice one or more parts of the process may all too often be disregarded or poorly executed. This assumption, of course, can be empirically tested and it might be worthwhile to do so. Also of interest, in this regard, is the question of the extent to which systematic reinforced practice in each of the above steps with abstract or simulated problems would lead to improved on-the-job performance. Here, the question is simply how much practice is necessary to produce how much improvement?

Despite the fact that such teaching does occur within the Army school system, it should also be noted that intuition plays a large role in too many on-the-job situations. While there is a place for intuition within the total scheme of things, there is no place for it within the modern Army. There are two fundamentally important reasons for this. First, neither an intuitive decision-maker nor anybody else knows actually what goes on in the dark recesses of his brain. Consequently, there is little to say, especially anything that might add to another person's powers of intuition. Second, intuitive decisions are becoming less useful in dealing with present-day military problems. Many commanders in the past, who made decisions on the basis of "hunches," had intimate knowledge of military operations, often built up over the years, and they unconsciously drew on this background of experience. With the organizational and technical military setting changing at an accelerating pace and with problems becoming more complex, commanders of tomorrow can place less reliance on long experience with the problems they must solve and the decisions they must make.

Survey of Experimental Literature.

Since so many excellent reviews of research in the area of decision-making have been published within the last few years (21) (49), another review of the area would seem to be unnecessary. Three considerations, however, justify the preparation of this survey. First, the previous reviews have focused primarily on studies carried out in university laboratories under highly controlled but militarily unrealistic conditions. Second, since the older reviews have appeared, several new and important experimental research papers bearing on the military problem have been published, and third, none of the previous reviews focused primarily on the few studies carried out in a military or quasi-military environment under highly realistic operational conditions.

At the outset it should be noted that the ultimate purpose of any future research in this area by this reviewer is to eventually contribute to the Army's capability of training officers and NCOs in those skills relevant to the making of tactical and administrative decisions. Therefore, all of the individual studies reviewed here were selected with this goal in mind. Any survey, of course, must be selective and if the reader discovers several important studies have been slighted or overlooked, the reviewer can only apologize for the omission and ask forgiveness for his cursory treatment of the truly significant.

Although a considerable body of theoretical literature on decision-making is available, most of it has arisen from the economic theory of choice, game theory, or statistical decision theory (7) (10) (49). What little experimental literature exists has been, too frequently, laboratory-bound, i.e., the extreme simplicity of the laboratory situations and their frequent dependence upon parametric assumptions, e.g., utility, deterministic probability estimates, etc., which do not exist in real life. Thus, a great deal of this literature is simply irrelevant and fails to contribute to our understanding of decision-making in real life situations or to the development of training procedures for improving the decision-making of the military commander.

As Bertin, Regan, and Berry (7) have noted, "The simulation of realistic situations and the collection of complete action records appears to present the most satisfactory approach to the identification of factors involved in the decision process as it operates in military situations." Following a rather intensive six months of "surveying the literature," the author of this proposal finds himself in wholehearted agreement. Therefore, after a brief discussion of what is and what is not "decision-making," most emphasis will be placed on those studies carried out in a military environment under fairly realistic conditions of simulated combat or other military operational or system simulation conditions. Secondary emphasis will be placed upon the few studies in sequential decision-making, in decision-making under stress, and decision-making under conditions of risk. These, it need hardly be stated, are so far all of the "laboratory" type.

a. What is Decision-Making? There are so many definitions and delineations of a "decision" and the "decision-making" process available that the naive and unbiased reader could easily conclude that those concerned with the problem do not know what they are talking about. This conclusion is, partly, correct. Our lack of knowledge and the diversity of approaches to the subject matter have brought us to the point that almost any and every type of cognitive activity has been described or depicted as "decision-making." Relatively few attempts have been made to separate or discriminate between chance- or risk-taking decisions, pure choice behavior, thinking, problem-solving, and decision-making. In economic theory, decision-making is usually treated as simply the choice between completely explicit alternatives. Here, it is assumed that the individual can assign a probability of occurrence and a utility to each of the outcomes. In terms of the theory the individual chooses his course of action in such a way as to maximize the expected utility. For practical situations, however, serious difficulties are encountered. These troubles are concerned with the assignment of probabilities and utilities to the various possible outcomes. Until considerably more work is done on the problem of scaling utilities, relating subjective estimates of probabilities, etc., this model cannot be adequately tested for practical decision-making usage. That a few such steps would have been taken in this direction seems highly likely. Among the more interesting of these attempts is the recent study by Becker, DeGroot, and Marschak (4).

Recognizing the problem of determining the utility function of a given decision-maker and the insufficiency of rank ordering the decision-makers' preferences, as well as the inconsistency of the chooser's preferences, they propose stochastic definitions of utilities in which probabilities (frequencies) of preference choices become the basic data; the implications of some of these models were derived, which enables the experimenter to decide whether a given model is consistent with a set of data. They have also worked out the appropriate statistical sampling tests.

For certain well-defined situations, game theory provides a set of rules for selecting a course of action from among the alternatives available. The theory is not concerned with the problem of <u>how</u> an individual actually selects a course of action in a situation to which the theory is applicable, but rather with the problem of determining what course of action should be selected. The rules for selecting a course of action are aimed at minimizing the loss. For most practical military situations, however, the theory is of little help. For example, in a simple, zero-sum, two-person, finite game the military commander 1) must know all of the alternative courses of action available to him and to his opponent, 2) he must then be able to assign a pay-off value to each combination of his own possible courses of action with each of his opponent's courses of action, and 3) he must also know and use the rules for selecting the course of action that will minimize his maximum loss or maximize his minimum gain. In real-life situations, even if the commander knows all of the alternative courses of action available to him, it is extremely rare that he would know even a few of the alternative courses of action available to the aggressor. In addition, the assignment of pay-offs to the various combinations of each of his own courses of action represents a requirement extremely unlikely of being met. A similar position has been taken by Edwards (19) (22). In the latter paper he states, "The minimax principle frequently encountered in the theory of games is so absurdly conservative and therefore often so severely sub-optimal, that it does not deserve serious consideration as a basis for real-life decisions except under very unusual circumstances of a sort not worth examining here." Also in this connection, the interested reader is encouraged to consult a recent article by Rapaport (47) on the uses and misuses of game theory in practical affairs.

For most decision-making situations faced by the average military officer in the course of his duty day, he rarely is required to make a choice between two completely specified alternatives. In the words of Berry (7), "The recognition that a problem exists at all, and the manner in which methods to solve it are discovered, are activities which in the laboratory would be described as "problem-solving," but which in real life are inseparable from the task of making choices between those alternatives that are perceived." Here, however, it is important to note that decision-making and problem-solving are not the same. Psychologically, we recognize as distinct activities such things as conditioning, discrimination, creativity, learning, etc., even though each of these involves an organism starting out from one situation and producing one kind of a response rather than another kind. As noted above, in the usual usages of the term decision-making, the alternatives are given whereas in problem-solving they are unstated. Also in problem-solving, the correct solution--once obtained--may be ambiguously verified by referring to the criterion stated in the problem. This is usually impossible for decision-making. It is possible to solve a problem, i.e., find the unknown alternatives and still be faced with a choice between them. And vice versa. In the last analysis, all would agree that decision-making is a matter of human judgment, and wherever human judgment is involved so are alternate courses of action. Decision-making then can be defined as <u>the selection of a particular course of action where the possibility of alternate courses exists</u>. Included in decision-making are all of those processes which intervene between the statement of requirement for the action and the final course of action taken. Among the more obvious yet essential processes that can be isolated, identified and studied are the following:

a. Number and kind of action alternatives.

b. Amount, rate and kind of relevant information flow.

c. Individual decision-maker or psychological variables, e.g., prior experience, reactions to stress, intelligence, reasoning, judgment, willingness to take a risk, etc.

Most of the psychological or descriptive, as opposed to the prescriptive* research, has taken place within one or more of the three categories above. The descriptive research is concerned with how human beings actually behave when faced with a decision situation. Most of this research, however, has been confined to exploring a few simple variable interrelationships

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* The "prescriptive" approach postulates a rational economic man or a statistical model in terms of statistical decision theory.

within the laboratory. While the descriptive workers have recognized the need for expanding their labors to encompass a wider range of decision-making situations and to move in the direction of a more realistic study of the known and relevant variables, so far their efforts have been few and far between. While the results of some of this work are of value to the military, the kinds of decisions in which any error of judgment is intolerable, e.g., the combat situation, have been generally overlooked. Studies of decision-making and the decision-relevant information-processing situation under realistic operational conditions are few in number. Investigations of the handling of sequential decisions under conditions of high risk and intense stress are missing. Little is known about subjective (Bayesian) as opposed to objective probability and utility as they bear on real life situations. Studies of the multiple-alternative situation and the effects of increasing and decreasing the range of action alternatives are clearly indicated. Further research in which commanders can trade off the cost of delay against a gain in certainty should also prove fruitful. Further suggestions for research will follow the review of the few studies that have attacked some of these problems in the military and other real-life situations.

b. Simulational Studies of Decision-Making in Military or Quasi-Military Situations. One of the earliest studies in this category was performed by Hayes and Smith of the Naval Research Laboratory in 1960 (25). In studying the various aspects of the decision-making process, Ss were required to make tactical decision based on three variables--speed, distance, and number of airplanes--in a simulated air-defense situation. The experimentally varied factors were 1) the amount of trade-off required for decision (correlation), 2) the adequacy of the forces available to the decision-maker (adequacy), 3) the form in which the information was displayed (arrangement). The dependent factor was decision time. Although they concluded that "at least some properties of complex decisions can be described without recourse to economic theory," in a second study (26) these authors had Ss dispatch defense squadrons to intercept an aerial raiding force. The choice lay in the selection of the particular squadron, among nine possibilities, to be dispatched. These squadrons differed from each other in eight independent dimensions. Considered from a utility viewpoint,[1] the task in making this decision was therefore to combine the utility derived from each of these eight dimensions. No attempt was made to scale the utility of these eight attributes, nor did they assume on a priori utility scale. The preferred choice was empirically determined when the Ss were informed of only two of these attributes. The squadrons were then arranged so that the four pairs of attributes, separately considered, all indicated the same choice as was made by pretest Ss. Based upon information regarding two, four, six, or all eight of the attributes, Ss were then given trials in which they had to dispatch squadrons. While the additional information apparently converged upon a single choice, knowledge of the value of the additional attributes did not improve the certainty with which the Ss made their choices. Though the additional information made the choices slower, it did not make the selection more accurate.

[1]To make a decision according to the simple theory of economic choice, the task is simply to determine the utility associated with two events and to select that which has the greater utility. It is not even necessary to have a cardinal expression for the value of the utility, provided the two can be placed on an ordered scale. A recent review by Edwards (19) of studies in utility theory has shown that the behavior of individuals is only grossly consistent with the underlying utility table or indifference map supposed by economic theory.

In a problem similar to the Hayes and Smith work, Doughty (16) used an air-defense simulation system which presented target information under realistic air-defense operational conditions. His exploratory work with this simulational equipment studied the changes in a number of behaviors as a function of an increase in the operator load. As Doughty has noted, the development of complex systems which provide for human control has meant that for some of these systems the inputs and outputs of the human decision-making function may be very elaborately specified. Exact definitions of what must be done in each of a large number of different decision situations can be made.

In a highly complex and realistic simulation of an air-defense direction center, Sweetland and Haythorn (55) performed an analysis of the required decision-making functions and systematically varied dimensions of the total task. Their intent was to discover relationships between the variable task dimensions and crew behavior. Using six experimental variables: 1) class of tracks, i.e., penetrating, local, or outbound; 2) density of air traffic; 3) crews; 4) watch period; 5) experience with same traffic density, and 6) distribution of traffic load among warning sites. Several sessions and several problems they studied a) the number of tracks carried, b) the percentage of tracks carried, c) the number of items of task-oriented behavior, and d) the average task-oriented behavior per track carried.

In general, they found that the crews maintained the "important" tracks and eliminated the unimportant ones. The increase in track load also caused the elimination of nonessential behavior. Only minor differences were noted between the crews in their performance. They concluded that there are at least three major elements in a large decision-making system: 1) Reality modeling; 2) model analysis; and 3) energy level. When reality is too complex to handle directly, Ss tend to construct models of the reality. This construction is essentially an inductive process and gives a simplified picture of the reality. Next, Ss analyze this model to determine what responses should be made. This process is essentially deductive. Pervading all this appears to be a norm that declares how hard the group or system will (or can) work to obtain the objectives. This tends to remain constant. If it happens that reality intrudes a heavier load than this normative rate permits, the least important activities are pruned, techniques are made more efficient, or better techniques are devised. They also suggest that, for complex systems, the systems analysts determine which areas are in need of decision rules and set these up in a positive form, e.g., "Do X only if A is black and B is large (if A is not black and B is not large, do Y)." Meeker, Shure, and Rogers (42) have constructed a chart which describes in detail the information flow required during the making of decisions by a SAGE sector battle staff.

The value of this sort of work lies in the precise specification of the information inputs and the outputs which must result if the human functions are successfully completed. Thus, many of the things entering into the individual decision process can be made explicit. These same researchers have also shown there are various kinds of decision-making "styles" that occur in military command settings (50). Based on observations and transcriptions of five air defense exercises, four 3-man (non-military) command staffs were rated by observers, self, and team members on items assessing individual and group decision-making. Fifty-eight item profiles characterizing each subject were intercorrelated, factored, and rotated to an orthogonal criterion. Four decision-making types (factors) were identified: (a) apprehensive - immature, (b) group facilitator, (c) conservativeanalytic, and (d) military field leader. Although the Ss were not military personnel working in a military setting, the results are of quite clearly considerable practical importance.

One of the most realistic investigations conducted under military operational conditions was a series of studies completed by the Air Force Operational Applications Laboratory. The first major experiment in the series (24) was concerned with the effects of over-all task load upon the performance of "tactical decision-makers" in an air defense center under circumstances where the information supplied them was essentially complete and correct. In addition, the threats which they were required to evaluate and counteract were of a conventional, air-breathing sort. The major task of the "commanders" was the selection, from a varied inventory of varying size, of an appropriate choice of counter weapons, where the outcome of any action was more or less uncertain. Actual evaluation of threat in relative or absolute terms was only a small part of their jobs.

The second study (12), similar in nature and design, studied the effects of the man-machine decision-makers of two additional variables besides sheer task load. One variable consisted of two levels of threat--slower, lower altitude, somewhat less "lethal" vehicles on the one hand and faster, higher altitude, more lethal vehicles on the other. The other variable consisted of a wide variety of kinds and amounts of information reliability.

Both of these additional variables were intended to sample the effects, on tactical decision-making, of threat evaluation and action selection situations which were more "futuristic" (in terms of weapon performance) and more "realistic" (in terms of surveillance system performance) than had been the case in previous experiments. The first major experiment was intended to establish, in part, some "base-lines" of decision-making performance. The second was intended to ascertain the above effects, if any, and to obtain some insight into the widely known abilities of men to make surprisingly good use of unreliable and incomplete information. In this study, five highly experienced Ss were required to perform threat evaluation and action selection functions under aerospace surveillance loads of from 60 to 96 incoming tracks. Other influential conditions were the overall flight performance level of the threats and the quality of the surveillance data presented to the experimental commanders. Task load proved to be the most generally influential condition. As the task load increased, there was increased weapon consumption, an increasing but negatively accelerated rate of kill or threats, increasing and positively accelerating amounts of damage and increased reaction time. The load build-up rate beyond which commanders began to lag behind in the selection of counteractions was found to be of the order of 5 - 6 tracks per minute. The performance level of the incoming threat did not produce clear-cut evidence of effects upon the commander's success at their tasks. Tracks whose position and identifying/descriptive data were 50 % - 60 % complete and correct were handled in about the same way as tracks represented by perfect information.

The commanders made only small numbers of inappropriate action selections. While the load range that was tested began to cause deterioration of action selection performance, no drastic break point was found for any measure. It was noted, however, that commanders based their actions upon only the broadest criteria, e.g., threat vehicle class, and did not or were unable to make fine discriminations of relative or absolute threat.

Both of the above studies were designed to study a complex, realistic and militarily relevant decision-making situation as opposed to the simpler, "neater," and more tightly controllable situations which have been the forte of the more basic, academic and theoretical endeavors. The same rationale and philosophy also governed the work of Berry (7) in his study of decision-making in a Naval Air Squadron. In order to provide a basis for the development of training materials for those decision-making tasks which may frequently face naval officers, a situational test was developed involving simulation of some of the duties of the Squadron Duty Officer. Results of a preliminary study, using 20 officers, indicated that ratings of the intermediate steps in the process by which the decision was reached could be made reliably, and the comparison of methods apparently used by the officers with those that seemed desirable on theoretical grounds suggested several topics that should be included in the development of training materials.

According to the author, training should include both generalized and precise examples of the decision complex, and identification of good and bad decision-making practices can be used as a basis for training. In particular, continuous and conscious review of the desired goal and the asking of appropriate questions are essential for good decision-making and should respond to training. Although the requirements for mechanical and human decision-making are not mutually reciprocal, certain computer strategies appear to hold when translated into the human context.

Another study by Kidd and Boyes (30), using college students as subjects but conducted under quasi-military conditions, is of some interest. Using three-man teams in a simulated tactical military operation, differential levels of information input distortion and observer overlap were compared. They found that input distortion degrades decision-making speed and accuracy and that the increased intensity of coverage provided by observer overlap did not moderate this effect. Detailed analysis of the activities associated with the information processing function were also made. They concluded that system simulation techniques do allow for controlled investigation of many sorts of evanescent social situations.

As Simon (53) has pointed out, a theory of decision-making must eventually consider the activities of acquiring and processing the information that precedes decision; it cannot assume and thus leave unexplained the basis for choice. The omnipotent rationality of economic man[1] must eventually be replaced by a concept of rationality which considers the capacities of the organism for assimilating and organizing information and the information state of the organism at the time of decision.

Unfortunately, once the boundaries of decision-making are extended to include information acquisition and processing activities, a host of theoretical and empirical issues are raised. On the basis of what information does the individual reduce the large set of alternatives in a decision situation to a set of feasible alternatives? What environmental cues determine the set of outcomes or consequences that are selected for consideration? How are tentative decisions generated and modified as information is acquired? How do the parameters of the information input and personality variables affect the amount of information acquisition before decision?

c. Studies of Sequential Decision-Making. Unfortunately, most of the experimental work in the field of decision-making has dealt with simple sorts of choice situations. Here, in the typical study, S is given a certain amount of information and then is asked to make a choice between alternatives

[1]According to Edwards (19), economic man is assumed to have the following properties: a) he is completely informed. He knows all action alternatives and the entire set of outcomes which could result from each action. b) He is infinitely sensitive. He is able to distinguish among subtle differences in alternatives and costs, no matter how small. c) He is rational. He can express preference orderings for all outcomes. These preferences are invariably transitive. He chooses so as to maximize some value (e.g., expected utility).

A and B. Sequential decision-making, however, is obviously more complex. The subject not only attempts to choose which alternative is correct but also must decide when he has sufficient information to make a choice. At any point in the decision process he may choose A or B or seek more information.

Most important real life situations are of the sequential sort. The combat commander, for example, must choose between two or more tactical plans. If further intelligence can be obtained the commander must decide whether or not to use the information available or wait until more is received. If he decides to wait, his decision may be more correct but if he delays too long he may lose the engagement or may lose the advantage of acting quickly. At some point the commander must decide that the value of the information to be gained is not great enough to require waiting for it before making a decision.

Although most studies of sequential decision-making have been of the statistical variety (20) (29), several more behavioral oriented studies are available. One of the more interesting is a study by Pruitt (46) which included two types of sequential decision-making tasks. In the first task, S took his information from a machine which flashed lights randomly either in the proportion of 60 per cent red and 40 per cent green, or 40 per cent red and 60 per cent green. Each time S pressed a button either a red or a green light would go on. Though two variations of this task were employed, in both variations S was required to decide which of the settings had appeared. The second type of task was the judging of length of a line. Two lines were presented on each of 20 slides. On all the slides, the line on one side (either right or left) was consistently the longer. S had to decide which line was longer after looking at any number of slides up to 20. In some of the task repetitions, S was scored according to a point system. The less information he required before making a decision, the more points he scored. Information in the machine task was defined as the difference between the number of red and green lights. Information in the line judging task was defined as the number of slides seen before making a decision.

The results showed there was a significant correlation between all the task variations in the amount of information sought, and that the effect of the incentive was to reduce the amount of information which the Ss required before making their decisions.

In a follow-up study of Pruitt's work, Worley (61) tested the effects of high and low incentive (money) on information seeking behavior in sequential decision-making situations. Three types of decision-making tasks were used: 1) a dice task, i.e., finding a "crooked" die by means of successive throws; 2) a marble task, i.e., deciding which of three jars of marbles contained the most red marbles; and 3) a clues task, i.e., locating a specific object by means of successively more revealing statements about the object. Worley hypothesized that (a) a high level of incentive would cause Ss to seek less information than would a low incentive, (b) amount of information sought on one type of sequential task would correlate with that sought on other types of tasks, (c) the correlation of information sought in one task with information sought in another task would be higher under the high incentive condition than it would under the low incentive condition.

The results failed to confirm the first and third predictions, i.e., increasing the incentive increased the amount of information sought. The second prediction, however, was confirmed in that the amount of information sought correlated significantly between the different types of task and the correlations were in the predicted direction.

In another study of information seeking in sequential decision-making, Roberts (48) studied the relation between level of anxiety and information seeking. Part of the study was designed to determine whether the correlation between anxiety and information seeking (46) would be obtained if a different test of anxiety and a different sequential decision task were employed. The second part of the study tested the specific prediction that Ss who had just experienced failure in attempting to solve a series of problems would seek more information in subsequent sequential decision-making than would Ss who had experienced success in attempting to solve an equal number of similar problems. Roberts' results failed to confirm the earlier correlation between anxiety and information seeking. The second prediction--that failure would tend to increase anxiety and success reduce it--was confirmed, but the expectation upon which it was based was not.

More recently, Lanzetta and Kanareff (31) made an attempt to determine the effects on information acquisition of varying the cost of information, the payoff for a correct decision, and the level of aspiration for performance. A secondary consideration was to examine the extent to which Ss' normal behavior was consistent with the "rational man" concept. Here their basic assumption was that Ss will acquire that amount of information or perform that number of information seeking responses, which maximizes their expected profit or maximizes the probability of a payoff. Using money as an incentive and a series of 25 problems each having several alternative choices, they found that the number of information seeking responses did not appear to be consistent with an expected value maximization model, although Ss did behave with some concern for expected profit. Also of interest was the fact that low information seekers spent more time in processing initial data and in making a decision. This outcome is hardly consistent with the usual conception of a "confident" decision-maker.

Clearly, additional work on the relationships between anxiety and other personality correlates, incentives, information seeking and the speed and quality of sequential decision making is urgently needed. Without presuming too much about the nature of the psychological processes involved, it seems reasonable to assume that the total available time for decision-making can be divided into two components--time spent in information processing and time devoted to information acquisition. In a forced-pace task the time spent in acquiring information must of necessity reduce the time available for processing it, i.e., reading, selecting, comparing. As the pool of available information increases or as the difficulty of understanding the information increases, the value of acquiring further information would presumably decrease while the value of processing time would increase. In general, then, one would predict less time devoted to information acquisition the greater the amount of information currently available, with the termination point of information seeking being a function of the difficulty of processing the information. If Ss differ in their ability or motivation for information processing, they should differ in the relative amounts of time allocated to processing and acquisition. Is it true, as the results of Lanzetta and Kanareff's study suggest, that the more secure and confident personalities require less information before making a decision?

At present, reliable, generalizable, and useful knowledge about human behavior in sequential decision situations is non-existent. Theory is, of course, in equally dire straits. Part of the difficulty in reconciling some of the experimental results with existing decision theory, information theory, instrumental conditioning or S - R reinforcement theory stems from our lack of knowledge about what specifically is reinforcing the acquisition of information. As many workers have asked, "Is the reinforcement a payoff?" Is it a reduction in uncertainty or anxiety? Or is it both? Do Ss differ in their responsiveness to a payoff versus uncertainty reduction as reinforcers? Obviously, more experimental work is needed.

d. Decision-Making Under Conditions of Risk. The problem of decision-making under conditions of risk has been approached from two points of view. The first approach has been characterized by attempts to derive a mathematical model for risk-taking. To date, all of these models are similar in that the individual's expected value of a bet can be quantitatively determined by multiplying the value of a payoff times the probability of obtaining that payoff. The models differ in that the measure of the value of the payoff can be objective (objective utility) or subjective (subjective utility). Objective utility is measured in terms of some quantity such as dollars, whereas subjective utility refers to the psychological value of the quantity to the individual. The measure of probability can also be objectively or subjectively defined in these models. Objective probability refers to the actual probability of winning or losing, while subjective probability refers to the individual's estimate of the probability of winning or losing. The latter may or may not correspond to the objective probability.

Of the various models that have been proposed, four representative types will be discussed. A basic assumption of all the models, however, is that the individual will behave in such a way as to maximize the expected value of a given outcome. Bernoulli (5) in one of the earlier models assumed that the individual selected a given alternative on the basis of objective utility and objective probability. In a second model this same worker asserted that individuals made a choice on the basis of objective probability and on the S's estimates of its utility, i.e., subjective utility. Unfortunately, this model proved insufficient to predict human decision-making under risk.

An objective definition of utility and a subjective definition of probability forms the basis of the third model offered by Coombs and Pruitt (14), although Edwards (19) earlier found this third model unsatisfactory, arguing that both utility and probability be subjectively determined. As one would expect, these concepts are quite difficult to measure and the problem of scale strength is unsolved, i.e., measurement of S's estimates of probability and utility require a scale stronger than ordinal but weaker than internal. Coombs and Komorita (13), in an attempted solution have proposed an ordered metric scale for individuals' preferences. Its value remains to be seen.

Alternative concepts which modify the basic assumption that individuals behave in a manner that will maximize the expected values have been proposed by several workers. Edwards (17) (18), for example, found evidence for probability preferences among betters. Some Ss preferred bets with a .50 probability of winning and avoided bets with a .75 probability. Coombs (14), in this regard, has argued that such preferences are confounded with variance preferences. By this he means that the Ss base their decisions not only on the expected value and the probability preference of a bet, but also on the dispersion of the possible outcomes. Some people seem to prefer to bet less and win less than to bet more and win more, whereas others prefer the reverse. For a given expected value, therefore, an S may have a preference for a certain amount of variance. Although Coombs (14) has demonstrated the existence of such variance preferences, the relationship between these variance and probability preferences remains unclear.

The second major approach to risk-taking behavior considers this behavior a dependent variable. Accordingly, most of the effort has been directed toward personality variables that correlate highly with risk-taking. One of the principal investigators in this area, Atkinson (1), has not only explored many of these personality correlates but has also developed an intriguing theoretical model to encompass the motivational factors influencing risk-taking behavior. In Atkinson's view, those individuals who have a high motivation to achieve success (high need achievers) would prefer bets with an intermediate probability of success, whereas those who have a high motivation to avoid failure (high fear of failure) would prefer bets with a probability of success near 0 or 1. In one study employing McClelland's Need for Achievement Test (39), he found that persons scoring low tend to take more risk and persons scoring high tend to take less risk. In another series of studies of the relationship between achievement need and task difficulty, Atkinson and Litwin (2), Atkinson, Bastian, Earl and Litwin (3), and Litwin (33), found that Ss with high need for achievement chose to work on tasks of moderate difficulty more often than Ss with a low need for achievement. Where the skill of the person is involved such facts seem well established, but in situations where the outcome depends entirely on luck, the evidence is not so clear-cut. In one of these studies cited above (3), it was noted that Ss with a high achievement need showed a definite preference for bets under intermediate odds as compared with very short or very long ones. Litwin (33) also found that Ss with high achievement need showed a greater preference for intermediate odds when the outcome depended on chance. Littig (32), however, found quite a different trend in using poker hands and with real money at stake. Here those Ss with high achievement need definitely and consistently preferred the shortest odds they could get, i.e., the safest bets. Thus, in a true gambling situation, Ss with high achievement need preferred the highest probability of success. Ss with low achievement need seemed to prefer the long-shot and especially when there was a lot of money to be won. Littig's results are more in line with Atkinson's general theory and Atkinson, in recognition of some of the discrepancies (particularly the fact that Ss with a higher achievement need sometimes show a preference for tasks of moderate difficulty) has proposed a model showing the interaction of achievement need and risk-taking. Atkinson first assumes that the incentive values of an achievement, i.e., the relative amount of satisfaction to be experienced in any personal accomplishment is a positive function of the difficulty of the task. Difficulty is represented in the model as decreasing probability of success (P_s). If, for example, Task A is difficult (1 chance in 10 of succeeding or 9 in 10 of failing) whereas Task C is quite easy (9 in 10 of succeeding or 1 in 10 of failing), incentive value is then assumed to be a simple inverse function of the probability of succeeding, or $1 - P_s$. When the probability of winning is high, an easy task, the amount of satisfaction experienced in winning is low. When the probability of winning is low--a difficult task--the amount of satisfaction in winning is high. Next, it is assumed that the extent to which motivation is aroused to approach any goal is a joint function of the probability of goal attainment (P_s) and the incentive value or amount of satisfaction accompanying attainment of that goal. Thus, the tendency to prefer or approach the difficult Task A for Ss with a high motivation to achieve (M_a) is the product of the probability of success (P_s), times the incentive value of success ($1 - P_s$) or (I_s) times the strength of the motive, or $M_a x P_s x I_s$= approach. From such assumptions, it follows that 1) the tendency to prefer or approach a task will be greatest when it is of moderate difficulty and will be less for either very easy or very difficult tasks, and 2) the stronger the motive to achieve the greater the differential preference for tasks of moderate difficulty. The model provides a concise description of what appears to be going on although McClelland (41) has suggested a modification to better handle what is called "perceived probability of success."

While it seems well demonstrated that Ss with high achievement need prefer tasks involving some objective risk and work harder at such tasks, we might ask: does this make them better decision-makers? Do good decision-makers like to take risks? Do they see themselves as taking greater risks? In psychological terminology, we are talking about "perceived probability of success." Here, also, the evidence is good that Ss with high achievement need tend to perceive their probability of success as greater, particularly when there are no facts to justify their estimates. Atkinson, originally, called attention to the fact that Ss who are high in need achievement tend to feel that their chances of winning are actually better than the stated odds (1). For example, they state higher levels of expectation for performance of a task at which they had no previous experience, and when the objective evidence is conflicting as to how well they are doing in a course, they tend to overestimate more the grade they will get in it than do Ss with low need achievement (1). There are, however, situations in which Ss with high need achievement do not overestimate subjective probability of success. When they have pretty good knowledge on the basis of past performance how they will do in a course, they base their estimates on that knowledge (40). Furthermore, Litwin (33) found that in the ring-toss game when his Ss were asked to estimate how many hits they would make from each line <u>after practice</u>, they did not show a greater perceived probability of success than the Ss with low need achievement. The difference between these situations and the earlier ones seems to lie in the greater number of cues in the latter situations on which the subjects can base a realistic estimate of how well they will do. In other words, the more unknown the situation which demands their achievement, the more self-confident they are as contrasted with the Ss with low achievement needs. As the reality cues become available they tend to base their judgments on these cues. They are not impractical "dreamers" over-estimating their chances of success at everything; instead, they rely on facts so far as they are available, and then fall back on generalized self-confidence. The difference can be readily explained in terms of Atkinson's model. When there is accurate knowledge of the difficulty of the task, they choose moderate risks or perceive themselves as able to do a little better than they have done. When there is no real knowledge of how well they can do, it is as if difficulty (P_s) and hence incentive value of success ($1 - P_s$) are based on generalized expectations divorced from their own performance potential. Further, it is as if this generalized knowledge of difficulty (P_s) continues to determine incentive value (I_s) but does not itself enter into the equation so that the resultant approach value is a simple product of $M_a \times I_s$. Since M_a is higher for the Ss with high achievement need, they should be more self-confident or show a greater approach tendency whatever the perceived difficulty of the task. When they know better how well they can do, the part of the P_s value affected by their performance potential enters in, and their preference becomes more modest and realistic. Accordingly, McClelland (41) has suggested a fruitful modification of Atkinson's model in the direction of splitting the P_s factor into a component based on general knowledge of the difficulty of tasks and another component based on knowledge of one's own competence at a particular task. McClelland suggests the following revision in the formula:

$$\text{Approach} = M_a \times P_{s1} \times I_s$$

$$\text{Where } I_s = 1 - \frac{P_{s1} + P_{s2}}{2}$$

And P_{s1} = Probability that I will succeed based on my past performance

P_{s2} = General estimate of the difficulty of the task.

Thus, when P_{s1} is unknown, approach becomes in effect a simple function of M_a and P_{s2}.

Two other findings deserve mention. As noted earlier, Littig (32) found that Ss with high achievement need do not overestimate their chances of winning in a gambling game. Scodel, Minas and Ratoosh (51) also found that persons high on need for achievement bet more conservatively (low risk) than those low on need for achievement. The high risk-takers in this study, however, achieved a lower fear of failure score on the Willerman test (60) than did the low risk-takers. In addition, intelligence was not significantly related to degree of risk-taking and Ss who were sophisticated about probabilities and expected values were no more likely to maximize expected dollar value than others. They concluded that low-payoff betters as compared to high payoff betters are a more other-directed, more socially assimilated, and more middle-class oriented group.

In general, the results of all of these studies point to the fundamental importance of personality variables in risk-taking. Any theory of risk-taking that ignores these variables will be grossly inadequate as a model for prediction. A note of caution is, however, in order. Not only is it obvious that there may be additional personality correlates of risk-taking yet to be discovered, but also a recent study of convergent validity by Slovic (54) indicates either that few of the so-called risk-taking measures actually measure the trait or that "willingness to take risks may not be a general trait at all, but rather one which varies from situation to situation within the same individual." For example, the confident individual may have the conviction he can modify the outcome of an uncertain situation by his own personal ability. If the outcome depends on luck (as may an honest gamble) rather than skill, he has no basis for confidence. If the outcome is clearly predictable on the basis of his past performance (swimming a river when he can't swim), he also has no basis for confidence. It is only in relatively new situations where the outcome depends on him that his willingness to take a risk will show up most clearly. The modification of the Atkinson model referred to earlier might be able to predict quite readily this behavior. A test of this model is certainly worth the try.

In any event, the role of the Army commander in many of his activities calls for decision-making under uncertainty. If there is no significant uncertainty and all that is required is the application of knowledge, or learned principles, or doctrine, in order to produce a desired or predictable result, then risk-taking cannot be said to be involved. True, all human activity requires decisions and some degree of uncertainty, but the degree of uncertainty surrounding the construction of a bridge according to sound engineering principles is measurably less than for the Army commander who must decide whether to employ a Davy Crockett or conventional firepower. On the other hand, military commanders are not ordinarily regarded as gamblers although the professional "card shark" certainly makes decisions under uncertainty. Analytically, the distinction is an important one. It does not depend on the fact that the gambler is operating under longer odds than the commander. The chances of success in some military operations may be on the average less than the odds under which some gamblers play. The point is that the gambler can exercise no control over the outcome (unless, of course, he cheats) whereas the commander can influence by his orders whether his decisions will turn out in the long run to be successful or unsuccessful.

There is, thus, a continuum running from a situation of little or no risk in which the required action is governed by rule, doctrine, or specialized knowledge to situations in which there is no precedent or knowledge to guide one as in the case of a perfectly balanced coin toss. On such a continuum, the military commander falls somewhere in the middle. He is often called upon to make "calculated" or moderate risks in which some skill and some luck are involved. The important and "to-be-thankful-for" fact is that in such moderately risky situations the outcome depends more clearly on his skill and knowledge than in the case of either extreme. At the doctrine end of the continuum, the commander need do only what anyone with the proper skill or knowledge can do, whereas at the gambling end, nothing he might decide upon will influence the outcome since by definition it depends entirely on factors outside his control.

e. Decision-Making and Stress. As noted above, for the Army or military commander the kind of risk-philosophy he characteristically adopts should be of considerable practical value to those concerned with assessing his qualifications for sensitive and critical command assignments. Another facet of equal--if not greater--importance is the commander's capability or ability to perform under stress. Certainly, it is evident that many life-or-death or other equally crucial decisions will have to be made under pressure of time, work-load, emotional upset, combat emergency, or the jaundiced eye of an irate superior. While there is some disagreement about the definition of psychological stress and its general relation to anxiety and anxiety states, it can be legitimately regarded as the state of an organism produced by some condition or event which threatens the physical or psychological well-being of the organism. It is also perhaps useful to discriminate between stress and general anxiety. It is, of course, quite normal to be concerned, solicitous, worried and restless about one's everyday problems. Fearful anticipation of potential unpleasantness is not only reasonable but it also warns us of trouble. Such emotion is necessary to motivate one to accomplish things and this desire serves, on some occasions, to further increase the degree of normal anxiety. It is this normal anxiety that gets us out of bed, keeps us on the job, makes us meet our responsibilities, and drives us to do our best. When one is ambitious, one has considerable anxiety. These feelings of insecurity, lack of self-assurance and confidence are normal and are usually alleviated when the goal is reached. If one is able to control them, worry and anxiety can be very useful. When anxiety becomes excessive, however, it is analogous to steam under pressure and when it explodes it may attach itself to any situation in the individual's life, producing agitation and tension which may be converted into pathological fears or physical symptoms. The primary difference between stress and general anxiety lies in the nature of the threat, whereas a stressor is usually overt, well-defined, and known to the individual, the cause of anxiety is covert, ill-defined, and vague, and not known to the individual. Although the definition of stress is at variance with other definitions, it agrees well with the definition of the physiologist Selye who has described a set of physiological changes by which one can infer that an organism is in a state of stress. Obviously, direct threats to the life of an organism are the most potent of the various stresses that might be applied. There are, however, many negative aspects and experimental difficulties involved in the experimental use of such threats and such extreme means should not be used unless the experimental study demands this sort of criteria, as--for example--was demanded by the study of combat stress performed by Berkun, Bialek, Kern and Yagi (6).

Within the laboratory, extreme temperatures and other unpleasant environmental situations, information overload, the stress of achievement failure, frustration of aspiration and similar threats to the integrity of the ego have often been used to produce stress in lieu of threats to the individual's life. Except in rare and infrequent combat situations, it is unlikely that the result of the commander's decisions is a life-and-death matter to him personally, even though it well may be a life-or-death matter to other individuals within his command.

The studies of decision-making under stress are few in number and none of them have any direct bearing upon decision-making by an Army commander in a military situation. From the few studies available, it can be concluded that the effects of stress on decision-making behavior depend largely upon its intensity, the S's level of motivation, and the requirements of the decision-making task. Mild stress may facilitate decision-making. If the S is well motivated and the task is relatively easy, he may be able to compensate for the effects of stress and perform up to his usual standards. If the S is highly motivated, he may overcompensate for the effects of a mild stress and perform at an even higher level. Stress seems to affect both attention and perception by enhancing attention and narrowing its focus in both time and space. Ss tend to concentrate more on the task at hand and to ignore both previous events and peripheral stimuli (8). Where cognitive demands, e.g., on memory are not excessive or where peripheral stimuli are irrelevant, this effect may be desirable, yet in most command situations this is not the case.

Under intense stress, Ss may develop a cognitive defense which expresses itself in aggression or in attempts to leave the stressful situation by withdrawing physically, psychologically, or both. The evidence also suggests that Ss show little benefit from practice occurring under extreme stress although extinction is delayed. Another negative effect is the fact that under stress Ss tend to become less efficient in their use of the available information and also accept hypotheses recklessly. Thus, the habits formed under intense stress are often qualitatively inferior to those acquired under less stressful conditions. Also noted is the fact that Ss often revert to well-learned or older forms of behavior and use them rigidly when under intense pressure despite the fact they are inappropriate to the situation at hand (8).

It is also well known that Ss differ in their tolerance of stress and their relative tolerance to different kinds of stress. Thus, the selection and training of decision-makers should depend upon a host of such subjective factors and these should be carefully looked into before critical assignments are made or before any attempts are made to predict future decision-making behavior.

Here, one of the most fruitful approaches may well be that currently being made within the framework of general systems theory. Herbst (27) has recently postulated the operation of three types of forces within any behavior system. These are a) forces deriving from the components, b) forces deriving from the system, and c) forces that have their source in the environment of the system. In the case of the individual, these correspond to a) <u>valence forces</u> defined as cognitive representations of strain states associated with individual activity areas, b) <u>internal pressures</u>, defined in terms of the perceived strain effects on the individual's behavior system as a whole resulting from the inclusion or exclusion of activity areas, and c) <u>social pressures</u> resulting from the interdependence of the individual's behavior system with that of other individuals.

In Herbst's terms, a state of situational stress is said to exist if an opposition is found in the direction of external pressures and the internal forces of the individual. For example, the child may dislike doing a household task, feel he should not do it, but perceive his mother as wanting him to help. It may happen that an internal opposition of forces exists, where the child dislikes the activity but feels he should do it. In this case, an external pressure in either direction will imply a state of situational stress. The existence of a state of stress implies a displacement of the system away from its equilibrium state which, by definition, is equivalent to a state of strain. Since one possible route toward strain reduction lies in reducing the strength or direction of opposing pressures, Herbst states that the degree of situational stress will be directly related to the degree of external adjustment processes. This, in turn, leads Herbst to make some specific assumptions and predictions about the effects of stress on performance level.

Several studies, as well as common observation, show us that frustration leads to a general reduction in the level of constructiveness but some Ss always show an increase. There are some individuals who appear to be stimulated by conditions of stress and produce a more effective performance while others show behavioral disorganization and a reduction in effectiveness. Clearly, the problem in need of solution is: what are the variables determining whether an increase of situational stress will lead to an increase or decrease in performance level, and what is the functional relationship between the variables involved?

According to Herbst, the key variables are 1) size of the <u>activity domain</u>, 2) the <u>degree of stress</u>, and 3) the <u>vitancy of the situation</u>.[1] The relationships between them in terms of situation dynamics are stated as follows:

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[1]<u>Activity domain</u> is defined as the set of activities in which the individual engages and <u>vitancy</u> is defined as the cognitive representation of the amount of energy associated with a given activity domain. Vitancy corresponds to the experience of involvement, emotional attachment, or commitment to an object, thing, or idea.

(a) To the extent that the vitancy of the situation is above a critical value, the size of the activity domain decreases with situational stress.

(b) To the extent that the vitancy of the situation is below a critical value, the size of the activity domain increases with situational stress.

In ordinary language, if we substitute level of performance for size of the activity domain, we find Herbst predicting a high level of performance under two distinct conditions:

"(1) The person is highly involved in the task, situational stress is low, and consequently the task is experienced as enjoyable.

(2) Task involvement is low, situational stress is high, and consequently the person gains little pleasure from his achievements. Similarly, a low level of performance will occur under two distinct conditions:

(1) The person is highly involved in this task, stress is high, and the situation is experienced as highly unpleasant.

(2) The task is perceived as being of no importance, no stress operates, and consequently no satisfaction or dissatisfaction is associated with the task."

According to Herbst, the view that learning and effectiveness of performance are a direct function of motivation has to be modified. The relation holds only under conditions of low stress. Under conditions of high stress, on the other hand, a reduction of motivation below the critical vitancy value is required to increase the effectiveness of performance. It is, of course, reasonable to assume that individuals will differ with respect to the critical vitancy value beyond which their activities become disorganized with increased stress. It is possible, therefore, as Herbst suggests, to use readiness of individuals to react to stress with negative emotionality, such as failure experience, humiliation, pessimism, and selfblame as a measure of their critical vitancy value beyond which stress leads to performance deterioration. That such a suggestion may bear considerable fruit finds support in a study by Waterhouse and Child (59), who found that individuals with high readiness for negative emotional reactions under stress (low critical vitancy value) showed a reduction in mean performance level under stress, while those with low readiness for negative emotional reactions (high critical vitancy value) showed an increase in mean performance level.

Despite the strengths and weaknesses of Herbst's model in particular, and of situation dynamics as part of general systems theory in general, the merging of clinical and personality theory with the domain normally encompassed by experimental psychology is a laudable step since neither alone has shown the level of predictive power needed by the applied psychologist or behavioral technologist. A further advantage lies in the systematic and orderly procedures whereby diverse experimental facts are integrated and organized in such a manner that additional hypotheses are generated, tested, and result in new facts that enlarge our understanding and our capability for solving practical problems. The application of situation dynamics to the problem of decision-making and the testing of Herbst's hypotheses about the effects of stress on performance level are strongly recommended.

f. Training Aspects of Decision-Making. Notably absent from the experimental literature are studies concerned with decision-making training. In this survey of the literature only three studies of direct relevance--two by Teichner and Myers (56) (57) and one by Berry (7), referred to earlier--were located.

In the first Teichner and Myers study (56), various elements of the decision-making process in a complex weapons system were examined in order to determine their capability of being modified by training as well as to determine which elements are most critical to successful decision-making performance. This study consisted of five experiments, each dealing with different problems in the decision-making process: a) human reception of information from a display system, b) storage of the information received in man's short term memory, c) status decision regarding the present situation, d) evaluation of possible action decisions available in man's long term memory, and e) the action decision which is optimum for the situation. They concluded that in order to improve both the quality and speed of decisions, attention should be paid to methods for improving the display and presentation of the decision problems. In their words, "This might be accomplished by repeating essential information which is to be rapidly perceived, and reducing excess information which is to be remembered for short periods of time." In addition, they suggest that significant improvements in decision-making might be realized from formal programs which provide training and practice in actual decision-making problems and which supply knowledge of general decision-making principles and pitfalls.

Continuing their same approach in the second study (57), Teichner and Myers studied other variables affecting action decisions. Some of the more positive findings of this study were as follows:

1. The rate of information storage seems more important to short-term recall than the quantity of information stored.

2. Training personnel to count as well as name multiple target images should be considered as a possible means of aiding short-term memory for rapidly stored events.

3. The effectiveness of practice depends upon the factors involved in the decision. Depending on whether the cause of poor performance in multiple

visual target identification is perceptual or due to inadequate short-term recall, practice may improve or worsen performance. In binary choice situations, long-term practice does improve the quality of decisions, but it is not clear whether this is due to improved estimation of event probability, or to a change in the operator's strategy.

In the Berry study of the training of naval officers in decision-making performance the conclusions and recommendations arrived at are of such considerable relevance for future study they deserve to be quoted in full:

"(1) Identification of decision-making situations. The term "decision-making" should be reserved for choices that require the officer to evaluate alternatives in preparation for action that is required. This should be distinguished from control functions which simply require the identification of a situation so that a pre-prepared action may be applied.

(2) Alternatives to decision-making in control functions. It appears likely that the apparently superior decision-making performance of experienced officers arises in part because these officers call upon past experience in a way that permits them to apply a previously developed solution when a similar problem is recognized. Especially where rapid control functions are required, it may be highly desirable to provide such training and in effect eliminate the decision making component of the performance. Such elimination is also achieved by some human engineering modifications of equipment, or by the provision of job aids for control tasks. This solution to the provision of control functions cannot be applied wherever novel and unforeseen developments may occur.

(3) Relevance of laboratory research on decision-making. Because of the extreme simplicity of laboratory situations employed for this purpose, and because of their frequent dependence upon parametric assumptions (e.g., regarding utility, probability, etc.) which are unmet in real life, this literature seems largely irrelevant to the development of training programs for decision-making by officers.

(4) Emphasis upon process. Determination of the intervening process by which people make decisions remains rudimentary. Nevertheless, development of techniques for decision-making in which officers may be trained cannot proceed far without improved understanding of this process. The technique developed in this study, depending upon simulation of complex situations and the collection of an extensive record, is cumbersome and expensive when compared with more traditional laboratory methods. However, this method offers greater promise for the identification of processes used by human subjects, and in particular for the identification of deficiencies in the process that might be remedied by training.

(5) Importance of criterion problem. The purpose of the development of training for decision making can only be to improve the quality of the decision produced. This effort cannot proceed without an unambiguous basis for the evaluation of decision performance. It is unlikely that explicit formulas can ever replace human judgment for this purpose, although they may be developed within limited areas and there provide a basis for the elimination of the decision-making aspect of control functions. It is essential that criteria for the adequacy of decision-making developed for training purposes be compatible with those that the officer will encounter in his dealings with his own superior officers and others who will evaluate his performance. This suggests that any long-run program for the improvement of decision-making performance must also be concerned with the manner in which judgments of decision performance are made, and possibly investigate training for that performance also.

(6) Identification of decision-making strategies. In order to provide a basis for a "core-curriculum" for decision-making training, a wide variety of task situations should be selected from the officer's duties. For each of these, criteria for the adequacy of decision should be enumerated. A model procedure (using the information processing computer languages, or similar descriptive approaches) should be developed for each of these. These model decision processes should then be examined for sub-processes or strategies common to all of them, or occurring frequently. These may then be examined to determine whether they appear trainable. For example, it appears likely that computer approaches to decisions would regularly commence by a review of those criteria bearing on the situation and the way in which they must be met in selecting a course of action. It appears likely that failure to go through this step is a frequent source of weakness in human decision performance, and one that would not be difficult to train.

(7) Evaluation of decision-making training. Since the aim of decision-making training is to modify the final action-selection performance, evaluation of that performance must be the final criterion of acceptability. However, during the stages of the development of training materials, it will be important to obtain not merely pass-fail information, but descriptive material on the consequences of training for intermediate stages of the decision-making performance. This will permit increased feedback and more responsive modification of the training methods. For this purpose, continued use and development of situational tests for decision making seem desirable.

(8) Generalization of decision-making training. Because the key to all-around proficiency in decision-making is the strategy for the handling of unforeseen or unfamiliar situations, it is important that any training developed in one context be generalized to other contexts not specifically included in the training program. This means that if one set of situations is used during training for decision-making, a different set of situations should be employed when the effects of training are tested."

In summary, it should be noted that every duty day, the typical commander makes a number of complex decisions. If asked to explain how he made such decisions, it is likely that he would be hard-put to give a reasonably precise answer. The typical commander rarely examines his own decision-making process self-consciously. If he did, he would probably discover that he does not follow a consistent pattern. True, he might profess to make decisions on the basis of what he believes to be relevant and pertinent factors. But perhaps more often he makes decisions on the basis of intuition or hunch, i.e., on the basis of ill-defined and inconsistent values and a large number of both relevant and irrelevant bits of old and new information stored in his head. Certainly, even the best of decision-makers would be the first to admit he has in his lifetime made many bad decisions and the first to express a desire for any kind of method or technique which would reduce his uncertainty and increase the wisdom of his choices. Concerned as we are here with improving the decision-making capability of the military commander, there is every good reason to believe that the adoption of a formalized decision-making procedure and training individual officers in its use could not fail to result in a general improvement in decision quality across the board. For example, the elementary aspects of a formal decision-making procedure would include:

(a) The decision-making environment, i.e., the identification of the decision-maker and the situation or climate in which he makes decisions.

(b) Objectives of the decision-maker, i.e., it is more the rule than the exception that a commander makes decisions on the basis of a single objective, without realizing that his decision might have a serious effect on the achievement of other objectives; in other words, recognition must be made that a multitude of conflicting objectives might exist.

(c) Alternative plans of action or strategies. In many situations, an unlimited array of alternative plans of action or strategies presents itself. In many others, however, the number of feasible strategies is small enough so that the alternatives can be easily listed. The important point to note here is that each possible strategy will generally have some effect in achieving each of several different objectives. For this reason, it is helpful to prepare an exhaustive list of strategies.

(d) The deterministic decision payoff. Once the objectives have been identified and the alternative plans outlined, the next step is to find some measure of the payoff or effectiveness of each plan of action.

(e) The probabilistic decision payoff. In most real situations the decision payoffs are not fixed but can be regarded as random variables. In other words, the payoffs are determined at least partly by chance and not solely by the strategies chosen. Under such conditions of risk, the concept of probability plays a central role in decision-making.

(f) The decision payoff under competitive conditions. The theory of decision-making under competitive conditions, as noted earlier, has been treated by mathematicians and economists under the rubric of the theory of games. As the title implies, the theory is rather light and applies only to simple games of skill. Though this is true in actual practice, conceptually the theory is regarded as one of the most important in modern economics. While it is mathematically difficult and almost useless from a practical point of view in that it is descriptive of only the simplest and most simple-minded of competitive situations, it is well worth considering as a conceptual framework for decision-making training.

(g) Measures of value or utility. In short, the objective of any decision should be a maximization of utility. In most practical situations the utility or value of a decision is hard to pinpoint, so the decision-maker assumes that his payoff in terms of units of utility is the same as his payoff in gains or losses. Yet the utility or true value of the outcome of a decision is different from one individual to another. When the decision is not made in a state of competition, this poses no insurmountable problem because the individual decision-maker can define the payoffs according to his own opinion of the relative values of various objectives. When a state of competition exists, however, the problem of relating each person's payoffs to the same scale of value seems impossible to solve. Recognition of this dilemma must, nevertheless, be made in any consideration of decision-making improvement or training.

g. Suggestions for Future Research. From the foregoing survey of the decision-making literature, it should now be clear that research on this problem is still in the inchoate state. Badly needed is additional research in the following areas:

(1) Information processing and studies of the interpretation of ambiguous information.

(2) Studies of individual differences and the effects of certain personality variables on the decision process.

(3) Studies of the effects of stress and anxiety on independent and sequential decision-making.

(4) Studies of the relationships between such cognitive variables as memory, intelligence, problem-solving, and creativity and the decision-making process.

(5) Additional studies of the degree to which decision-making skills can be improved through training, i.e., through reinforced practice, the expansion of the alternative course of action base, and through relevant cue discrimination training.

To be of maximal value to the Army commander, all of this work should be carried out under fairly realistic operational conditions. As Chenzoff, et al. (10) have noted, "The important point is that for research purposes, experiments should aim at some degree of realism, but exact simulation need not be achieved. Since criteria of good performance in the real system are not constant, but rather are likely to change as new rules are formulated, the critical measure of operator effectiveness would be his ability to achieve whatever type of performance is asked for, within the scope of his equipment capability."

Each of these suggested areas of research will now be discussed in turn.

1. Information Processing. The empirical studies of decision-making cited earlier have typically provided the decision-maker with an information base in terms of which a choice among alternatives must be made. The information base includes specification of the alternatives, the possible consequence of a choice, and probabilistic data on the relationship between alternatives and outcomes. The information-acquisition processes preceding decision are assumed to have occurred and, in essence, are simulated by the experimenter. Normally, Ss do not have the option of delaying a choice until additional information is available or in order to seek further information regarding potential alternatives, outcomes, or the relationships between alternatives and outcomes.

The experimental paradigm embodies the boundary conditions of economic decision theory and it is not surprising that the studies using it have focused on testing one or more of the theoretical assumptions or predictions. Unfortunately, once the boundaries of decision making are extended to include information acquisition and processing activities, a host of theoretical and empirical issues are raised. These issues must be faced and effectively dealt with if the military commander is to be helped in any significant fashion. We know that command functions involve broad problems of planning, assessing the capabilities of the command's forces and those of the enemy, allocating resources, alerting, and committing the command's forces. These functions require the gathering of large amounts and many classes of information, aggregating the information, and processing it to enable the commander to make knowledgeable, deliberate decisions in a context of changing objectives. Here, what we do not know is as follows:

On the basis of what information does the commander reduce the large set of alternatives in a decision situation to a set of feasible alternatives? What environmental cues determine the set of outcomes or consequences that are selected for consideration? How are tentative decisions generated and modified as information is acquired? How do the parameters of the information input and the subjective variables (e.g., intelligence, memory, risk-taking) affect the amount of information-acquisition before decision?

In addition to these questions is the question of the interpretation of ambiguous information. Here, Chenzoff, et al. (10) have cited five kinds of problems in need of experimental clarification.

(a) There are many practical situations (e.g., surveillance situations) in which people have to make decisions based upon subjective evaluations averages, variabilities, trends, and correlations. Mathematical statisticians have given scientists new opportunities to extract meaningful data from such human performance tasks, e.g., their statistical tests and procedures offer the psychologist a basis of comparison between statistical and human decisions; the ways in which human performance departs from these established calculated statistical criteria should reveal a good deal about this form of human decision-making and its main limitations.

(b) The recognition of patterns by machines is still one of the most difficult procedures for computers to undertake. It, therefore, seems of the highest importance to undertake experimental work on pattern reading by human subjects since this is expected to be one of the last forms of work to be handed over to machines. The need for this is all the more urgent since the recent enormous increase in the number of photographs with air surveillance information may soon produce such vast quantities of information that the data available will outrun the facilities for analysis.

(c) At a much more complex level of decision-making the judging of the relevance of past experience (data stored in memory) as well as of current intelligence information to the problem at hand, is a typical process often required of relatively senior decisions makers. Knowing what to discard in forming a judgment can clearly make the difference between success and failure. Yet, little if anything has as yet been done on this kind of problem.

(d) One of the most important forms of subjective judgment exercised in deciding a course of action is that concerned with estimating the relative gains to the system likely to follow from each of the various possible outcomes. Much more should be known about the mental yardsticks that military men use in arriving at a decision. No one seems to know the subjective values that are used in these estimates. Much work has been done, however, on the betting situation where the gain to the system is measured on the relatively straightforward basis of money. Such work cannot readily be tested to see whether it is applicable until these many other values in military situations are made more explicit. The longer they remain inexplicit, the longer they remain unexplored.

(e) Of major research interest here is the study of how missing or erroneous information affects the human's interpretation of the displayed data. If humans can compensate for missing data (up to a point) but are misled by wrong data, more stringent filtering would be indicated. Research might also be aimed at determining the value of displaying information with associated level of confidence numbers.

Although not usually considered under the heading of information processing, the cognitive processes of memory and thinking are obviously involved. In a recent comparison of human performance with that of a computer, Tomkins (58) has offered a novel theory of memory. According to his theory, human memory consists of two components or functions analogous to the computer storage and retrieval. In his own words, "We have distinguished sharply the storage process, as automatic and unlearned, from the retrieval process, which we think is learned. Both are duplicating processes, but one is governed by a built-in unconscious mechanism and the other by a conscious feedback mechanism."

While it is recognized that a direct empirical test of this assumption is difficult--if not impossible--the idea is, nevertheless, intriguing. It is well known that recognition is significantly easier than recall. Yet, according to Tomkins, "recall" or "retrieval" is "learned." If learned, then recall or retrieval should be expected to improve with practice whereas recognition requiring only a matching of the given with the stored may not be amenable to improvement with practice, i.e., learning. A cursory search of the relevant literature on memory, forgetting and learning did not reveal any specific studies bearing on this issue. Therefore, it is believed that experimental pursuit of this idea is in order recognizing, of course, that improvement of recognition with practice still would not invalidate Tomkin's theoretical position.

In an unpublished study by Norman, cited by Edwards (22), Ss were presented several bags each containing 1000 poker chips. Some bags contained blue and red chips in the proportions P and 1-P; other bags contained blue and red chips in the proportion 1-P and P. For example, five bags were 60-40 blue to red, five others were 40-60. A bag was randomly chosen, chips were drawn randomly with replacement from it, and after each draw Ss were required to estimate the posterior probability* that the bag was one in which blue chips exceeded red. In spite of the simplicity of this task, the Ss were unwilling to reach conclusions, i.e., they were either unwilling or unable to estimate extreme probability. From another series of unpublished studies also cited by Edwards (22) in which Ss could buy, for a price, information which could reduce, though not eliminate, the risk of an eventual decision, it was found that Ss who failed to purchase just the right amount of information are much more likely to fail by buying too much information rather than by buying too little. Edwards interprets this and the other facts as indicating that people require too much information, and are unwilling to reach firm enough conclusions on the basis of what they already have. He, accordingly, recommends that whenever possible the task of drawing conclusions from available information should be automated.

It should be noted, however, that the Ss used in these studies were untrained college students and that no external measures of risk-taking were utilized. Certainly, there is good reason to believe that experienced risk-takers or military commanders may well behave differently when faced with these sorts of tasks. A repetition of these sorts of studies, using experienced command personnel and comparing the performance of high and low

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* Posterior probability ($P(H|D)$) is defined as the output of Bayes' theorem--a definition of probability which modifies probabilities in the light of new information taking the form of the equation: $P(H|D)=\frac{P(D|H)P(H)}{P(D)}$. In this equation P(H) is the prior probability of some hypothesis H. $P(D|H)$ is the probability that the datum D would be observed if the hypothesis H were true. P(D) is the conditional probability of an event D.

risk-takers, should throw some additional light upon this issue.

2. Individual Differences and Personality Variables. There are many people who have all of the necessary intellectual capabilities, yet because of various personality problems do not make good decisions. Everyone knows this, just as everyone knows how difficult it is to discover the particular personality dimensions that are involved. As noted in the foregoing survey of risk-taking studies, most of this work has been carried out in the laboratory under non-military conditions.

Obviously, what is needed is an assessment of the individual's risk-taking tendencies along with his decision-making ability in an operational military setting or one which realistically simulates the job-requirements. McClelland's modification of Atkinson's model is badly in need of empirical testing and of further experimental evaluation. Studies of group decision-making and the individual's willingness or unwillingness to follow his own judgment in defiance of the group would also be of value.

3. Effects of Stress and Anxiety. Conspicuous by their absence from the experimental literature are studies of the effects of stress and anxiety on decision-making. In view of the fact that most command decisions of any degree of importance will occur during a time when the commander is under duress--either brought on by the enemy in a combat situation or by the pressure of time, probable loss of prestige, work-load or the critical regard of superior officers in the administrative situation, it is even more surprising that few experimental studies have been undertaken. Such studies of independent and sequential decision-making, carried out under realistic military operational conditions and including the measurement of certain personality variables (mentioned in the previous category), should receive top-priority by any future investigator concerned with command decision-

making. Although there are some hairy and difficult problems that must be faced in the conduct of such studies, such difficulties should never be allowed to deter the experimental effort.

4. Relationship Between Other Cognitive Variables and Decision-Making.

With regard to cognitive processes, the psychological literature frequently refers to "the decision-making process," "the problem-solving process," and "the creative process." These terms suggest that these activities can be clearly distinguished in terms of the processes involved. In fact, creativity has been defined in terms of a unique process. Although such a possibility cannot be excluded, many theorists argue that creative thinking is best defined--not in terms of process, for it involves a variety of processes--but in terms of product: creativity is that thinking which results in the production of ideas or other products that are novel and worthwhile. In a similar fashion, problem-solving is that thinking which results in the solution of problems and decision-making is that thinking which results in choice among alternative courses of action. In this view, decision-making, problem-solving, and creativity are all to be regarded as kinds of thinking. The question of the degree to which these, and other kinds of thinking, involve the same or different processes is a question to be solved by empirical investigation, not by definition.

Here the psychological problem can be stated as follows: What are the processes involved in thinking, i.e., in problem-solving, decision-making, and creativity? How many are there? How do they work? Can they be improved with training? It can be safely said that, at this time, none of the answers to the above questions are available.

To supply some of these needed answers, it might be of value to administer batteries of psychological tests--tests of aptitudes, attitudes, personality and cognitive skills—as well as abstract tests of decision-making ability at several levels of command authority. At each level of command, performance on the psychological tests and on the abstract problems could be related to the officers' performance on typical command and staff tactical and administrative problems selected from the branch service school curricula, the Command and General Staff College curriculum at Fort Leavenworth, and from real-life situations faced by field unit personnel under combat and non-combat conditions. Relationships between these various measures and between the various levels of command should provide many invaluable clues as to the kinds of cognitive skills important in decision-making.

5. Improvement of Decision-Making Through Training. Recent work by a number of investigators in the areas of creativity, problem-solving, and thinking has shown that many such cognitive skills can be improved through training. Maier (35) has increased the proportion of successful problem solutions by lecturing subjects to seek various problem difficulties and to "keep your mind open for new meanings (and) . . . for new combinations." Maltzman and his associates (Maltzman, Brooks, Bogarty and Sumners (37); Maltzman, Bogarty and Breger (36); Maltzman, Simon, Raskin and Licht (38), have been orienting subjects toward the same objectives by forcing them to generate unusual (low valence) associations to common stimuli. Shaw's results (52) suggest that subject's motivation to achieve a high quality product may be increased by increasing their share of responsibility for the group output. Maier's human relations training course (34) has also shown that group problem-solving facility can be increased. More recently, Hoffman (28) has defined and stated the conditions necessary for creative problem-solving. Although they have not yet been put to the experimental

test, these conditions do tie together much of the contemporary research and suggest ways and means for producing improved performance. In addition to this work, Ericksen (23) has recently shown that for some skills abstraction learning is no more difficult than perceptual learning. He further suggests that if some of the compounding variables could be eliminated, abstraction learning in the classroom or via the teaching machine might be achieved in a manner more comparable to the speed and efficiency of perceptual learning.

For these reasons, it seems likely that the cognitive processes that lead to the selection of one from among a "known" set of response alternatives (decision-making) are also amenable to training. As Miller (43) has recently summarized, the information essential to training for decision-making consists of the following elements:

1. The stimulus variables in the problem.

2. The response alternatives.

3. The variables in the goal conditions and their relative priorities.

4. Implications of the exercise of response alternatives.

5. Strategy rules for selecting response alternatives in order to optimize goal conditions in given stimulus situations. Such rules may include procedures for efficiently getting additional information toward an ultimate decision.

6. Allowable time between the situation arising and control action.

As Miller further notes, only when these kinds of information are available can there be effective <u>practice</u> undertaken in decision-making relevant to the job. In general, this kind of analysis and this sort of information is missing from the usual study of command decision-making. The consequence of this lack is that training becomes either impossible or inadequate. In a recent article on obtaining guidance from uncertain evidence, Brig. Gen. Washington Platt (45) has urged that commanders give more attention to the modern techniques of experimental analysis, probability theory, sequential analysis, and formal logic as means whereby their decision-making capabilities can be improved. Modern management training courses have also recently adopted this same experimental statistical approach (11).

In summary, it seems apparent that, at this time, the best attack on problems in the area of command decision-making would include both a vigorous experimental program plus a systematic attempt to apply already existing methods as wisely and judiciously as possible to the training of officers and noncommissioned officers at every level of command.

REFERENCES

1. Atkinson, J. W. "Motivational determinants of risk-taking." Psychol. Rev., 64, 1957, 359-372.

2. Atkinson, J. W. and Litwin, G. H. "Achievement motive and test anxiety conceived as motive to approach success and motive to avoid failure." J. Abnorm. Soc. Psychol., 60, 1960, 52-63.

3. Atkinson, J. W.; Bastian, J. R.; Earl, R. W.; and Litwin, G. H. "The achievement motive, goal-setting, and probability preference." J. Abnorm. Soc. Psychol., 60, 1960, 27-36.

4. Becker, Gordon M.; DeGroot, M. H.; and Marschak, Jacob. "Stochastic models of choice behavior." Behav. Sci., Vol. 8, No. 1, Jan. 1963, 41-55.

5. Bernoulli, D. "Exposition of a new theory on the measurement of risk." Econometrica, 22, 1954, 23-36.

6. Berkun, Mitchell M.; Bialek, H. M.; Kern, R. P.; and Yagi, K. "Experimental studies of psychological stress in man," Psychol. Monogr., Vol. 76, No. 15, No. 534, 1962.

7. Berry, Paul C. Psycholigical Study of Decision-Making, Tech. Report NAVTRADEUCEN, 797-1, US Naval Training Device Center, Port Washington, New York, 14 March, 1961.

8. Block, Clifford H. "Interrelations of stress and anxiety in determining problem-solving performance," Office of Naval Research, Tech. Report 8, Dept. of Psychology and Indust. Admin., Yale University, New Haven, Conn., Oct. 1962.

9. Bray, Charles W. "Toward a technology of human behavior for defense use," Amer. Psychol., Vol. 17, No. 8, August 1962, 527-541.

10. Chenzoff, Andrew P. et al. Human Decision-Making as Related to Air Surveillance Systems, AFCCDDTR-61-9, Operational Applications Office, Directorate of Technology, Air Force Command and Control Development Division, Air Force Research Division, Bedford, Mass., 31 Dec. 1960.

11. Clough, Donald J., Concepts In Management Science, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1963.

12. Connolly, Donald W.; Fox, W. R.; and McGoldrick, C. C. Tactical Decision-Making: II. The effects of threatening weapon performance and uncertainty of information displayed to the decision-maker on threat evaluation and action selection. ESD-TR-61-45 and AFCRL 1100, Air Force Cambridge Research Laboratory, Bedford, Mass., Dec. 1961.

13. Coombs, C. H. and Komorita, S. S. "Measuring utility of money through decisions," Amer. J. Psychol., 71, 1958, 383-389.

14. Coombs, C. H. and Pruitt, D. G. "A study of decision-making under risk," Report No. 2900-33-T, Willow Run Laboratories, Univ. of Michigan, Ann Arbor, April 1960.

15. Department of the Army. Staff Officers' Field Manual, Staff Organization and Procedure, FM 101-5, November 1954.

16. Doughty, J. M. A simulation facility for the experimental study of decision-making in complex military systems, AFCCDD-TN-60-32, AF Command and Control Development Division, Bedford, Mass., July 1960.

17. Edwards, W. "Probability preferences among bets with differing expected values," Amer. J. Psychol., 67, 1954, 56-57.

18. Edwards, W. "Probability preferences in gambling," Amer. J. Psychol., 66, 1953, 349-364.

19. Edwards, Ward. "The theory of decision-making," Psychol. Bull., 51, 1954, 380-417.

20. Edwards, W. "Reward probability, amount, and information as determiners of sequential two-alternative decisions," J. Exp. Psychol., 52, 1956, 177-187.

21. Edwards, Ward. "Behavioral Decision Theory," in Annual Rev. of Psychology, Vol. 12, Annual Reviews, Inc., Palo Alto, Calif., 1961, 473-498.

22. Edwards, Ward. "Probabilistic Information Processing In Command and Control Systems," ESD-TDR-62-345, Operational Applications Laboratory, AF Systems Command, USAF, Bedford, Mass., March 1963.

23. Ericksen, S. C. Studies In The Abstraction Process, Psychol. Monogr., Vol. 76, No. 18, Whole No. 537, 1962.

24. Fox, W. R. and Vance, W. H. Jr. Tactical Decision-making: I. Action selection as a function of track, load, threat complexity, reliable data presentation, and weapon uncertainty. ESD-TR-61-42 and AFCRL 997, Air Force Cambridge Research Laboratory, Bedford, Mass., Oct. 1961.

25. Hayes, J. R. and Smith, Elizabeth. Decision-Making Studies. Part I: The trade-off of variables in decision-making. US Naval Research Laboratory, Washington, D. C., NRL Report 5418, Jan. 6, 1960.

26. Hayes, J. R. and Smith, Elizabeth. Decision-Making Studies. Part II: Information processing limits and decision-making. US Naval Research Laboratory Reports, August 1961.

27. Herbst, P. G. "Situation dynamics and the theory of behavior systems," Behav. Sci., Vol. 2, No. 1, Jan. 1957, 13-29.

28. Hoffman, L. R. "Conditions for creative problem solving," J. of Psychol., 52, 1961, 429-444.

29. Irwin, F. W. and Smith, W. A. S. "Value, cost, and information as determiners of decision," J. Exp. Psychol., 54, 1957, 229-232.

30. Kidd, J. S. and Boyes, Fred. "Input distortion and observer overlap in decision-making," Management Sci., Vol. 6, No. 1, Oct. 1959, 123-131.

31. Lanzetta, John T. and Kanareff, Vera T. "Information cost, amount of payoff, and level of aspiration as determinants of information seeking in decision-making," Behav. Sci., Vol. 7, No. 4, Oct. 1962, 459-473.

32. Littig, L. W. "The effect of motivation on probability preferences and subjective probability," unpublished doctoral dissertation, University of Michigan, Ann Arbor, 1959 (original not seen).

33. Litwin, G. H. "Motives and expectancy as determinants of preference for degrees of risk," unpublished honors thesis, University of Michigan, Ann Arbor, 1958 (original not seen).

34. Maier, N. R. F. "An aspect of human reasoning," Brit. J. Psychol., (Gen. Sect.), 24, 1933, 144-156.

35. Maier, N. R. F., Solem, A. R., and Maier, A. Supervisory and Executive Development, John Wiley & Sons, Inc., New York, N. Y., 1957.

36. Maltzman, I., Bogarty, W., and Breger, L. "A procedure for increasing word association originality and its transfer effects," J. Exp. Psychol., 56, 1958, 392-398.

37. Maltzman, I., Brooks, L. O., Bogarty, W., and Sumners, S. S. "The facilitation of problem solving by prior exposure to uncommon responses," J. Exp. Psychol., 56, 1958, 399-406.

38. Maltzman, I., Simon, S., Raskin, D. and Licht, R. "Experimental Studies In The Training Of Originality," Psychol. Monogr., 74, No. 6, Whole No. 493, 1960.

39. McClelland, D. C., Clark, R. A., Roby, T. B., and Atkinson, J. W. "The projective expression of needs: IV, The effect of need for achievement on thematic apperception," J. Exp. Psychol., 39, 1949, 242-255.

40. McClelland, D. C., Atkinson, J. W., Clark, R. A., and Lowell, E. N., The Achievement Motive, Appleton-Century-Crofts, New York, N. Y., 1953.

41. McClelland, David C. The Achieving Society, D. Van Nostrand Co., Princeton, N. Y., 1961.

42. Meeker, R. J., Shure, G. H., and Rogers, M. S. A review of the group decision-making research projects. SDC document TM-731, Systems Development Corporation, Santa Monica, Calif. June 25, 1962.

43. Miller, Robert B. "Task Description and Analysis," in Psychological Principles In Systems Development, ed. by R. M. Gagne, et al., Holt, Rinehart, and Winston, New York, N. Y., 1962.

44. Newman, W. H. and Summer, C. E. Jr. The Process of Management, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1961.

45. Platt, George W. "Guidance from Uncertain Evidence," Mil. Rev., Dec. 1962, 46-54.

46. Pruitt, D. G. "Informational requirements in making decisions," Am. J. Psychol., Vol. 74, 1961, 433-439.

47. Rapoport, Anatol. "The use and misuse of game theory," Sci. Amer., Vol. 207, No. 6., Dec. 1962, 108-118.

48. Roberts, John S. "Information Seeking In Sequential Decision Making As Dependent Upon Test Anxiety And Upon Prior Success Or Failure In Problem Solving," in Experiments On Decision Making and Other Studies, ed. by Donald W. Taylor, Tech. Report 6, Dept. of Indust. Admin. and Dept. of Psychology, Yale University, New Haven, Conn., Dec. 1960.

49. Rodgers, Dorothy J. Decision Making, Human Factors and Training, Information Systems Operation, General Electric Company, Washington 14, D. C., June 1960.

50. Rogers, M. S., Shure, G. H., and Meeker, R. J. Decision-making styles in a military command setting, SDC document SP-709/001/00 Systems Development Corporation, Santa Monica, Calif., 28 August 1962.

51. Scodel, A., Ratoosh, P., and Minas, J. S. "Some personality correlates of decision-making under conditions of risk," Behav. Sci., 4, 1959, 19-28.

52. Shaw, D. M. "Size or share in task and motivation in work groups," Sociometry, 23, 1960, 203-208.

53. Simon, H. A. Models of Man, John Wiley & Sons, New York, N. Y., 1957.

54. Slovic, Paul. "Convergent validation of risk taking measures," J. Abnorm. Soc. Psychol., 65, No. 1, 1962, 68-71.

55. Sweetland, Anders and Haythorn, W. W. "An analysis of the decision-making functions of a simulated air defense direction center," Behav. Sci., Vol. 6, No. 2, April 1961, 105-116.

56. Teichner, Warren H. and Myers, J. L. Training Aspects of Decision Making, Tech. Report: NAVTRADEVCEN 588-1, US Naval Training Device Center, Port Washington, New York, March 1961.

57. Teichner, Warren H. and Myers, J. L. Training Aspects of Decision Making, Phase II, Tech. Report: NAVTRADEVCEN 588-2, US Naval Training Device Center, Port Washington, N. Y., 5 June 1962.

58. Tomkins, Silvan S. and Messick, S. Computer Simulation of Personality: Frontier of Psychological Theory, John Wiley & Sons, Inc., New York, N. Y., 1963.

59. Waterhouse, I. K. and Child, I. L. "Frustration and the quality of performance, III: An experimental study," J. Pers., 21, 1953, 298-311.

60. Willerman, B., Lewit, D., and Tellegen, A. "Research in cohesive and disruptive tendencies in coalition-type groups," Office of Naval Research, Tech. Report No. 6, N 8 ONR-66216, 1957.

61. Worley, Donald R. "Amount and Generality of Information Seeking Behavior in Sequential Decision Making as Dependent on Level of Incentive" in Experiments On Decision Making And Other Studies, ed. by Donald W. Taylor, Tech. Report No. 6, Dept. of Indust. Admin. and Dept. of Psychology, Yale Univ., New Haven, Conn., Dec. 1960.