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DEVELOPMENT OF A TAXONOMY OF HUMAN PERFORMANCE:

A Review of the First Year's Progress

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TECHNICAL PROGRESS REPORT 1

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ABSTRACT

This report briefly describes technical progress during the first year of a five year project to develop and verify a taxonomic system for the classification of human task performance. During this initial year, the major efforts on the project proceeded along four lines of activity: (1) review of previous taxonomic efforts, (2) development of an integrative model, (3) development of provisional classification schemes, and (4) development of a human performance data base. Previous taxonomic efforts were reviewed to provide guidelines and suggest approaches for the development of classification systems. An integrative model was developed to indicate which areas had to be taken into account in the development of a comprehensive task taxonomy. A provisional classification scheme, based on human abilities identified in earlier correlational studies, was developed to indicate the feasibility of using such an approach and to isolate some of the practical problems that might be encountered in the development of a taxonomy. Work on another provisional classification scheme, based on observable characteristics of tasks, has been initiated. The requirements of a Human Performance Data Base were defined to provide a resource and a research tool for testing provisional classification systems being developed. Finally, plans for the immediate future have been developed to insure continuity to present efforts.

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INTRODUCTION

One of the most critical problems in the behavioral sciences today is the lack of an adequate system for the classification of human performances. Without such a system it becomes increasingly difficult to organize and apply the results of behavioral research to the solution of applied problems.

Since the early 1950's, when man's performance came to be viewed within a system's context, methods of optimizing system performance have been sought through: a) careful allocation of functions to man and to machine, b) the design of the hardware to be compatible with man's capacities and limitations, c) selection of personnel matching human abilities with task requirements, and d) training of personnel in task performance. As new systems have been developed, vast amounts of descriptive material about man's performance in these systems have been generated. However, faced with the design of succeeding systems, past experience has provided few rigorous guidelines for determining the applicability of previously acquired data to new man-machine systems.

At the same time laboratory research on factors affecting human performances (e.g., stress, drugs, noise, learning) has yielded vast amounts of data, but there is great difficulty in extrapolating principles from such laboratory research to human performance in real-world tasks. Behavioral scientists find it difficult to relate the results of their own research to other presumably similar studies and human factors technologists have difficulty relating previous research to their needs to apply research data. A major problem which limits generalization, communication, and application of research results is the absence of a unifying set of dimensions allowing one to relate the human performance observed in one situation to new task situations. Many categories in common use (e.g., "cognitive", "motor", "perceptual"; or at another level "problem solving", "information processing") turn out to be "too general" and the kinds of detailed job elements derivable from task analysis data (e.g., "rotates knob control") seem "too specific". What is lacking is a taxonomy of human performance which can serve as a basis for describing human tasks.

Many prominent behavioral scientists in basic as well as applied fields have recognized these problems and have called for a method for such a taxonomy. Fitts (1962), Melton and Briggs (1960) are notable examples:

> "The importance of an adequate taxonomy for skilled tasks is widely recognized in all areas of psychological theorizing today. A taxonomy should identify important correlates of learning rate, performance level, and individual differences. It should be equally applicable to laboratory tasks and to tasks encountered in industry and in military service" -- P. M. Fit , Chapter 6 (p. 178) in Training Research and Education, R. Glaser (Ed.), Univ. of Pittsburgh Press, 1962.

> "It is clear to those working in the area of engineering psychology, and it should become clear to others, that this vigorous and expanding universe of knowledge has semantic and taxonomic problems which have not been overcome. Nor can they be overcome in any stable way by the ingenuity of organizers of its literature. The roots of these difficulties are many, not the least being the semantic and taxonomic problems of experimental psychology ... Foremost among deficiencies of this type is the lack of taxonomies of tasks or of skills"--A. W. Melton and G. Briggs, Annual Review of Psychology, Stanford University Press, 1960.

> "It is unfortunate that psychologists lack a behavioral taxonomy which is related to the generalization characteristics of task performance. Such a taxonomy would enable the task analyst and training designer to find a common ground in the psychological research literature" --R. B. Miller, Chapter 2 (p. 57) in Training Research and Education, Op. cit.

What was true in 1960 and 1962 is no less true today.

Value of a Performance Taxonomy for Describing Human Tasks

A taxonomy of human performance has important practical and scientific implications in a variety of fields of interest to the Department of Defense, to other counterparts of our society, and to state-of-the-art questions. In fact, a number of ostensibly disparate problems are drawn together and can be viewed in a new light by the application of such a taxonomy. Among the most important of these problems are the following:

1. System design. The planning and allocation of man and machine functions in systems requires the making

of decisions about human performance at all levels of complexity from system to component. An important input to such decisions is the category of performance with which one is dealing, and the consequent application of quantitative data within this category to the estimation of capabilities.

2. Job definition. New systems generate new jobs. New technological methods, including automation, have marked and varied effects upon jobs, generating new ones, eliminating old ones, and altering others. Although jobs are defined by tasks, such methods often do not by themselves permit clear identification as to job resemblances and the degree of change which will be needed in training to produce new job occupants. To make such determinations, one must consider the types of performance involved in a new (or altered) job, and also the conditions which will insure establishment of such performances in the most efficient manner.

3. Selection and training. For jobs both old and new, there is a continuing need for a method of relating the requirements of jobs to the specifications of selection and training of personnel. Human performance categories appear to provide the basis for such a method.

4. Performance measurement. The measurement of human performance is a matter of great significance in many areas. In research and development work on human capabilities, many investigators have recognized the need for "standards" of human performance which can serve as points of reference for the effects of experimental variables. In a broader sense, the question of measurement enters into such inadequately solved problems as the assessment of training outcomes, and the evaluation of systems including human performers. For all of these purposes, the development of a behavioral taxonomy would provide the foundation for new and valuable techniques.

5. Generalizations of research to new tasks. One of our current limitations is the difficulty of extrapolating research from one task to another, whether this be from laboratory to operational task, between laboratory tasks, or between operational tasks. For example, the effect of a given environmental factor (e.g., high temperature) on task A may be known, but will this hold for task B, or task C? An effective system of task categories, based on empirical knowledge of the human functions underlying these task performances, should assist us in making such generalizations.

6. <u>A basis for standardizing laboratory methods of studying human performance.</u> A critical problem in the experimental study of factors affecting human performance is the lack of standard tasks and measures which can help integrate and/or compare results from various laboratories; an end product of research on taxonomic questions can be the specification of those tasks which are most diagnostic and reliable as measures of specifiable human functions. Such measures may become standard in many types of future laboratory research on factors affecting man's performance capacities.

Purpose of the Project

The present report describes technical progress during the first year of a five year project, the objective of which is to develop a taxonomy of human performance and to verify its practical and scientific utility. The classification system developed should allow more dependable generalizations about human performance to be made.

The program has several phases. To provide a firm foundation for the program, the first year involved considerable conceptual and methodological development, bringing together concepts and methods applicable to the problem from diverse fields, such as job and task analysis, experimental psychology, human factors technology and differential psychology. All these fields, in one form or another, are concerned with the specification of performance functions required in human tasks. However, little communication has occurred across these fields, and this presents one of the problems of generalizing results from one field to the other.

One of the first steps in the project was to bring together staff representing these diverse fields of interest, to assist in resolving differences in approaches, methods, and terminology. Many of the differences between these fields of interest were more apparent than real. Each field has developed a specialized vocabulary and severe problems of communication were encountered during the early phases of the project. However, with continued participation, discussion, and common review of salient reports and articles, many communication problems have been resolved.

The first year also involved considerable consultation with prominent investigators and experts in these different fields, who, in one way or another, had been involved in work relevant to taxonomic issues. Additionally, an extensive effort was made to develop a library of diverse reports and literature bearing on taxonomic issues and describing previous taxonomic attempts in the behavioral and other sciences, to provide additional guidelines for the present programs.

Based on these reports, on existing empirical data, and on rational analysis, the first year involved the development of sets of provisional categories of human performance. These categories are being applied to existing human performance task descriptions to assess the utility of various classification systems in organizing data derived with these tasks, so that the possibility of generalizations across tasks may be increased.

Subsequent years of the program involve continued testing of provisional classification systems against the human performance data base being developed, experimental refinement, testing of the taxonomy with newly developed laboratory tasks, and validation of the derived taxonomic system against complex task performance.

Objectives of the Report

The present report will describe progress made during the first year. The major efforts to be described are the following: (1) reviews of previous taxonomic efforts, (2) development of an integrative model, (3) development of a provisional classification scheme, and (4) definition of the requirements for the Human Performance Data Base. Previous taxonomic efforts were reviewed to provide guidelines and suggest approaches for the development of classification systems. An integrative model was developed to indicate which areas had to be taken into account in the development of a comprehensive task taxonomy.

A provisional classification scheme, based on our knowledge of "human abilities", was developed to indicate the feasibility of using such an approach and to isolate some of the practical problems that might be encountered in the development of a taxonomy. Another provisional classification system involving task characteristics rather than abilities or functions is being developed as an alternative approach that might prove useful. The requirements of a Human Performance Data Base were defined to provide a resource and a research tool for testing provisional classification systems being developed.

The progress that has been made along each of these four lines of activity is summarized in the following sections. The purpose of these summaries is to indicate the general nature of the work that has been accomplished during this first year. Specific descriptions of this work will be contained in separate reports.

Consultations and Visits

During this period project personnel held discussions with the following individuals:

Dr. Earl Alluisi, Professor of Psychology, University of Louisville, who is identified with one of the major attempts to develop analytical measures of component human performances and has developed a battery of tasks around his performance classification, under Army, Air Force, and NASA sponsorship.

Dr. Robert Gagne, Professor of Psychology, University of California, who has long been associated with attempts to cast task analysis information in terms of a limited number of "human functions" and who, in his book "The Conditions of Learning" (1965), discusses learning principles in terms of nine "general" categories based on a hierarchical classification system.

Drs. John Taylor, Wayne Fox, and Ernest Montague, HumRRo, Monterey, who have developed experimental tasks utilizing Gagne's categories, for testing the interaction of learning methods and ability level for Army personnel. They have also been working with a classification system for ordering vocational training objectives.

Drs. Robert Witte, Ruth Ginsberg, and Calvin Thomson, San Jose State College, who have recently completed an Air Force sponsored project attempting to classify the results of learning studies in order to derive generalized principles.

Dr. Robert B. Miller, IBM, Poughkeepsie, New York, who is known for his pioneering work in the development of task analysis and classification methods and the analysis and specification of performance requirements for training.

Dr. Warren Teichner, Institute of Environmental Psychophysiology, Northeastern University, under a NASA project, has been concerned with the classification of environmental variables in terms of physiological and performance effects, and previously had directed work relating the effects of environmental stressors to human performance measures.

Drs. Donald Haggard and E. E. Miller, HumRRo, Ft. Knox, Kentucky, who have been working on taxonomic models of skilled performance, the former emphasizing structural issues and the latter concentrating on response processes as a basis for classification.

Drs. J. P. Guilford and R. Hoffner, Aptitude Research Program, University of Southern California. Dr. Guilford was formerly Director of the Air Force aptitude research program, and has long been identified for his pioneering and extensive factor analytic research on intellectual abilities.

Dr. Lois L. Elliott, Central Institute for the Deaf, St. Louis, who has carried out research on the dimensions of perceptual performance.

Dr. James W. Altman, American Institutes for Research, Pittsburgh, who has worked extensively on problems of task and training analysis, systems design and on the dimensional problems of vocational job performance.

Dr. Kasten Talmadge, American Institutes for Research, Palo Alto, who has been directing projects under Navy sponsorship concerned with classifying learning styles and task design factors relating to learning effectiveness.

Dr. Lawrence E. Reed, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio, who has been involved in extensive work on the computerization of task analysis data.

The results of these visits and consultations are included in the reviews described in separate reports. However, we may stress that these consultations reinforced the view of a need for a human performance taxonomy linking basic and applied areas. Different investigators have approached the problem from different angles, often tangentially and frequently with the narrow focus of a specific substantive area of interest. Also apparent was the lack of satisfaction with current progress being made and with the limited scope of previous efforts. It also appears evident that previous attempts at developing classification schemes did not reach the stage of testing their utility or quite often, of producing a system which even lends itself to such testing. Finally, these discussions were extremely useful in pointing up the difficulties that have to be faced in developing a taxonomy.

REVIEW OF PREVIOUS TAXONOMIC EFFORTS

Three areas of review were conducted during this period. One area concerned previous classification systems developed in the behavioral sciences with emphasis on their purposes and methods. The second area concerned a more detailed look at various descriptor schemes for classification systems including those derived from task analysis. The third area concerned classification systems developed in the biological and other physical sciences and their implications for taxonomic problems in the behavioral sciences.

Classification Systems Developed in the Behavioral Sciences and Human Factors Technologies (George R. Wheaton)

This review was conducted to assess the "state-of-the-art" in the classification of tasks or human performance and to obtain guidelines for developmental efforts within the Task Taxonomy project. With these purposes in mind, more than fifty papers were selected for review. The intent was to examine each of these papers with respect to three taxonomic issues: (1) the purposes of various schemes, (2) the type of descriptors or attributes upon which classificatory systems have been based, and (3) procedures or methods employed for the achievement of classification.

The survey suggests that past classifications have had one of two major objectives in mind. On the one hand, behavioral taxonomists have proposed classification systems having applied objectives in a limited field. Most numerous among these applied systems are those which attempt to classify tasks with respect to training techniques or learning principles. With the aid of such a classification system, it is hoped that new tasks may be identified as belonging to a particular class. Then, for that class of tasks, an attempt is made to establish the best method for training operators. The utility of such schemes has yet to be tested, however.

Other classification systems have been proposed with more general theoretical objectives in mind. These systems could provide an organizational framework for a particular body of knowledge, such as stress research, for example. Classification of tasks along these lines would enable investigators employing different stressors and different tasks to meaningfully compare and contrast their results. The review suggested that a task classification system could be developed with both applied and theoretical objectives in mind, and that such a system might ultimately be the most useful.

With regard to the second major issue, that of the kinds of descriptors or attributes employed for classification, diverse bases were found. Generally speaking, classifications have been proposed in terms of: a) the behaviors observed during task performance; b) the behaviors, functions, or processes presumably required during task performance; c) the abilities which the operator must possess; and d) characteristics of the task in terms of its stimulus and response properties (e.g., complexity, sequential nature, etc.). Of these alternative bases, the abilities and task characteristics approaches seemed most promising at this time for further development, particularly in terms of the objectivity which they may provide.

Examination of the third issue, classificatory methods and procedures, suggested that relatively little has been accomplished in this area. Few systems are currently developed to the extent that they can be utilized or evaluated. Most systems, however, do appear to require a qualitative approach to classification based upon the presence or absence of critical attributes. Quantitative procedures are beginning to receive attention particularly in light of the new advances of numerical taxonomy within biology.

The paper concludes that behavioral taxonomy is still in its infancy. Nevertheless, considerable strides may be possible in the development of a classification system: a) having both theoretical and applied objectives; b) based on the description of critical abilities and/or task characteristics; and c) developed on a qualitative or quantitative basis. The paper contains certain guidelines and criteria for conducting such efforts.

Descriptor Schemes for Human Task Behavior (Alfred J. Farina)

The purpose of this survey was to define different approaches to the description of human task behavior and to make a more detailed examination of various descriptor schemes. What descriptors are employed? What level of descriptors are used? How are descriptions of human task behaviors used? Included in this report is a review of task analysis concepts and methods which may have relevance to the classification of human task performance.

Many investigators have attempted to describe human task behavior. Some have suggested descriptive terms, generally undefined, which they considered to be useful in viewing task behavior. Others contributed more by providing well defined descriptors with interrelationships being specified. A few have made empirical efforts to develop their schemes and a very few have progressed to the point where the schemes are assessable on either a quantitative or qualitative basis.

Within the system context a process has been developed to provide detailed statements of human performance required during system operation. The generic name for this process is task analysis. Task analyses have yielded a variety of data, but various analyses have used different content descriptors and different levels of description. The content descriptors are generally related to: "human behavior", "performance", "equipment", or "workplace". The level of content varies from a very specific level, e.g., "move index finger", to a very gross level, e.g., "bank aircraft". These descriptions are used for various purposes: e.g., reliability of task performance, maintainability of equipment, personnel requirements, training requirements and human engineering.

Other descriptive approaches have considered man as a major system component whose primary function is information processing. In this approach, a variety of information processing terms are employed in describing human functions. For example, the term "filtering" is defined as a condition determining the range of sensory inputs to which the person must attend. In general, this descriptive approach uses functions which are rationally derived, and attempts to posit computer-like mechanisms to account for human performance in tasks.

Another descriptive approach attempts to describe human activities for specific purposes, such as defining training needs. The attempt here is to characterize a task in terms of selected attributes. Descriptions relevant to other purposes are deliberately omitted. For such attributes as: "procedure following", "monitoring", "communicating", etc., task attributes are defined prior to task specification, with the expectation that all tasks can be rated with respect to the relevant attributes.

Still another approach may be labeled the functional approach. People using this approach have attempted to describe human functions required to perform tasks; that is to say, the task is described in terms of the functions required to perform it. A wide variety of descriptive terms are used as labels for these functions (e.g., problem solving, decision making). The most empirically based of these is one utilizing descriptions based on human abilities (e.g., manual dexterity, verbal fluency, perceptual speed) identified in factor analytic research.

The "lexical" approach is an attempt to develop a hierarchical structure of descriptive terms. This approach has been found to be useful in categorizing books and other documents in information retrieval systems. However, investigators who use this approach seldom define the meaning of the descriptors they employ at any level.

The survey concludes that the various approaches used to describe human task behavior are themselves amenable to description and classification. A useful product of this review is a matrix of terms, concepts, and descriptors utilized across behavior systems in an attempt to define common and unique categories. Emphasis is placed on methods of measurement and on developing a comprehensive, but non-redundant set of categories, at various hierarchical levels of generality, for use in the analyses of task and performance data in later phases of the project.

Taxonomic Efforts in the Biological Sciences (George C. Theologus)

The purpose of this portion of the review of classification in the sciences and technologies was to examine taxonomic efforts of the biologists in order to determine their significance for the classification of human performance. The review is specifically directed at biological classifications since they appear to have been more concerned with classification than other sciences and technologies and hence were expected to shed some light on the problems of, and approaches to classification in the behavioral sciences.

The focus in the review is on the principles and procedures which the biologists employ in classifying rather than on the content of the classification. The review of biology establishes that there is an order or priority in beginning a classificatory effort. First, one must state the purpose for classification. Three general purposes can be defined: a) classification can be undertaken because one wants to relate the objects or events in the classification to some exoteric (external) variable or set of variables of interest (consociative classification), b) because one wants to show the usefulness of the objects to man (teleological classification), or c) because one wants to reveal the interrelationships among the objects themselves (theoretical classification).

Once a purpose for classification has been established the characteristics or attributes of the objects or events to be classified can be specified. If the purpose of the classification is consociative, then the relationships of the objects to external variables constitutes the basis of the classification (e.g., "forest plants or cave salamanders"). If the purpose is teleological, then the usefulness of the objects to man (e.g., "animals providing food for man") is classified. And if the purpose is theoretical, then objects are classified in terms of their inherent characteristics (e.g., "blood chemistry").

The third step in classifying involves the question of how one should classify, given a purpose for classification and a specification of the attributes of the object or event to be classified. The question of how to classify reduces to a question of how and where to seek the relationships, by similarity and contiguity, necessary for classification. An examination of biological classification reveals that there are three major schools of thought concerning how one should classify. The first is Linnaean taxonomy, based upon Aristotelian logic, which reduces the "how" of classification to an attempt to define the "essence" or "essential nature" of a group of organisms. Some unique set of characteristics is necessary and sufficient (e.g., "breasts characterize mammals") The major criticism of this approach is that it leaves classification to the mercy of the subjective opinions of its practitioners.

A second class is represented by Darwinian taxonomists who hold that the theory of evolution constitutes the only valid taxonomic basis for classification. Due to the extremely small amount of data available (e.g., the fragmentary nature of the fossil record) this theory is deductive or at best vaguely inductive. The major criticism of Darwinian taxonomy is that deductive theories and their resulting hypothesized relationships do not provide a sufficient basis for classification. The third school of thought is numerical taxonomy which holds that the relationships by contiguity and similarity should be sought in a numerical analysis of the overall similarity of the organisms based upon the widest possible range of physical and functional characteristics of the organisms themselves (e.g., morphological, genetochemical, cytological). The outstanding aims of this approach are repeatability and objectivity in classification.

The review of taxonomic efforts in the biological sciences emphasizes that one must develop an adequate classification system before one attempts to classify in any subject matter area. The behavioral sciences have only recently recognized this; much of our limitation on generalizations about human performance data stems from the arbitrarily established performance categories employed to characterize a given task. Although there is still some controversy in the biological sciences the development of classification systems is a major scientific endeavor. The review underscores the need to establish the purpose and methods for developing a classification system before one attempts to classify. With respect to the three major schools of taxonomic thought in biology, it appears that numerical taxonomy may have most to offer for taxonomy in the behavioral sciences because of its emphasis on quantification.

A HEURISTIC MODEL FOR DEVELOPING A CLASSIFICATION OF HUMAN PERFORMANCE (Armand N. Chambers)

With the preceding reviews as background, attention was given to the development of a model of human performance as a means for more systematically exploring the role of classification in the behavioral sciences and human factors technologies. This, in turn, is intended to provide the basis on which further developmental efforts at classification can be undertaken. This model is concerned with making more explicit: a) what the objectives of both the scientist and technologist are; b) how they go about achieving these objectives; and c) what the role of classification is in this process.

With respect to objectives it is concluded from this analysis that scientists and technologists alike are concerned with prediction of human behavior although each may proceed in a somewhat different manner. The behavioral experimenter, for example, is interested in predicting the effects on dependent variables. Usually, he is concerned with few variables and attempts to control them precisely. Frequently, he may appeal to some conception of an "intervening" variable to account for the relations he often observes between independent and dependent variables. In contrast, the human factors technologist is interested in manipulating many more, but less precisely controlled, independent variables to produce some desired or required human performance of a given type and level of proficiency. His "variables" tend to be more global in nature than those of the laboratory experimenter.

The classes of variables which are involved in the prediction or production of human performance are next examined by means of the model. Two general types are considered: a) the "intervening" or "mediating" types of variables by means of which the subject is presumed to respond, and b) the "independent" or "input" classes of variables.

The first of these intervening variables are "human functions", or "abilities" - constructs which may be used to refer to the capabilities of man to actually perform. Examples of these are "visual acuity", "pattern perception", "problem solving", "reaction time", etc. Next, several classes of variables, which may also be "intervening" in nature, that influence human performance are identified. These include the anthropometric variables (such as "arm reach"), physiological variables (such as PO^2 blood saturation", "body core temperature", etc.) and psychological variables (such as "attention", "attitudes", "motivation", etc.).

The classes of independent variables, which both the scientist and human factors specialist alike manipulate, include the "task characteristics." These are the performance requirements imposed and the conditions under which the tasks must be performed. These include the "procedures" or "instructions" that man is expected to follow in task performance, the "hardware", "apparatus", or other "persons" with which the operator interacts, and the "criteria" which constitute acceptable task performance. The conditions under which the tasks must be performed involve both "physical" and "social" environmental classes of variables (e.g., temperature, "vibration", "isolation", "group composition", etc.).

Finally, task performance also can be manipulated through the "selection" (including "physical", "medical", "education", and "experiential") and "training" (both "physical conditioning" and "education") classes of variables. Which one of these classes of independent variables is manipulated provides the basis for distinguishing between the different types of human factors specialists who are concerned with human performance. These include, for example, the "manpower specialist", the "training specialist", the "human engineer", the "life support engineer", the "mission planner", etc.

The modes of operation of each of these specialists, as well as both the behavioral experimenter and theorist, are next examined within the framework of the model to determine the role of task classification in supporting their activities and, further, to determine those characteristics a classificatory system(s) should possess if it is to meet their needs. It is concluded that all of these "users" of a human performance classification system require data about human responses (dependent variables), human functions (intervening variables) and task characteristics (independent variables). Beyond this point, the classes of variables that are of concern to each depend to a large extent on the areas of interest of the particular scientist or technologist. For example, the training specialist will be interested in manipulating training "principles", "content", and "materials" to achieve specified human performance types and proficiency levels; the human engineer will be interested in manipulating hardware "selection" or "design" variables to achieve acceptable task performance. In all cases, however, it seems evident that the classes of variables that each manipulates must be related (in the independent-dependent variable sense) to the task characteristics--human functions--task response chain of variables if they are to be of value in the prediction or production of human task performance. These appear to be the basic building blocks required in any classification of human performance.

Further, it seems to be impossible to distinguish between the various technologists and scientists, on the basis of their mode of operation, the level of detail, or structure that a task classification system should possess. Each may work at a very gross level or at a very detailed data level. However, these diverse modes of operation suggest some of the ways in which a classification system or systems could be utilized. For example, the scientist or technologist alike may find a classification system useful as a "document retrieval" system, or at a more refined level, as an "information retrieval" system. In an information science sense, the "descriptors" in the classification system could be arranged hierarchically and be sufficiently well defined that they permit the user to search large masses of literature and quickly, accurately, and comprehensively locate documents (or information) which contain data about only the variables of interest to him. This would require, of course, that the information had been indexed in terms of an adequate classification system. If the classification system is still further refined beyond the descriptor level to the dimension level (i.e., quantifiable variable level) then it should be possible to use it as a basis for modeling or theory construction in the scientific-predictive sense. In other words, it would permit the systematic comparison and relating of conditions and results between the experiments in terms of a common task classification scheme. There seems to be no convenient point to distinguish clearly where a qualitative classification (descriptor) system would stop and a quantitative (variable) system would begin since there is considerable overlap.

The provisional model of human performance provides a basis for making decisions about further efforts leading to the development of a useful classification system for both theoretical and applied purposes. Some conclusions and recommendations suggested by this analysis may be summarized as follows:

a. Any development efforts at the classification of human performance must consider the task responses, task characteristics, and human functions. Some combination of these appears to be basic to any human performance classification system.

b. Efforts at classification can begin at either a broad descriptor level or at the variable level. However, the former approach would seem to have more immediate payoff in terms of usefulness to scientists and technologists alike than the latter. Either approach, however, must be based on the known relationships between variables to the extent that existing research knowledge permits.

c. Since the development of any classification system, either as an information retrieval aid or as a scientific-predictive aid involves considerable resources to implement, it is desirable to concentrate on the development of some restricted area within the broader framework; for example, in organizing performance data on the effects of noise. The primary concern is to demonstrate that the classification system which is being developed, however restricted it might be initially, is both feasible and useful, and provides a model for the large-scale efforts required to develop other areas.

d. Maximum use should be made of available techniques and knowledge based on both existing classification systems and research data. The problem seems more to be one of organizing and integrating existing terms, concepts, and data than looking for some unique or simple solution to the problem. Coordinated efforts supported by extensive computer technology are required to make significant progress. Agreement on the use of terms and their definitions is basic to the successful development and usage of any classification system. A considerable indexing effort will be required to refine them to the point where they will aid in the comparison and interpretation of research data even in a restricted area.

e. Finally, as the classification system begins to emerge it must be evaluated. As an information retrieval aid this requires that some assessment is made of the efficiency and accuracy with which studies can be retrieved which are relevant to the particular users' interests and problems. As an aid in scientific prediction the evaluation must come in the form of its usefulness as an aid for interpreting and integrating research results. Subsequent evaluation of the system involves laboratory testing of generalizations across tasks defined in terms of the classification system developed and in the prediction of complex task performance from laboratory data. Other forms of evaluation could derive from assessment of the usefulness of the system for planning research programs to fill in missing data and specifying how research should be reported to permit greater generalization.

DEVELOPMENT OF PROVISIONAL CLASSIFICATION SYSTEMS

With the reviews described as background, a number of intensive efforts were initiated to develop provisional classification systems for tryout. These efforts were along two major lines: a) one concerned with classifying tasks in terms of human functions or abilities required to perform these tasks; b) a second concerned with classifying tasks in terms of task characteristics or parameters. Initial tests of these provisional systems are to be made against a Human Performance Data Base to be described in a later section.

The Human Functions Approach to Task Classification (Edwin A. Fleishman and Tania Romashko)

This effort can be divided into two major approaches. One classification being developed is based largely on empirical data on "human abilities" derived from correlational-experimental studies of individual differences in human performance. The second is based on a synthesis of rational categorization systems developed by investigators in human engineering, training analysis, and experimental psychology.

Human Abilities Classification

With respect to the first effort, the purpose is to investigate the feasibility of classifying tasks in terms of a specified set of human abilities, largely derived from previous programmatic factor analytic work. General categories such as intellectual functions, perceptual functions, etc., do not appear to be "unitary" processes. Although such categories are in common use, knowledge from research on correlations among human performances indicates a greater degree of specificity than this and considerable diversity of function within these broad categories. From this, there is reason to be skeptical that any small number of general categories is going to be successful in allowing dependable predictions of human performance; for example, in the area of perceptual-motor skills, the category of "perceptual-motor" is likely to be relatively useless in generalizing from one "perceptual-motor" task to another. "Manual dexterity", "multi-limb coordination", and "response orientation" are just a few examples among others which represent types of perceptual-motor abilities. Research indicates that individuals who excel in one of these sub-areas do not necessarily excel in others. Yet many still use the term "perceptual-motor" as if it were unitary. ("Cognition", "perception", "strength", etc., have been employed in a similar fashion.)

It would appear that we already know quite a bit about performance dimensions from experimental-correlational studies already completed, and these allow us to be much more specific about task dimensions than do the more general categorical terms. Such abilities have been found related to performances in a variety of human tasks. For example, "spatial-visualization" has been found related to performance in such diverse tasks as aerial navigation, blueprint reading, and dentistry. Such a category helps integrate a great variety of superficially diverse tasks along a common dimension.

As an example, let us take the term tracking, a frequent behavioral category employed by laboratory and systems psychologists alike. But we can all think of a wide variety of different tasks in which some kinds of tracking are involved. Can we assume that the behavioral category of tracking is useful in helping generalize results from one such situation to another? Is there a general tracking ability? Are individuals who are good at compensatory tracking also the ones who are good at pursuit tracking? Do people who are good at positional tracking also do well with velocity or acceleration controls? What happens to the correlations between performances as a function of such variations? It is to these kinds of questions that much of our own previous programs have been directed.

Ability categories derived from experimental-correlational methods appear to provide a solution to the problem of classifying the behaviors derived from task analyses. The basic objective of studies using this method has been to test hypotheses about the organization of abilities accounting for performance in a wide variety of diverse tasks. Generally, a subarea of human performance is explored, where tasks are specifically designed to tap certain hypothesized ability categories. The tasks are administered to samples of subjects and the correlations among them obtained and then subjected to factor analytic study. Later studies introduce variations in the tasks to sharpen the definition of the categories. Task parameters may be systematically varied to investigate the relation between these parameters and ability requirements. This is done through an examination of correlations between performance on reference measures and performance on tasks whose parameters have been varied. The purpose is to define the fewest independent ability categories which might be most useful and meaningful in describing performance in a wide variety of tasks.

It is perhaps not too extreme to state that most of the categorization of human skills, which is empirically based, comes from such correlational and factor analytic studies. We can think of such categories as representing empirically derived patterns of <u>response consistencies</u> to task requirements varied in systematic ways. In a sense this approach describes tasks in terms of the common abilities required to perform them. The fact that individuals who do well on task A also do well on tasks B and C but not in tasks D, E, and F indicates, inferentially, a common process involved in performing the first three tasks distinct from the processes involved in the latter three. To account for the observed consistencies an ability is postulated. Further studies sharpen and define the limits and generality of this particular ability.

Some of the ability categories which have been identified are more general in scope than others. But it is important to know, for example, that it is not too useful to talk about "strength" as a dimension; that in terms of what tasks the same people can do well, it is more useful to talk in terms of at least three general strength categories which may be differentially involved in a variety of physical tasks.

It might be useful to provide some examples of how one examines the generality of an ability category and how one defines its limits. The specification of an ability category is an arduous task. In the principle investigator's own work the definition of the Rate Control factor may provide an illustration. In early studies it was found that this factor was common to compensatory as well as following pursuit tasks. To test its generality, tasks were developed to emphasize rate control, which were not conventional tracking tasks (e.g., timing the movement of a control stick to coincide with a given stimulus change). The factor was found to extend to such tasks. Later studies attempted to discover if emphasis on this ability is in judging the rate of the stimulus as distinguished from ability to respond at the appropriate rate. A task was developed involving only the timing of button pressing in response to judgments of moving stimuli. Performance on this task did not correlate with other rate control tasks. Finally several motion picture tasks were adopted in which the subject was required to extrapolate the course of a plane moving across a screen. The only response required was on an IBM answer sheet. These tasks did not relate to the core of tasks previously found to measure "rate control." Thus, our definition of this ability was expanded to include measures beyond pursuit tasks, but restricted to tasks requiring the timing of a muscular adjustment to the stimulus change.

A similar history can be sketched for a variety of ability variables identified. Thus, we know that the subject must have a feedback indicator of how well he is coordinating before the Multi-limb Coordination factor is measured; we know that by complicating a simple reaction time apparatus, by providing additional choice reactions, we measure not reaction time but a separate factor (Response Orientation). However, varying the stimulus modality involved in a simple reaction-time task does not result in measurement of a separate factor. Statements of the kind made above, about human performance categories, their inclusion and their limits, could not have been made without the empirical work.

We have evidence that a taxonomy thus developed does help integrate a wide variety of behavioral data and phenomena. However, we do not yet know the extent to which the use of such ability categories in describing human tasks helps us generalize human performance data based on the manipulation of independent variables (such as the effects of noise on training or procedural variables). We also do not know the extent to which these categories can be used by human factors and other specialists in describing human tasks. Major efforts are being directed at answering these questions.

First a review of the extensive factor analytic literature was conducted with particular emphasis on programmatic work. From this review those factors best substantiated were selected. The resulting list covers a range of human performance capabilities including a variety of "cognitive", "perceptual", "motor", and "sensory" functions. A description of each ability factor has been developed and refined. Where more than one investigator identify equivalent or comparable factors, an effort was made to integrate their results. A review of test loadings for each factor allowed additional specifications to be added to the original definitions. Through a series of revisions, an effort was made to delineate the extent and limit of each factor in the ability list and to provide operational definitions which would clearly differentiate among the various abilities.

A series of studies has been carried out to evaluate the utility of these kinds of categories in describing a variety of different kinds of tasks. Specifically, a format was developed by means of which task descriptions, selected from the literature, could be analyzed in terms of the extent to which raters could estimate the degree of each ability required to perform each task. The tasks selected were those described in the literature of learning and human performance research and ranged from simple laboratory devices to complex simulations of operational tasks.

Careful definitions of each ability were provided to the raters. The objective of this series was to evaluate: a) the overall reliability with which such analyses could be made, b) the differential reliability of different categories, c) possible differences between simple and complex tasks in the usefulness of this method, d) possible differences in obtained reliability and differentiation ascribable to the training of the rater, e) methods of profile and similarity analysis for describing similarity among tasks, and f) semantic problems that need to be dealt with in refining this approach.

It should be kept in mind that these studies represent one of the first times that a common framework of concepts has been attempted for describing human tasks across a variety of disciplines and specialities. In this case the categories were developed from correlational studies of individual differences and applied to task descriptions developed by experimental and human factors psychologists. The purpose of these studies is to establish the feasibility and reliability of this provisional system, and to upgrade it, prior to its tryout against the Human Performance Data Base being developed. This subsequent step would provide for summarizing performance data (e.g., effects of "noise on different categories of performance") in terms of the categorization system.

Pre-testing was accomplished using raters from the professional staff of A.I.R. This pre-testing established preliminary rater agreement on different categories and suggested areas of needed revision. The studies which followed utilized a system of 50 ability categories and six tasks representing sub-categories of motor, perceptual, and cognitive functioning at different levels of complexity. Kits of materials for this were sent to 60 "experts" in behavioral measurement, with an excellent percentage of returns. The results are being compared to those from a parallel sample of 30 psychologists representing a cross section of experimental, human engineering and industrial psychological specialities.

The data are being analyzed according to various inter-judge agreement and similarity scaling techniques. While initial results show some agreement on the critical or moderate involvement of categories, best agreement occurs when categories are judged not to be involved in task performance. Based on these data, modifications in procedure are indicated and are being developed.

Other Systems of Human Functions

Progress has been made on the synthesis of other rational, but less empirically based, categorization systems utilized by behavioral scientists in human engineering, training analysis, and experimental psychology. These kinds of classifications are among the most commonly used, but they vary with the investigator, in their level of description, and in their specification of the kinds of behavior included. Our description of the earlier reviews and reports prepared under this project highlights these problems.

In attempting to compare various functions one is confronted with two interrelated considerations. The first is the need to equate essentially similar descriptions on the basis of their definitions despite differences in descriptor levels; the second is the recognition of the variety of levels of specificity employed by the authors of the classification system reviewed.

For example, is the function "monitoring" as used by Folley, the same as the "scanning" function as used by Miller, or the "watch-keeping" function used by Alluisi or the "signal detection" function used by Kidd? And how do these relate to "vigilance" a category of performance used by many? How does one relate experimental data obtained on a task described by one or another of these terms? Are we dealing with the same or different functions? Obviously, we cannot generalize performance data across tasks or predict performance on new tasks until we know.

The problem of level of specificity is illustrated by the often employed terms "decision making", and "problem solving" as defined by a number of respected investigators. First, it should be noted that some authors use only one term or the other, some use both terms as two types of descriptors, others use both terms interchangeably as a unit descriptor, while still others combine these two terms into the broader category of "intellectual", "cognitive", or "reasoning".

One investigator (Kidd) defines "decision making", as involving input integration, synthesis prediction, comparison and response selection, giving examples of varieties of decision making (e.g., cause and effect attribution, time-line analysis and prediction, pattern construction). Another (Lumsdaine) emphasizes application of conceptual rules as a basis for diagnosing or interpreting. A third investigator (Altman), defines decision making as choosing one out of a field of alternative actions in a probabilistic situation, including the following of an optimum strategy in non-rote behavioral sequencing.

Altman distinguishes decision-making from problem solving, which involves resolving courses of action where routine applications of rules for decision making would be inadequate. Problem solving here implies integration and adaptation of existing principles into novel, higher order rules.

Contrast Altman's definition of problem solving with that of Teichner, which includes a combination of: a) successive searching (scanning or monitoring), b) coding--naming a detected signal or grouping stimulus characteristics into a classification, or the using of rules to relate or transfer codes, and c) switching--the selection of a categorical choice of action.

Finally, for illustrative purposes, we may view those investigators such as Alluisi, who use the terms as a single category. Folley, for example, includes elements of gathering information, making estimates of missing data, evaluating probability and reliability of data, and recollecting precedents. Miller, while lumping decision making and problem solving, places emphasis in the former on response selection or formulation in the absence of a dominent association between cue and response pattern and purpose, where the latter emphasizes additionally, processing by strategy rules.

These examples have parallels within the many different categories we have under analysis. The questions raised are not simply academic ones since the investigators involved have also been actively involved in training and systems design and in the generation of experimental data. Furthermore, many of these investigators have been particularly concerned with the problem of generalizing across tasks. Yet the gap in doing this is apparent.

In our present line of activity careful attention is being given to such categories, as utilized by previous investigators, starting with as detailed a specification of the behaviors as possible. Elements of these behavioral specifications are isolated with a view to identifying common and unique features. The goals are: a) to derive a limited set of non-redundant functions at several clearly defined levels of description; b) to supply operational definitions which can be used in applying these functional classifications to new tasks; and c) to test out the extent to which these functional categories help organize the performance data in selected areas being developed in our Human Performance Data Base. At present, the category labels and the elements of their definitions (and where possible the means of their measurement) have been organized in matrix form for further content analysis and refinement.

Development of a Provisional Classification of Task Characteristics (George R. Wheaton, Alfred J. Farina, William J. Baker)

The preceding section has described efforts at developing classification systems in terms of the human functions required to perform them. Such classifications emphasize the human intervention in task performance. Since the generalizations we eventually hope to make are to the behaviors of individuals in many different types of tasks, a classification based on such linking dimensions appears to be critical, but cannot be fully assessed at this time.

It is possible, however, to conceptualize tasks per se, independent of the human operator's abilities or functions. At one level, for example, these characteristics could be in terms of the kinds of controls (i.e., rotary knobs, joy sticks, etc.) or kinds of displays (indicator lights, digital readouts, etc.), or the many other types of hardware with which man may interact during the operation of a system. These are only a few of the many characteristics which might be collectively employed to describe tasks prior to their classification.

Awareness of this possibility has given rise to an alternative effort to develop attributes and dimensions which may be used to classify tasks. This "task characteristics" approach to classification could serve at least two important functions: 1) it might provide a more systematic method for handling the large numbers of terms involved in task analysis data; and 2) it might provide a systematic structure for the matching of human functions with the task characteristics which place demands upon those functions.

Initial steps in the task characteristics approach to classification have centered on the development of a logical system consisting of carefully defined terms. As is true in so many areas of behavioral research, semantic problems must be met and overcome before substantive progress can begin. In particular, it has been necessary to carefully define the concepts of "performance" and "task".

A working definition of performance has been adopted which treats performance as explicitly goal-directed behavior. For example, keeping a stylus in contact with a target for 30 seconds, when instructed to do so, represents explicitly goal-directed behavior. It is explicit in the sense that the goal is indicated to at least the performer and one independent observer can verify whether or not the goal has been achieved. As a consequence, indication of the goal must then include a clear specification of some state, output, condition, etc. to be achieved by the operator.

Obviously, a great many forms of behavior exist which cannot be included under this definition of performance. Specifically excluded are those behaviors, which might be emitted in response to an implicit or at best ill-defined goal. For example, we cannot consider behaviors occurring during response to the Rorschach because of poor specification of goals. Until we can develop methods which will permit their inclusion, they must be set aside from the system we are presently trying to develop. This system is concerned solely with explicitly goal-directed behavior or performance.

Given the preceeding definition of performance we have found it convenient to treat a task as a construct which is potentially capable of eliciting performance. But in order for the task to elicit performance it must possess certain properties. Specifically, a task is viewed as containing the following characteristics:

1. The task contains an explicit goal which identifies for the operator the state or condition to be achieved as a result of task performance.
2. The task contains input stimuli representing sources of information external to the operator but to which he must attend if the goal is to be achieved.
3. The task contains a set of procedures which specify particular responses to be made to the input stimuli during task performance.

Some implications of the above task properties are particularly important for classification. Procedures are viewed as an integral aspect of the task. For example, a concise statement of how the task is to be performed is basic. If a violation of procedures occurs, the question of goal attainment cannot be asked meaningfully for that task. The operator, by definition, has performed some task other than the one assigned to him. This distinction between assigned task and task actually performed will become critical during later stages of the study which attempt to account for response measures in terms of task characteristics. A second implication stems from our interest in task goals, input stimuli, and procedures. It can be assumed that the task performer's perception of the task seldom agrees precisely with that of the person who levies the task. Consequently, if a descriptive system is to be developed which has some empirical basis, we must utilize operationally defined and objective task characteristics rather than the differential perceptions, attitudes, abilities, etc., of persons performing the task.

The identification of task properties including goal, input stimuli and pr-.edures leads to consideration of what it is that may serve to differentiate among tasks or, conversely, to permit an assessment of task similarities. Toward this end, the task properties of goal, input stimuli, and procedures are being analyzed in an attempt to identify more specific attributes in terms of which tasks may be compared and contrasted. The literature reviews previously cited have suggested task attributes of interest to other investigators. For example, investigation of task procedures suggests that the following information will usually be present:

1. A detailed specification of the signals which are employed to initiate and terminate performance;
2. A statement concerning the sequencing of goal-directed behaviors including fixed, branched, or random sequences;

3. Specification of the effectors to be utilized during task performance;

4. Identification of the output devices such as controls or materials to be manipulated, etc.

Analysis of these and similar information classes associated with task goals and input stimuli is being conducted to isolate dimensions which will provide the bases for task classification. For example, termination signals can be viewed as either "self-generated" or "externally imposed", as "time determined" or "production determined". Joint consideration of initiation and termination signals permits derivation of a "task duration" dimension.

It is anticipated that judges equipped with a list of task dimensions or attributes will be able to go beyond the qualitative judgment of "present" or "absent" to supply quantitative data in terms of measurements, counts, or ratings for each dimension. These data would then be subjected to numerical taxonomic techniques, i.e., one of the many possible forms of multi-variate cluster analysis, to establish classes of tasks.

Once these task dimensions are established, subsequent work on the project will include applications to the tasks contained in our Human Performance Data Base. The objective here would be to provide empirical verification of the utility of the task dimension approach to task classification in yielding consistencies in experimental data and in providing improved generalizations of principles involving human performance. If successful, this should make it possible to relate characteristics of tasks, specified in precise ways, to expected effects on performance under various conditions (training conditions, types of environment, etc.).

A second consequence of this phase would be the specification of the task characteristics of laboratory tasks to be synthesized in the third year of the project. Such tasks would allow for: a) the experimental manipulation of task characteristics to evaluate more precisely the relation of such task variations to human function requirements; and b) the testing of generalizations regarding the effects on performance of independent variables (e.g., noise) on tasks with similar or different characteristics.

DEVELOPMENT OF A HUMAN PERFORMANCE DATA BASE (Arthur L. Korotkin, Marjorie J. Krebs, and Charles A. Darby)

The development and validation of any taxonomy of human performance is highly dependent upon the data in the existing literature, i.e., the results of experimental studies. However, if this large and complex body of experimental research is to be useful, it must itself be organized. Therefore, the first step, and a necessary prerequisite to the classification of human performance, is the classification of the many studies dealing with human performance. An information system is under development to provide access to the research relevant to the classification of human performance. Ultimately, this system will act as a means by which the current and future literature can be indexed, stored, and retrieved using the taxonomy of human performance which will be developed as an end product of this program.

The specific initial application for the information system will be to the development and validation of alternate provisional taxonomies. The alternative provisional taxonomies being developed will attempt to identify classes of human performance which are similar and/or which are similarly affected by experimentally manipulated conditions. The information system will offer a means by which relevant studies can be assessed and analyzed to determine if such positive relationships do indeed exist between or among classes of human performances.

An initial step in the development of the system is the creation of a "controlled vocabulary". The controlled vocabulary is a comprehensive body of terms. These terms are being selected on the basis of their uniqueness of meaning and will be used to represent the documents in the literature for both indexing and retrieval purposes. The use of a controlled vocabulary delimits the universe of acceptable descriptors and this improves the consistency (reliability) with which documents are represented (indexed) in the system. It also insures compatibility between the indexer and the system user by acting as the interface -- a bridge between their two functions. Thus, the user and classifier are using the same (controlled) vocabulary for both functions.

Another initial step required to achieve a standardized data file for these diverse areas is the development of a standardized indexing format. All studies will be described by a set of standard requirements which include such elements as independent variables, dependent variables, subjects, apparatus and/or procedures, and results. The controlled vocabulary is used to describe each of these elements of experimental studies, thus achieving some level of standardization. An effort is currently underway to develop such a standardized format for representing each research study in the document file. (In this connection the relevance and possible applicability to this system of other indexing efforts, e.g., the notational system displayed by Verplanck, are being examined.)

As an initial data resource, research studies in five areas have been selected. The criteria for selecting the areas were: a) the existence of a relatively large amount of experimental data; b) the absence of any major attempt to systematize the results in these areas; c) differences in the effects on performance when different tasks are employed; and d) interest on the part of the scientific and technical community in these areas.

The five areas selected for this initial effort are two environmental areas, (a) auditory noise and (b) atmospheric thermal environment; two training variables, (c) knowledge of results, and (d) massed versus distributed practice; and a psychophysiological area (e) psychoactive drugs.

We have selected noise as the first area in which to index and store documents. These efforts will then be expanded to encompass the other areas as the study progresses. The development of the information system is viewed as evolutionary in nature with the noise area viewed as the prototype.

Mod I of the system with its small volume of documents will employ manual search and retrieval techniques. The manual system will serve as a model for optimizing the document representation forms and controlled vocabulary. As the data base increases in size Mod II will evolve using automated retrieval supported by our in-house IBM 1130 capability. Document analysis and indexing will continue to be manual.

At the point where one of the taxonomic schemes is accepted as the working model, the vocabulary will be revised in a major fashion. Additional terms will be added from the taxonomy itself permitting access to the literature in terms of the new taxonomy as well as the original controlled vocabulary. This will constitute Mod III, the final version of the information system.

The other outstanding feature of Mod III will be the capability to retrieve data rather than documents. By inputting to the system the analytical products of the task classification efforts concurrently underway, a data base as well as a document collection will be created. It is anticipated that the user will be able to retrieve study data as well as study documents. These data will be limited to the effect of the independent variables upon the selected task performances. However, even such a limited data base does provide, in addition to a resource for the current project, a unique research tool with broader applications beyond the task taxonomy effort.

PLANS

During the second year activities on the project will include:

1. Completion of provisional classification systems, now under development. This includes systems based on human abilities and functions, and task characteristics. This includes further experimental tryouts of formats and scaling techniques for analyzing currently available task descriptions.

2. Use of Data Base formats against literature in selected performance areas. This includes completion of document acquisition and coding for the following areas: effects of noise, effects of thermal environment, effects of drugs, effects of

knowledge of results, effects of massed-distributed practice.

4. Computerization of the Human Performance Data Base.

5. Application of the provisional task classification systems to the description of tasks in the Data Base.

6. Organization of the research data in terms of alternative classification systems.

7. Evaluation of the classification systems developed in terms of indices of consistency of findings within and between categories.

8. Generation of human performance principles relating independent variables to the task classifications.

9. Submission of individual reports integrating experimental literature in terms of a common framework of human performance classification within and across substantive areas (e.g., effects of noise, drugs, etc.).

10. Conduct of preliminary experimental studies, using presently available laboratory equipment, linking variations in laboratory task elements to variations in human functions required for effective task performance.

11. Initiation of design recommendations, and specifications for more comprehensive laboratory development consisting of selected, synthesized tasks based on the provisional task categorization system shown most promising. The tasks synthesized

should allow for: a) more systematic linking of variations in task characteristics to variations in human functions required, and b) testing of generalizations regarding the effects of independent variables on human performance within and between human task categories.

12. A series of reports will be published during this second year describing the integrative reviews, the theoretical model, the provisional classification systems, the Human Performance Data Base effort, and the integration of human data in the selected substantive areas. A major report, at the end of the second year, will summarize progress made in developing a taxonomy of human performance.

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PROJECT RELATED REPORTS DURING THIS PERIOD

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13. ABSTRACT
This report briefly describes technical progress during the first year of a five year project to develop and verify a taxonomic system for the classification of human task performance. During this initial year, the major efforts on the project proceeded along four lines of activity: (1) review of previous taxonomic efforts, (2) development of an integrative model, (3) development of provisional classification schemes, and (4) development of a human performance data base. Previous taxonomic efforts were reviewed to provide guidelines and suggest approaches for the development of classification systems. An integrative model was developed to indicate which areas had to be taken into account in the development of a comprehensive task taxonomy. A provisional classification scheme, based on human abilities identified in earlier correlational studies, was developed to indicate the feasibility of using such an approach and to isolate some of the practical problems that might be encountered in the development of a taxonomy. Work on another provisional classification scheme, based on observable characteristics of tasks, has been initiated. The requirements of a Human Performance Data Base were defined to provide a resource and a research tool for testing provisional classification systems being developed. Finally, plans for the immediate future have been developed to insure continuity to present efforts.

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