NTDC HUMAN FACTORS PROGRAM

DR. JAMES J. REGAN
DR. GENE S. MICHELI
Human Factors Laboratory
Naval Training Device Center

We will briefly describe the organization of the Laboratory and say something about the kinds of people making up its staff. Then we will give you an overview of the technical program according to eight major categories, with selected examples of current and future projects within each. The projects we have chosen to discuss are those that we hope will most interest you and/or those on which you may be most likely to help us in solving some of our problems.

There are four departments within the Human Factors Laboratory, namely: (1) Psychological Applications - - in which most of the human factors consultation effort is centered; it maintains a regular review of Center developments and products, insuring that they reflect modern human factors engineering and training practices; (2) Training Technology - - which is our research and development activity; its mission is to conduct in-house research in the area of applied human learning; (3) Training Effectiveness - - which is an organizational reflection of the increasing concern at all levels of the Navy with formal, scientific evaluations of the training usefulness of training devices; (4) Adaptive Training - - which is concerned with a number of approaches to the improvement of training systems through making training more of an individual experience for the trainee than has typically been the case.

All the professionals in the Human Factors Laboratory are experimental psychologists, the majority holding the doctorate. Their backgrounds and interests include physiological, engineering and educational psychology. In fact, the staff represents the entire range of psychological specialties, with the exception of clinical.

We would like to devote the remainder of this talk to a brief description of the current and future elements of our technical program. This description will be organized around the way of looking at training device development shown on Figure 75. Our forty plus current and planned projects fall rather neatly into this classification scheme.

The first category - - - the Trainee's World (Figure 76) - - is of primary importance and should be considered in any meaningful analysis of the training problem. We have to consider the trainee and the world of which he is a part. Individuals come to a training situation at different levels of competence, they learn at different rates, they perform differentially in the training situation depending on their aptitudes, interests, personality and learning styles, and they respond differently to various training methods. Consideration of such individualization of instruction is perhaps the most talked about issue in educational technology circles today.

A study is being conducted to learn how to match the individual differences of the trainee (his aptitudes, interests, prior knowledge, and learning style) with the particular design and use of a training system. Information was obtained on the aptitudes and interests of Navy enlisted men by obtaining their Navy Basic Battery scores and administering thirteen other tests. Two experimental training systems were developed, one reflecting inductive, and the other deductive, training methods for an aircraft recognition course. The same was done for a course on the Transportation Technique, which is a mathematical method used in operations research.

A WAY OF LOOKING AT TRAINING DEVICE DEVELOPMENT

TRAINEE'S WORLD

METHODS OF ANALYZING TRAINEE'S JOB(s)

NEW MEASURES OF TRAINING PERFORMANCE

THE INSTRUCTOR

MAJOR DESIGN ISSUES

EXPLOITING THE COMPUTER

DEVICE EFFECTIVENESS

TRANSLATION

Figure 75.

TRAINEE'S WORLD

INDIVIDUAL DIFFERENCES

TASK DIFFICULTY

FEEDBACK AND CUING

DECISION MAKING

STRESS IN TRAINING

Figure 76.

The results of this study strongly show the effect of learning styles and suggest that multi-track training based on learning styles may be a cost-effective way of enhancing learning.

One way of effectively manipulating the trainee's world is to vary the difficulty of the task he is performing. Just how difficult ought the training task be to produce the most effective training? A related question is on the effects on training methods of the nature of the training tasks. For example, should training methods used in learning procedures differ from those used in decision making? We are currently engaged in a study to determine whether one can generalize findings about task difficulty across different types of tasks.

Feedback and cuing are two forms of enhancing the learning process. Cuing may be thought of as a form of guidance, or the giving of information as to the correct response prior to the trainee's response. Feedback is information concerning how well the trainee did what he was supposed to do, or the giving of information after a decision was made. A long-term study on the training of auditory discrimination found cuing and feedback to be equivalent in terms of percentage of correct detections and discriminations on test trials. However, feedback resulted in risky behavior - - a more lax response criterion (as shown by a large number of false detections) while cuing resulted in a more cautious approach, shown by a decrease in false positives.

It appears then, that the relative effectiveness of feedback versus cuing as training methods depends upon the specific task being taught. Feedback was more advantageous when the task requires the detection of larger percentages of signals, regardless of the number of false responses. Cuing was superior when cautious behavior, that is, few false detections are permitted.

We are interested in the role of stress in training. Almost everyone is convinced that stress influences the way in which people learn and perform. Generally, the feeling is that stress should be present in the training situation. Research in this area is being initiated.

The next category - - Methods of Analyzing Trainee's Jobs (Figure 77) deals with approaches to determining what the job of the trainee is. All of the methods listed are related to a training situation analysis. A training situation analysis is a study of existing or future military situations where training is indicated. Its purposes are to determine whether training devices can help to solve the training problems involved, and, where a need for training devices is indicated, to furnish the basic information necessary to their effective design and use.

METHODS OF ANALYZING TRAINEE'S JOB (S)

TASK ANALYSIS AND CLASSIFICATION

ANALYSIS OF UNDERSEA SALVAGE SIMULATION

TACO TASK/TRAINING EFFECTIVENESS

TASK QUANTIFICATION

Figure 77.

Task classification is associated with decisions concerning training device design. Basic to the whole matter of how to train is an assumption that training methods, techniques, and equipment features are a function of the nature of the training task. For example, if a preflight check were identified as a procedures task, a different training device would be designed from that designed if the same preflight check had been classified as a perceptual motor task.

Although all agree that training should be based on what people have to do, no adequate system for categorizing tasks has yet been developed. Members of our Laboratory are attempting to develop improved task classification systems. Information is being obtained about the skills required in using training devices. Once we are able to classify the tasks and functions in current use satisfactorily, we can choose samples of these tasks for research which will facilitate the translation of research findings into practice.

Another project subsumed under this category is the analysis of undersea salvage simulation. This study will attempt to define practical methods of training for deep diving, and it should result in statements of the training problems, the areas where training will be required, and a recommended system for training.

Another example is an analysis of the airborne ASW tactical officer's (TACO) duties. This project will then determine the training equipment needed to support the training of the TACO to perform these duties.

A further example under this category is a task quantification study. Quantitative indices of the characteristics of instructor's and the trainees' tasks are being sought so that the effectiveness of a given amount and type of training on a given task can be predicted. These experiments will establish how the degree and rate of learning is affected by tasks which contain various amounts of one or more task characteristics.

The next step of training device development concerns itself with the measurement of trainees' performance. It should not be surprising to learn that performance measurement occurs this early on the list of categories. It is essential in conducting a training situation analysis to have information on the accuracy with which and time in which tasks can be performed by both untrained and trained people in order to determine where the biggest payoff in system effectiveness can be brought about by training.

Research on eye movements is seeking to determine the relationship of eye movements to performance. The hope is that analysis of eye movement patterns will reveal those patterns characteristic of skilled performers. This, in turn, will lead to an attempt to teach unskilled performers to develop the patterns of skilled performers. This has implications for such tasks as search, multi-display tracking and monitoring.

Other research plans include using various physiological indices to determine levels of alertness. The objective is to train operators to improve their performance by becoming more aware of their internal body states. A trainee will be provided with quantitative data on his body state, such as fatigue and alertness so that he may take appropriate remedial action when the undesirable limits of either are reached.

Team communications is another new measure for assessing trainees' performance. This measure is being developed to be used as a tool for assessing team behavior during a complex team training mission. The relationship between ASW helicopter team performance and the content and flow of communications within the team during attack is being investigated. The predictive value of the index of ASW team communications will be validated using a large sample of ASW helicopter teams.

Another new measure with a lot of potential for measuring performance is the effective time constant. This measure was found to be related to final level of precision of control and to rate of learning. (Dr. Matheny will elaborate on this new measure of training performance in the next talk.)

The other items, namely, computer generated performance comparisons, response latencies, and sequential and confidence testing, are all related to one of the most important single developments to come along in years in the area of training technology, namely, computer based training. We will say more about this a little later in the talk.

The advent of automated training devices makes it possible for the instructor to devote more attention to those of his functions which are pedagogical in nature, and less time to operate-like functions. The projects listed in Figure 78 are concerned with the optimal participation of the instructor on each of the roles he might play.

The Synthetic Flight Training System (SFTS) is a training device which will be used at the U. S. Army Aviation School and aviation field units for helicopter training. It will have an adaptive training feature, whereby the trainer automatically adjusts the difficulty of the task as a function of how well the trainee is performing. The human factors inputs to this project are mainly concerned with the size of the difficulty steps, the error tolerance levels and the choice of parameters that should be varied.

One of the areas that can profit most from the introduction of computer hardware and software technology into training systems, involves the role of the "instructor-operator" in automated Weapons Systems Trainers (WST's). It is becoming increasingly apparent that many of the functions now performed by the instructor-operator could more appropriately be relegated to computer control. We have a project to determine the guidelines for relegating routine instructor-operator functions to computer control.

Some major design issues which have confronted us in training device development over a number of years are indicated in Figure 79. We continue to attack these design problems. One project is on the role of motion in flight trainers with the broad view of assessing the contribution that motion makes in vehicular control trainers.

THE INSTRUCTOR

SFTS ADAPTIVE TRAINER

AUTOMATED WST

TASK QUANTIFICATION

Figure 78.

MAJOR DESIGN ISSUES

MOTION SIMULATION

VISUAL SIMULATION

GENERALIZED SONAR TRAINING

SIMULATING FLIGHT DYNAMICS

Figure 79.

A project on visual simulation is being conducted as a joint effort with members of other NTDC laboratories and directorates. It is a broad scale attack on an historically troublesome simulation problem faced by training device designers - - that of providing a visual representation of the trainee's world. Particular attention in this project is directed at the problems associated with the simulation of terrain as viewed from aircraft.

Another design issue is often referred to as generalized training. An example of this that is currently underway is the development of a research tool called the generalized sonar maintenance trainer which is undergoing experimental examination at the Fleet Sonar School in Key West. Preliminary research indicates that trainees can be as effectively trained to perform maintenance tasks with a generalized device (containing representative circuitry and components) as with the operational equipment itself.

A final example is concerned with establishing the effects on flight training of reducing the fidelity of simulation of flight dynamics. Beyond certain points, it has historically been quite expensive to incorporate certain nonlinear terms into dynamic flight equations. This project seeks to assess the effects on subsequent performance of fidelity reduced in various ways.

The computer is an innovation of today's technology that we must exploit in training device design and use. Typical projects in which we are attempting to exploit the computer are automated instructional systems and machine controlled adaptive training. Other projects include the use of the computer for developing enriched student-computer interfaces and computer-aided problem solving. An experimental training facility will be developed in which the functional characteristics of a wide variety of training systems can be identified, simulated and evaluated. This simulation facility will provide a tool for testing, before design decisions are made, the characteristics of training equipment with respect to such subsystems as the instructor and student stations and with reference to the extent and nature of the simulation required. An in-house laboratory study on ways to improve the student-computer interface utilizes our IBM 1050 (AV) terminal, which consists of a teletypewriter input-output device, a slide projector which provides for 320 image projections, and a tape recorder. The terminal remotely accesses an IBM 1440 system.

How do we know when a training device is doing the job it was designed to do? It is only recently that we have begun to evaluate the effectiveness of training devices from the standpoint of transfer of training. We intend to provide not only for the evaluation of specific training devices, but also to develop methods and guidelines for others to determine training device effectiveness. An evaluation recently completed is that of the skill retention of those trained on the ASROC trainer. In this project performance changes by members of ASROC teams undergoing training at Norfolk were measured and their skills re-evaluated at periods ranging from 8 to 32 weeks after training. Two rather straightforward conclusions were reached - - one is that the people do in fact learn in the ASROC trainer, and the other is that they rapidly forget what they have learned when they go to sea. As a way of conducting refresher training it was decided to return to the trainer only selected key members of the ASROC team to determine the effect on the upgrading of the entire team. This was found to be as efficient as returning the entire team to the trainer for refresher training.

Our project on training system evaluation guidelines is concerned with the general problems of measurement encountered when one attempts to assess individual and group trainee performance in the field and with providing guidance in solving these general problems.

The instinctive firing apparatus evaluation was completed this past summer. (The French refer to training in quick-firing a rifle from the hip as "instinctive" fire.) A small spotlight is attached to the barrel of the rifle and operates when the trigger is pulled. Preliminary data analysis shows that there is transfer from this training to actual firing of a rifle.

The carrier landing trainer evaluation will determine the extent to which the skills learned in the trainer transfer to actual carrier landings. A transfer of training experiment will be conducted to compare pilots who are trained on the trainer before starting flight training with pilots who are trained without practice on the trainer.

We have rapidly run through selected examples of the projects that the Human Factors Laboratory is engaged in or planning. In concluding, we would like to say a few words about an area in which we have an increasing interest, namely, the problem of translation of laboratory research findings in human learning into forms that can be useful in operational settings. This operation of translation is also referred to as "bridging the gap," "operationalizing," and "learning engineering."

One step in this translation process is the collation of all NTDC human factors reports into an annotated bibliography. This annotated bibliography will soon be available and given wide distribution. These abstracts will "advertise," so to speak, the data available for application to current problems.

Another step in the translation process is the implementation of research results into further research studies which are closer to real-world problems. Ultimately we want to translate research findings directly into training devices.

An example of this type of activity is the translation of data on machine-controlled adaptive training studies into specifications for the adaptive training features of the Synthetic Flight Training System (SFTS). In addition, NTDC has for a number of years been supporting research on team training with particular emphasis on decision making in tactical situations such as anti-air warfare and anti-submarine warfare. A point has now been reached where findings should be evaluated in terms of what needs to be done in order to incorporate them into training systems.

We don't want to see technical reports filed gathering dust on a shelf. A research report, either from our laboratory or from a contractor, should be the beginning rather than the end of an endeavor. We want to implement the findings of our research studies into training device design and use. But, this translation process is the hardest part of the entire research process. An all out effort is being made to do this, but the point is that much thought and effort is required. However, we have committed ourselves to this type of effort on all our projects.

The reason the translation process is so difficult is that there is no training ground for the development of research translators. Who should be trained for this function and how to train for it are areas requiring investigation. We would be interested in your ideas on this subject. In fact, we welcome your views on any aspect of our program.

THE USE OF THE EFFECTIVE TIME CONSTANT IN TRAINER DESIGN

DR. W. G. MATHENY
Life Sciences, Inc.

Before discussing the effective time constant of a man-machine system and what possible use it could be in the design of trainers, I want to give you some background and some explanation of why there should be any need for such a concept at all.

In 1950, I was involved along with the late Alex Williams as an investigator in a project which set out to determine the answer (or at least a partial answer) to the question: What is the relationship between transfer of training, and the fidelity with which the equations of motion are represented in a simulator? After a year of study we learned something about the mathematical models used to describe the motions of aircraft and how these math models become physical models in simulators to represent or simulate the dynamic response characteristics of the aircraft. We learned also that there could be different math models for a given a/c, or at least different variations of a model for a given aircraft, when that model was actually reduced to hardware in a simulator. We concluded that if we were to conduct transfer of training experiments to test the effects on transfer of training of even the major portion of the possible variations of the way the model could be implemented in a simulator we would, without doubt, be carrying out experiments into the 21st century.

We learned, or were told at that time, that the problem of the relationship between amount of transfer of training and fidelity of simulation was really not a problem at all since it cost very little more to implement the equations to make a really high fidelity trainer than to make one of lesser fidelity. In the face of this declaration and in the face of the number of experiments to be run if we chose as our independent variables in transfer experiments variation of the math