If enough interest is expressed to warrant such a workshop, a suitable time will be established for convening one at the Center, and correspondents will be notified.

LEARNING, RETENTION AND TRANSFER

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The mission of the Training Technology Department of NTDC's Human Factors Laboratory is to conduct in-house research in the area of applied human learning, such as the transfer of training in complex human task, the identification of new indices of human learning, and the evaluation of basic learning research findings in complex applied settings.

This department of the Human Factors Laboratory has two programs of research, namely:

1. Physiological factors in relation to training.

2. Learning, retention and transfer.

Today I will talk only about the latter of these two programs. I will try to give you an overview of projects from this program. The projects I have chosen to discuss are those that I hope will most interest you and/or those on which you may be most likely to help us in solving some of our problems.

This program will investigate the variables of learning, retention and transfer and their interrelationships in order to determine the conditions which lead to the best on-the-job performance. We seek to obtain the kind of information that will be readily translated to the design and utilization of training devices.

We think the need for this program is obvious. Military personnel must learn new skills and retain them for long periods of time. The tasks used must allow transfer of skills from the training situation to the operational one. These three functions, namely, learning, retention and transfer, are thus of central significance to military training. Their relationships must be understood if training is to be efficient. Unfortunately though, there is not a well established body of experimental findings concerned with the learning of complex skills, nor reliable information about the nature of the tasks used for military training, nor adequate information available about the transfer value of tasks used to study learning in the laboratory.

We need to develop and evaluate new training methods and to determine the optimal utilization of established training methods for specific training situations. In addition, we need to identify those characteristics of the training situation that lead to effective on-the-job performance and to determine the measures of performance during training that are predictive of retention and transfer.

The projects of this program that I will discuss today are grouped under two subprograms.

A. Training Methods.

B. Relationships among Learning, Retention and Transfer.

A. Training Methods

This subprogram will develop and evaluate new training methods and will determine the optimal utilization of established training methods for specific training situations.

Projects

1. Adaptive training (self-adjustive circuitry)

Recently some pioneering work has been done on adaptive training using self-adjustive circuitry (by Edwin Hudson of Otis Elevator Co., Charles Kelley of Dunlap and Associates, and Henry Birmingham of NRL) wherein a tracking trainer automatically adjusts the difficulty of the task as a function of how well the trainee is performing. (For the purpose of our discussion we wish to define tracking as a continuous control task involving the following and "lining up" of one system with some other system.)

We decided to add adaptive circuitry to a piece of research equipment called the General Vehicular Research Tool (GVRT)(which was originally fabricated for us by Dunlap and Associates). Alfred Weinrauch, of NTDC's Computer Laboratory, and I decided to have the self-adjustive circuitry change the relative proportions of the coefficients of the tracking order components in the system equations so that the dynamics of the tracking task can automatically vary from zero order (that is, a simple positioning task) to second order (that is, a task with acceleration dynamics), and various combinations of zero, first and second order dynamics.

We are in process of conducting an in-house study, using Stetson University students as subjects, to determine whether it is more beneficial to have adaptive circuitry keep trainees at an easy, medium or difficult level of performance throughout training, considering also the ability level of the trainees. In other words, good and poor trackers will be mixed in each of the easy, medium and difficult levels of performance. The apparatus will adjust the task so that both the good and poor trackers in, say, the medium task, are kept at a medium performance level. Of course the task will have to be made more difficult for the better trainees in order to keep them at a medium level of performance. Then transferring to a test tast without adaptive circuitry will show the influence of adaptive training on tracking.

2. Under contract we have studies being conducted on:

(a) Whether training effectiveness can be increased by employing training methods which differ as a function of trainee characteristics; and

(b) The effects of cuing and knowledge of results as training techniques for auditory detection and auditory discrimination with a view towards sonar operations.

Dr. Kasten Tallmadge of the American Institutes for Research obtained Navy Basic Battery aptitude scores, composed of a General Classification Test, an Arithmetic, Mechanical, Clerical and an Electronic Technician Selection Test, and administered the Spatial Orientation and Spatial Visualization subtests of the Guilford-Zimmerman Aptitude Survey and the Kuder Preference Record to Navy Radarman trainees.

Two experimental versions of the Maneuvering Board segment of the Navy Radarman course were designed. The first of these experimental courses was designed to emphasize Gagne's Type 3 (Chaining) learning. It was oriented toward the rote memorization of fixed procedures for solving maneuvering board problems. The second experimental course was designed to reflect Gagne's Type 7 (Principles) learning, and emphasized the teaching of principles, concepts, and rationales involved in maneuvering board operations.

No interactions were found between trainee aptitude or interest characteristics and method of training.

This finding of no significant interactions between trainee characteristics and training methods, may, however, be a positive finding. That is, perhaps it is not possible to advantageously use a "track" system in radar training.

Further research is investigating the possibility that interactions between trainee characteristics and training methods may appear when the variable of subject matter content is introduced into the design.

In the other contractual study mentioned, Dr. John Annett of the University of Hull in England gave some trainees information as to when a signal would appear or whether the signal was of greater, equal or less intensity than a standard signal prior to the appearance of the signal (this was called cuing). Other trainees were given the same information after they made a decision (this was called knowledge of results, or KR). There was no significant difference in these training approaches on test trials in terms of percentage of correct detections or discriminations. However, cuing and KR resulted in different response effects. That is, KR 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.

The relative effectiveness of cuing versus KR as training methods may be a function of the specific task being learned. KR appears more advantageous when the task requires the detection of larger percentages of signals, regardless of the number of false responses. On the other hand, cuing gives better results when cautious behavior, that is, few false detections, are desired.

For further work on this project, sonar sounds are to be analyzed into component sounds. Then, as one training approach, a pastiche of sounds will be built up.

3. The last project I will mention under this subprogram is one on a Motor Skills Kinesthetic Trainer which was developed by Human Factors Research, Inc. A trainee in a tracking task holds on to and follows the motions of his control stick, which is slaved to the control stick of another trainee.

The hypothesis tested was that trainees would learn something from the kinesthetic and proprioceptive feedback they received from this situation, which will shorten the time it would ordinarily take to learn the task.

The results found were unexpected. I believe that different results would be obtained if the master control was an experienced tracker, instead of another trainee. We obtained the equipment from HFR and will repeat the study in-house, this time adding a condition using an experienced tracker.

B. Relationships Among Learning, Retention and Transfer

This subprogram will identify those characteristics of the training situation which lead to effective on-the-job performance and will determine the measures of performance during training which are predictive of retention and transfer.

Projects

1. A classification of task functions, training devices and training problems.

In developing training devices engineers tend to simulate operational situations and equipment in as realistic a way as possible. There have been relatively few attempts to determine the relative success of this approach. A few studies have suggested that non-realistic simulation may sometimes be as effective in training as realistic simulation. It is also possible that some kinds of training requirements can be most effectively met by realistic simulation and others by some abstract process or by some combination of the two.

In order to solve this problem, it is necessary to describe the nature of different training tasks, as well as the components of training tasks.

It is necessary to develop a classification of training devices, training task functions, and training problems. Such a classification could provide a basis for the choice of tasks and problems to use in laboratory studies that have a relation to the real-world.

Most experiments performed in laboratories have little obvious relevance to the kinds of situations typical of military problems. In order to judge the possible transfer value of typical laboratory tasks for the military training situation, we need to know something about their relative similarity to the components of military tasks.

Dr. Arthur Blaiwes of our staff is currently performing this task of taxonomy. He is developing a classification system and is obtaining, by means of interviews, and possibly by a questionnaire, information about the skills required in using training devices, the kinds of decisions involved, and the difficulty of the sequences of events that occur, among other things. In other words we are trying to specify the population of training devices, tasks and functions in current use so that samples of these tasks can be chosen for research which will facilitate the translation of research findings into practice.

2. A theoretical analysis of transfer of training.

This problem is important because of the fact that much training is conducted under conditions or at a time that may differ from the conditions in which the training will be used. For all practical purposes the entire training process demands extensive transfer of training (or carry over) if the training is to have any value.

We hope to conduct this study in-house, but current lack of manpower has prevented us from starting this yet. Perhaps you can help us here.

The variables we are most interested in are: (1) The role that similarity of stimuli and response have on the amount and direction of transfer of training. (For the psychologists in the audience I will just mention in this connection the Skaggs-Robinson hypothesis and Houston's and Osgood's transfer surfaces); (2) The time interval between original training and application in an operational situation. (This variable has received some attention from researchers in transfer of training. It is particularly significant in the development of training devices, because a considerable amount of time may elapse between the original training and the use of the training in an operational situation); (3) Initial level of skill where training is begun; (4) The degree of proficiency achieved on the training task; (5) The amount of retention over time; and (6) The type of task used.

3. Component practice in training devices.

We are in process of planning an in-house study in this area, which is related to the whole versus part training problem. The purpose of this project is to find ways of modifying the standard practice sequences used with training devices so as to take into account difficulty level of the component parts of the task.

Training on complex military systems requires extensive repeated practice, and practice on training devices is typically given in the normal sequence in which the total task is performed

This procedure tends to give equal practice to each part of the task, even though the different aspects of the task may be of varying difficulty. The result of this approach is to make the easy components of the task well learned and the difficult components of the task relatively less learned.

We plan to analyze the component functions trained for in a complex training device (or situation) and the sequences in which they occur. Another analysis will be made of the relative difficulty level of each of these component functions (or part-tasks). We hypothesize that differential amounts of practice on specified components of the complex skill and/or a systematic re-arrangement of the component parts will result in greater amounts of transfer to the total task than does a "natural" arrangement.

If this approach is successful, it could lead to a reduction in the time needed for training and/or a higher level of performance may be acquired.

4. Relationships among learning, retention and transfer.

The similarity of this project's title to the title of our whole program gives some indication of the importance we attach to it. We hope this project, which will be a two-year contractual effort, will be the start of a long-term series of experiments designed to establish parametric relations among learning, retention and transfer.

A great deal of learning research has been done by psychologists. A surprisingly small amount of research has been done in the area of transfer of training. This should be disturbing to all of us in the training business, since the ultimate objective of training is the transfer of what was learned to the operational situation.

Most research focuses primarily on either learning, retention or transfer, to the exclusion of the other two. In this project, however, we are interested in performance during training, performance at some later time with respect to the material learned earlier, and performance on some task different from the one used in training.

Conditions of learning have been set forth (e.g., graded difficulty; knowledge of results). Some factors affecting retention (e.g., overlearning; interpolated activity) and transfer (e.g., stimulus and response similarity) have been identified. However, little attention has been given to determining the effects on learning that optimizing the conditions for retention or transfer might have. The purpose of this project is, through investigating these three performance measures and their interrelationships, to identify those characteristics of the training situation which will lead to effective on-the-job performance and to determine those measures of performance during training which will be predictive of retention and transfer. This proposed study has been advertised in the Commerce Business Daily. We would welcome expressions of interest and capability in this area from those of you in the audience who have not already done so.