ESD-TDR-64-234

DESIGN AND USE OF INFORMATION SYSTEMS FOR AUTOMATED ON-THE-JOB TRAINING

11. DESIGN OF SELF-INSTRUCTIONAL FEATURES

TECHNICAL DOCUMENTARY REPORT NO. ESD-TDR-64-234

JANUARY 1964

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Benjamin C. Duggar
Sylvia R. Mayer

DECISION SCIENCES LABORATORY
ELECTRONIC SYSTEMS DIVISION
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 7682, Task 768204

(Prepared under Contract No. AF 19 (628)-455 by Bio-Dynamics Incorporated, Cambridge, Massachusetts.)

DDC AVAILABILITY NOTICES

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FOREWORD

One of the research goals of the Decision Sciences Laboratory is the development of design principles for automated training subsystems which could be built-into future Information Systems. Such subsystems would provide Information Systems with the capability of training automatically their own operators. The need for such on-the-job training has already become apparent. To be able to design such a capability requires first the solution of many conceptual and experimental problems.

Task 768204, Automated Training for Information Systems, under Project 7682, Man-Computer Information Processing, was established to formulate and answer some of these problems.

This report is one in a planned series supporting Task 768204. It was prepared as a joint effort of the staff of Bio-Dynamics, Inc., working under terms of Contract AF 19(628)-455, and Decision Sciences Laboratory, Electronic Systems Division. The authors are Drs. Thomas B. Sheridan and Benjamin C. Duggar of Bio-Dynamics, Inc., and Dr. Sylvia R. Mayer, Contract Monitor.

Ms. S. Molner, R. Rosenberg, J. Mickunas, and Dr. A. Johnson of Bio-Dynamics, Inc. are contributing directly to the research activities which provide a background for development of the general principles described in this report.

Design and Use of Information Systems

for Automated on-the-Job Training

II. Design of Self-Instructional Features

Abstract

This report is concerned with human engineering factors in the design of Information Systems. In particular it is addressed to the design of self-instructional features for these systems. It describes theories, methodology, and design principles for implementation of self-instructional features. The design principles were induced from the exploratory research on laboratory models of Information Systems which is reported in Volume I of this series, from studies on current Information Systems, and from a literature review.

The operational concepts underlying this study are stated, and an equipment design philosophy is proposed to complement this operational concept.

This Technical Documentary Report has been reviewed and is approved.

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KEY WORD LIST

1. TRAINING
2. TRAINING AIDS
3. HUMAN ENGINEERING
4. DESIGN
5. AUTOMATION
6. TEACHING MACHINES
7. COMPUTERS

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I. INTRODUCTION

This report outlines some general design principles relating to the implementation of self-instructional features in future Information Systems. These principles were derived from study of existing Information Systems, a literature review, and from a series of exploratory studies on Information System models which were described in a previous report (1).

A. The Air Force Requirement

The proposed design philosophy of this study is dictated by the planned operational concept for advanced Information Systems. These future computerized systems will serve as real-time, problem-solving and decision aids for staff and command-level users. As such they must provide maximum flexibility in operation to the extent that the problem solver can instantly re-program them.

This operational concept implies that the user must have extensive information on the workings and capabilities of the hardware and software aspects of the equipment. In turn, this fact poses a requirement for training aids and performance supports continuously available at the man-machine interface. It also demands the use of the operational equipment for on-the-job and proficiency training in the operation of the equipment.

The future Information System user will not be the traditional "equipment operator" who solves a limited number of well-defined problems in a prescribed manner. He will be a specialist in some Air Force mission area. He will use the Information System on an intermittent basis to solve a broad range of dynamic problems which demand creative methods of attack - methods which cannot be pre-specified.

This operational concept and the new-style user it implies impose the requirement for a new approach to time-tested military solutions for the training of equipment users.

B. Assumptions Underlying Traditional Approach to Equipment Design

The assumption underlying traditional equipment design is that the equipment will be used only by the completely proficient. Traditionally, the bare minimum (or less) of cues for operation are provided at the man-machine interface. The user is expected to have all required skills and information for operation in his repertoire.

The activities which lead up to the ultimate state of proficiency are viewed as belonging to a unique type of behavior - "training" - which is regarded as totally different from "job performance." Furthermore, training and job performance are assumed each to require different types of equipment support.

C. Assumptions Underlying Proposed Approach to Equipment Design

A different set of assumptions underlies the design philosophy proposed here for advanced Information Systems. It is proposed that equipment be designed to support operation by a broad continuum of users from the newly-assigned who understands little about the equipment (but much about the operational problem) to the fully proficient. Furthermore, individual users can be expected to fluctuate widely over time in their proficiency. Thus, the equipment should supply maximum cues required to guide and support equipment-operation performance. These cues would be depended on in their entirety by the new user, to a lesser degree as he has practice, until ultimately he can ignore most of the cues. After a period of no practice on the equipment he might have to revert to use of a greater number of cues.

The assumption underlying the proposed approach is that Information Systems must support a range of users from minimum to maximum skill, rather than, as has been traditional in equipment design, only the user of maximum skill. Evidence indicates that equipment can be human-engineered to support several levels of user proficiency. The major difference in behavior during "training" versus "job performance" thereby would rest in the number of available cues used and the performance time. The cues, supports and training aids which are proposed here for availability at the man-machine interface are referred to as "self-instructional features." They range from such techniques as color-coding for guiding fixed procedures to computer-directed programed instruction built-into the system.

D. The Methodology

The first step in developing self-instructional features is to perform a task analysis. In its simplest form the task analysis may appear to be nothing more than a very complete set of job instructions. For simple tasks, this complete set of instructions may be all that is needed for training. In more complicated situations the task analysis will be used to specify what capabilities the user must have and to suggest what modifications should be made to the operational equipment to reduce the requirements on the user, or to provide self-instructional features.

After the task requirements have been determined methods of teaching the required skills or of modifying the machine or designing the interface to make its functions so manifest as to obviate the need for training should be developed. Although aids may be developed to reduce the total task training requirements, necessary training in use of the aids themselves should not be overlooked.

II. TASK ANALYSIS

Before considering the implementation of teaching functions in complex machines a detailed problem statement should be prepared. The problem statement should define those capabilities which will be required of the human operator for acceptable operational performance (the terminal state), the initial capabilities which the operator may be expected to process (the initial state), and any intervening levels of capability which, when reached, signal a change in instructional techniques, aids, or requirements (the intermediate state(s)). Identification of the necessary operator capabilities requires a task analysis. Thus, the analysis of the task characteristics represents an essential first step which provides basic data for the problem statement, outlines constraints on possible solutions, and may even suggest the solution. The task analysis specifies what capabilities are required for each aspect of the task, who must have these capabilities, and is used in specifying constraints on how the required skills may be taught using the operational equipment.

A variety of task analysis techniques is available to the analyst (2, 3, 4, 5, 6, 7, 8). Selection of a particular method for analyzing, verbally describing, or graphically modeling the task should be based on the end requirements for the task analysis. For example, the analysis of the SAGE IND Director's task, described in a previous report (1) was directed towards the identification of the contingencies affecting each action and specification of sequences of actions. Graphic logic flow diagrams and symbology were developed and used to model these task characteristics. Manipulative skills and sub-tasks such as use of light-gun or contacting pilot by radio were not analyzed separately but were symbolically represented as single actions. The SAGE task analysis was used in developing an instruction program for teaching the decision making aspects of the task. A more detailed task analysis would have been required for the development of a program to also teach the manipulative skills. The task analysis of the experimental "numbers game", described in a previous report (1) outlined an "optimum strategy" for obtaining the solution. Selection of each successive test number was based on specifiable contingencies relating to previous test numbers. From the task analysis those concepts and bookkeeping techniques which the operator should be taught were easily identified.

In general, task analyses used in developing instructional programs must identify all information inputs to the operator, all actions that the operator may take, all decisions the operator must make, and the contingencies which determine each action or decision. Each element in the task can then be analyzed for the following operator requirements:

a. understanding of symbols and prior knowledge of other data,

b. perceptual skills

c. organization and interpretation of these skills and knowledge into task performance,

d. manipulative skills.

Operator requirements should be specified in terms of acceptable performance criteria, such as error rate, time to completion, allowable tolerance, etc.

III. PROGRAMED INSTRUCTION WITH OPERATIONAL EQUIPMENT

After the task has been analyzed and the operator requirements identified, methods of providing operators with the required capabilities may be evaluated. Alternative methods include such possibilities as: selection of operators possessing the required skills, simplification of the task so that instruction is not required, and teaching the required skills to the operator trainees. In practice, a combination of all three techniques is generally used. The designer of Air Force Information Systems equipment may have only limited knowledge of the skills that the potential users will possess and be severely restricted as to the degree to which the task can be economically simplified. Consequently, consideration of instructional requirements and techniques will be appropriate for most systems.

Components used in a conventional teaching machine are outlined in Figure 1. Overlap in characteristics of teaching machine components with those of the operational equipment can be exploited in implementing self-teaching functions as outlined in Figure 2. The displays and controls of operational equipment are often used at present for training and evaluation exercises, although instructors or referees may be needed for response evaluation and reinforcement purposes. In other situations access to the

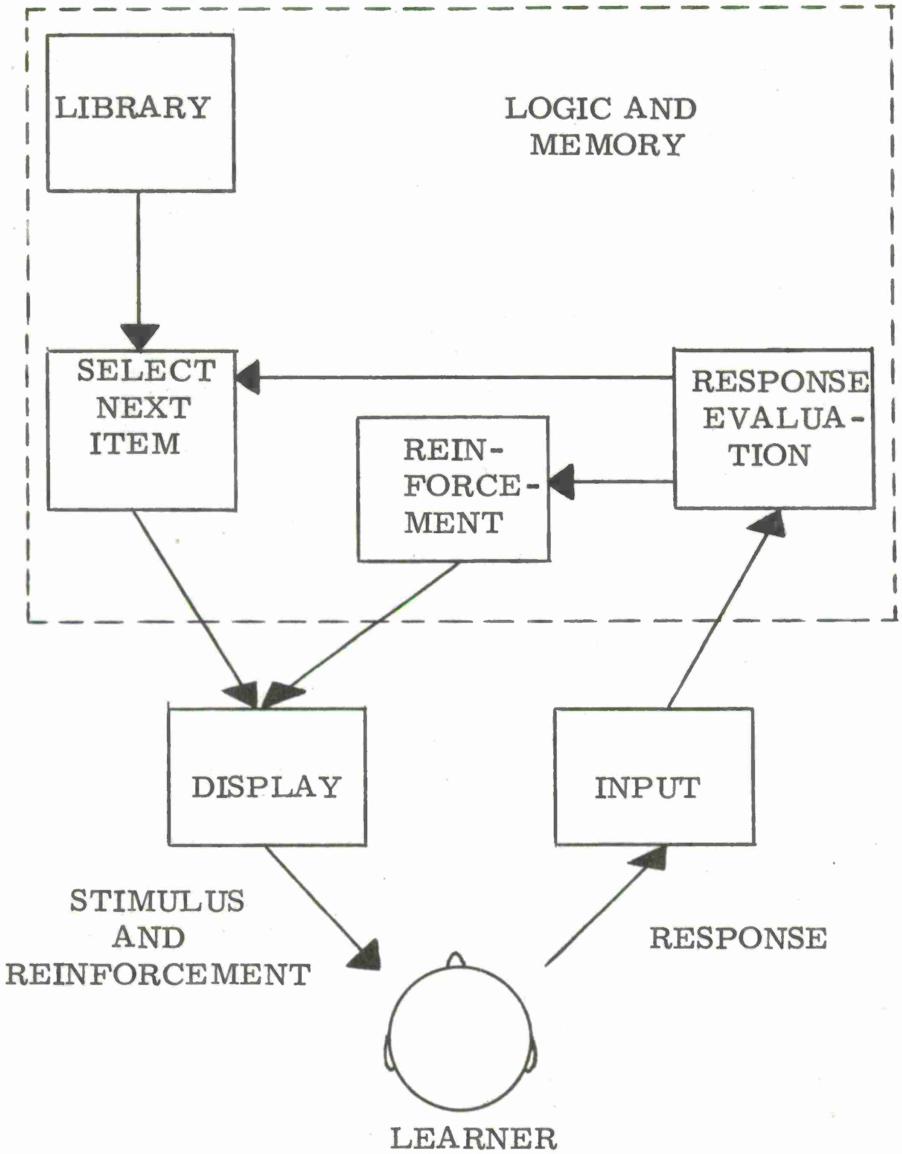

Figure 1. Components of Conventional Programed Instruction Equipment (adapted from Stolurow[1])

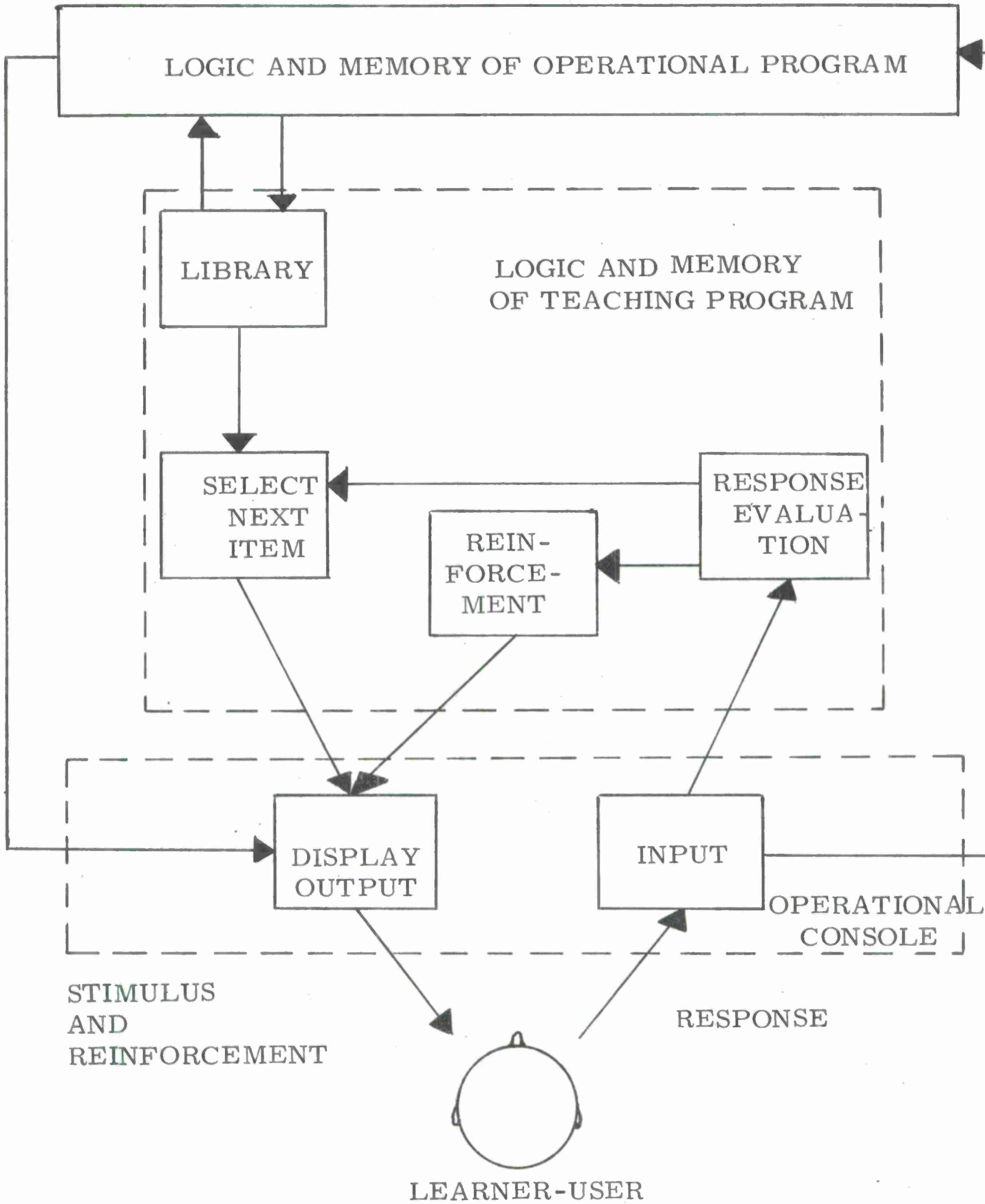

Figure 2. Information System with Built-in Programed Instruction Subsystem

display generating equipment and computer program may permit use of "canned" training programs in which response evaluation is performed automatically and immediate reinforcement provided.

Most Air Force Information Systems now in development have inherent data-processing capability which can be harnessed to supply computer-directed instruction. For the 473L Air Force Control System, an operational specification (9) has been designed to provide programed instruction in the form of active on-console training in writing and processing query language statements. This computer-directed program will tailor training to the proficience level of each trainee. Trainees will compose and enter queries directly into the operational console and will be provided feedback by the computer program on the operational display.

Thus, given considerable skill, ingenuity, and time on the part of an instructional programer and a computer programer, it is possible now to provide computer-directed programed instruction in Information Systems. However, to make this efficient training method economically as well as technically feasible for wide application, many hardware and software problems must be resolved (11).

Those aspects of programed instruction which have implications for equipment design parameters include: a) the necessity for immediate feedback of results, b) the active responses by the operator should proceed in small steps so that he makes few errors in the course of mastering the task, c) reinforcement techniques should be used to strengthen the learning (in some situations knowledge of results may provide adequate reinforcement), and d) instruction should proceed at a rate governed by the rate of acquisition by the operator. In some cases it may not be possible to include all of the above features except at excessive cost. In such cases it would be desirable to have sufficient data for evaluating cost-effectiveness of various trade-offs and modifications. Such data are not readily available. Further experiments are being conducted to develop general procedures and data for analyzing economic trade-off with instructional efficiency.

The first three of the above listed considerations all relate in a general way to characteristics of the reinforcement given the learner (i.e. that which modifies his behavior). The fourth, rate of instruction, is important in that it is ineffective if too fast, and inefficient if too slow. Some of the conditions which affect the reinforcing properties of a stimulus are described in the following paragraphs.

a. The learner must understand the information conveyed by the stimulus. This understanding may have to be taught, particularly when feedback of system status is used as the reinforcer (knowledge of results). For example, in the initial model of the SAGE IND Director's task in this project the change in the light display was used as a signal to the learner that he had completed the button sequence correctly. However, the learner first had to be taught to understand the meaning of a light display change before it fulfilled this function. A number of common signals have sufficient association value to permit correct reinforcing interpretation without instruction. Aversive stimuli such as red lights, raucous buzzers, "ERROR" signs, etc. generally indicate a mistake in performance. Common stimuli which convey information that behavior is correct include green lights, "RIGHT" signs, and production of the desired end result (for example, indicator on the timing dial moves when the tuning knob is turned). When the evaluation of behavior is more sophisticated than the binary decision "right" or "wrong", indicators such as scales, dials, intensity of color signals, or similar graded displays may be used. This would be particularly applicable in training behavior such as is required in the "numbers game", where a learner's response (i.e., the test number selected) may be evaluated as better or worse than other possible responses, but not absolutely correct or incorrect.

b. The reinforcement must occur after the response with a minimum time delay. It has been shown that the effectiveness of a reinforcer in strengthening desired behavior decreases as the time interval between the response and the reinforcement increases, even if no other (overt) behavior intervenes. Hence, the desired achievement is "immediate" reinforcement or feedback of results. For continuous tasks, such as continuous control tracking, it is inherently difficult to provide effective reinforcement directly related to the response (the response is continuously changing and the reinforcement may not be perceived as associated with the appropriate response characteristics).

c. The reinforcement may be positive, negative, or combination of the two types. However, excessive or improper use of one type or the other may destroy the reinforcing properties of the stimulus, and may even hinder the learning process. In general, positive reinforcement (agreeable stimuli or rewards) is more effective than is negative reinforcement (aversive stimuli or punishment) in molding behavior. As the learner or user masters the task and becomes "sure" of himself some forms of stimuli which continuously tell him that "You're right" may become a nuisance. In using positive reinforcement when learning through use of operational equipment it would be desirable to substitute knowledge of results in terms of system status in place of artificial reinforcers as the operator learns the meaning of system status variables (see discussion on schedules of reinforcement). An excessive use of negative reinforcement may also hinder learning by creating a frustrated or negative attitude. If the task cannot be taught in sufficiently small steps so that errors are infrequent, the value of positive reinforcement will increase and particularly aversive negative reinforcers should not be used.

d. There are no firm rules regarding the quantity or degree of physical characteristics which should be used for various types of reinforcement. If the reinforcement is money, the quantity is important. Optimum quantity will vary with the type of reinforcer, frequency of anticipated correct and incorrect responses, and reinforcement history of the particular learner. When using lights as reinforcers the intensity and duration, for example, should be selected to insure both attention getting and reinforcing properties.

e. The schedule of reinforcement should be varied according to the state of learning which has been achieved. No general answer can be given to the question, "When shall reinforcement be administered?". The previously described experiments with the console model of the SAGE IND Director's task demonstrated that initially it was important to give reinforcement often, to guide the operator in developing hypotheses about what the task really was. Unreinforced responses were difficult for the subject to relate to his hypotheses, and thereby delayed or reduced learning. However, after a period of training, the subject will have learned short sequences of actions sufficiently to consider the sequences as individual units or "chunks". The most efficient reinforcement schedule is then to reinforce only after the response "chunks" are emitted. Considerable logic and memory capability is required for a machine to decide when chunking has occurred, and what changes in reinforcement schedules should be made. When operators receive their initial, intermediate, and advanced instruction by using the actual operational equipment, provision for altering the reinforcement schedule should be included.

The above considerations deal with the technical decisions that the designer must make in implementing instructional features in operational equipment. The present study has not been sufficiently detailed to permit the drawing of conclusions regarding the economic decisions that the designer must make. Inclusion of self-instructional features generally involves increased capital equipment and design costs. In addition, the complexity of the system may or may not be increased with increased maintenance costs. Consequently, the designer must relate each technical decision to the economic realities governing system design. A detailed task and training analysis provides a powerful tool for economic analysis of system design factors. Such an analysis will indicate the actual costs of having a man perform various functions within the system, as well as indicating where operator load may be increased if significant equipment or personnel savings could be realized.

IV. SEQUENCING AIDS

If the task analysis indicates that the order in which actions are taken is important to system performance, then consideration of sequencing aids is appropriate. Highly developed sequencing aids may simplify the task sufficiently to eliminate the need for learning the sequences. However, in other situations the aids will assist the user in proper sequencing during his training period and then be ignored when training is complete. Principal categories of sequencing aids for Information System equipment include:

a. color coding of controls, diagrams, or panels

b. flow charts or diagrams

c. spatial layout of console controls

d. word cueing (visual or acoustic)

e. alphanumeric or symbolic coding and cueing.

Since the effectiveness of the sequencing aid is dependent on the user's understanding, requirements for teaching the symbology and/or terminology of the aid should also be evaluated. For example, it was necessary to teach the symbology of the logic flow diagrams used in the console model SAGE IND Director's task which was previously described. Instruction was necessary even though the symbology was simple and logical (i.e., buttons along a color coded line proceeding from left to right indicated an ordered "and" sequence, while buttons spatially oriented one above another and all enclosed in a color coded box indicated an unordered "and" sequence).

The categories of actions included in sequences, the types of sequences, and the contingencies associated with "branch" points should be considered in selecting sequencing aids. For example, obtaining information from a data processing system may involve activating a selector switch, use of a light gun for target identification, and then activation of a switch to obtain a readout of the requested information. If the two switches and the light gun are used only in this sequence, the two switches might be placed on either side of the light gun rack, all coded the same color, and labeled 1, 2, 3 in order of use. If other forms of readout are used, depending on specified contingencies, the appropriate readout switch might better be located adjacent to the alternative readout switches, and all such switches coded according to the contingent display. Sequencing from the light gun to alternative readout switches might then be aided by arrows printed on the console panel leading from the light gun rack to the group of switches. Alternatively a lucite strip around the switches might be illuminated whenever the light gun was activated.

Characteristics of a number of sequencing aids have been outlined in the following paragraphs. Consideration of these characteristics may provide guidelines for specifying aids for particular systems.

a. Color Coding: Although only a very limited number of solid colors may be rapidly discriminated, through use of stripe or checkerboard patterns several dozen distinctive codes can be used. Logic flow diagrams for the console model of the SAGE IND Director's task employed thirteen color codes (ten solid color and three stripe patterns). The stripe patterns were observed to be equally or more discriminable than corresponding solid color codes. When viewing conditions are not optimal (i.e. low levels of illumination, glare sources, colored ambient lighting, etc.) colors must be selected with greater care to avoid use of poorly differentiated codes. Color codes can be applied to individual controls, console panel areas, or to panel flow charts. Use of colors with high association values may facilitate training. For example, emergency controls might be red, or located on a red panel. However, the association value of colors is highly dependent on the individual's past experience - red and green might indicate acetylene and oxygen controls to a chemist - and care should be taken to avoid situations in which undesirable associations could increase error during operation.

Color codes have been widely used to indicate categories of console controls (for example, all display controls of one color, and all communications controls of another color). Experiments with the abstract console model of the SAGE IND Director's task have demonstrated that color codes also work well for flow diagrams. Wasserman (12) has also demonstrated that four color coding of circuit diagrams is superior to four types of lines used as codes in terms of speed of following and number of errors.

b. Flow Charts or Diagrams: Flow charts allow rapid following of sequences of actions, provided the operator understands the logic symbology used. If sequences of use of controls and displays can be specified in advance, diagrams or overlays can be placed on the panel with arrows and/or other high association value or learned symbols. The flow charts may be color coded to avoid errors where paths branch or cross, although identification of contingencies by color codes may require additional instruction. Active flow charts, such as may be constructed using illuminated lucite bars or overlays, may be particularly useful in instructing sequential activity, but means of identifying the appropriate sequence for activation may be more difficult to implement. However, if logic circuits are provided to guide the operator from control to control by means of lights or illuminated strips, the same circuits may also be useful in implementing reinforcing stimuli at small additional cost.

In using flow charts as sequencing aids it is important to identify the starting point, direction in which to proceed, points where contingencies should be checked, ordered versus unordered sequences, and to utilize symbology which has a high association value. Restricted flow charts can be used wherever sequence can be specified, even though the particular sequence represents only a portion of the task. For example, if display focus is always adjusted after display gain is altered, an arrow from the gain to the focus control is appropriate.

Flow charts used in teaching sequences can be projected onto consoles when overlays or permanent flow charts are inappropriate. The slide projector may be synchronized to a taped lecture which explains task components, contingencies, and procedures. A servo controlled light pointed could also be used to trace out the sequences of actions. Use of these techniques have the advantage of not interferring with the design of the operational equipment, and yet allowing the learner to obtain his training in the actual operational environment.

In discussing instruction through display of equipment operated sequences the following distinctions should be made: a) passive display of operations may consist of slides, diagrams, etc. which the user reviews at his own pace, b) active display of operations, such as through taped lecture and automatic pointer, involves a forced pace.

The disadvantage of the display teaching technique is that the trainee is not required to make an overt response. It would be possible in some situations to devise a system whereby a manipulator would grab the user's hand and force the user to follow through the sequences. A simpler system might involve having the trainee manipulate a light pointer to "track" an automated pointer, and then measure the "errors". These approaches are in contrast to the Skinnerian "free operant" approach which would be to instruct the trainee minimally, allow the trainee to perform the operations in large segments, measure or evaluate the performance, then accordingly reinforce the behavior; any partially correct response would be rewarded at first, but gradually the class of rewarded responses would be restricted.

c. Spatial Layout: Where sequences can be specified in advance spatial layout of controls will be effective (i.e. proceed from left to right, top to bottom). If controls are used several times in a sequence, spatial layout will require duplication of controls, or a combination of flow diagrams and partial spatial layout. The natural tendency of the human operator to proceed from left to right and top to bottom can often be advantageously used for layout of subsets of sequenced controls.

d. Word Cueing: Word cueing (visual or auditory) can be used in a variety of forms for instruction in the sequencing of actions. In its simplest form a set of written instructions can be given to the operator, automatically displayed, or printed on the console panel. In complex systems in which computer programming for a "training mode" can be implemented it may be possible to display worded instructions after each step in the solution of a "canned" problem. Even if the optimum sequence cannot be specified beforehand, general guiding instructions may be displayed according to an acceptable strategy (both the form and content on instructions are important to effectiveness, and guiding comments may not lead to the best or most rapid learning of querying-reasoning sequences, as demonstrated in the "numbers game" experiments).

In using word cueing the selection of words may be restricted by the amount of prior training of the operator. Labeling of controls will not in itself aid sequencing.

e. Alphanumeric or Symbolic Coding and Cueing: Alphanumeric coding is particularly useful in designating sequences. People are accustomed to proceding through the alphabet from a to z, and through an array of digits according to increasing numerical value. More complex codes combining alphabetic and numeric characters can be devised and taught to the users. Such codes can be used alone or to complement color or symbolic codes .

Symbolic codes can be devised which greatly increase the utility of logic flow diagrams as sequencing aids. Alphanumeric information added to the symbols used in flow charts has been used to specify sequences of actions and governing contingencies in the SAGE IND Director's task (1). However, it was determined that users did require training in interpreting the symbology before they could properly sequence actions by following the flow chart.

V. QUERYING -REASONING AIDS

The successive refinement of hypotheses about (the cause of) data, given successive presentations of data known to be from one of a given set of causes, may be regarded as learning. Consequently, devices which assist in selecting appropriate data requests, integrating present data with past data, and computing or inferring the probability of each of a set of hypotheses may be used as instructional aids. The human operator appears to be good at making judgements about effects (data) given causes (hypotheses) and poor at judging causes given effects. Presumably this is because of an ability in "thought experimentation" or "gedanken experiments", (fabrication of a mental model of a process for a given cause or hypothesis) and not because of ability to do mental bookkeeping. Aids or instruction in bookkeeping or in determining causes, given effects, (as, for example, by use of Bayes' theorem) should have a high potential for improving performance.

In the "numbers game" experiments (1) several forms of instruction were evaluated. In the initial stages of learning an automated bookeeping function provided the greatest amount of performance improvement. When the automated bookkeeping was discontinued a sharp performance decrement was observed, but most subjects soon adopted manual bookkeeping techniques similar to those which had previously been automated. The use of the automated bookkeeping thus appeared to act both as a means of task simplification and as an instructional technique. It is anticipated that implementation of simple logic and bookkeeping tasks in complex Information System equipment may greatly reduce the amount of instruction required. Operators who have been trained initially on equipment which automatically performs much of the routine logic and bookkeeping operations should require only minimal reinstruction when called upon to perform the same task with less automated equipment in the field.

Guidance in querying-reasoning behavior may be provided through a display of "Socratic" comments after each action. However, there is some evidence (our experience with the numbers game) that such comments may not be effective for all subjects during the early phases of instruction (Socrates used this technique with fairly advanced students). Such comments may be useful primarily in guiding advanced trainees in understanding the fine nuances of optimal strategies.

VI. CONCLUSION

Varying degrees of self-instructional capabilities can be included in Air Force Information System equipment. However, there are many unknown factors associated with the economics of such features. Before proceeding with design modifications a detailed task analysis should be performed to identify the required operator skills. After the operator requirements have been identified for each decision or action then: a) the sequences should be examined for possible inclusion of simplifications or sequencing aids, b) contingency analysis and bookkeeping requirements should be examined for possible simplification through automation, and then c) instructional requirements should be derived by comparing the remaining required skills to those of operator trainees.

Several techniques and considerations relating to the aiding of proper sequencing of actions, logic analysis, and querying-reasoning behavior have been described. Use of some of these techniques will reduce instructional requirements, others are designed to teach the required skills when the operator trainee receives his initial instruction on the operational equipment. Through the use of portions of the operational equipment, or the entire system, conventional programed instruction features can be provided with a minimum of additional equipment. However, consideration of such inclusion should occur early in the design process so that sufficient flexibility to meet changing instructional requirements may be assured.

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