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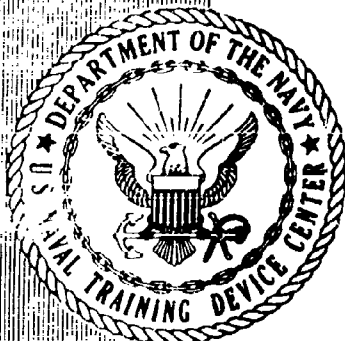
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Technical Report: NAVTRADEVCEEN 784-1

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**DERIVING TRAINING DEVICE IMPLICATIONS
FROM LEARNING THEORY PRINCIPLES**

**VOLUME I:
GUIDELINES FOR TRAINING DEVICE DESIGN,
DEVELOPMENT AND USE**



**U.S. NAVAL TRAINING DEVICE CENTER
PORT WASHINGTON, L.I., NEW YORK**

Technical Report: NAVTRADEVGEN 784-1

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VOLUME I:

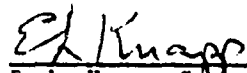
GUIDELINES FOR TRAINING DEVICE DESIGN, DEVELOPMENT AND USE

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ABSTRACT

DERIVING TRAINING DEVICE IMPLICATIONS
FROM LEARNING THEORY PRINCIPLES

VOLUME 1:
GUIDELINES FOR TRAINING DEVICE DESIGN, DEVELOPMENT, AND USE

Investigation was made of the feasibility of developing criteria for the design, development, and use of training devices on the basis of principles formulated by current psychological learning theories. A number of implications for the training device situation were derived from learning principles common to most contemporary theorists. Additional implications were derived from principles characteristic of, or particularly emphasized by, specific learning theorists. The derived implications were presented as a set of guidelines to extend and amplify present human factors guides for training device design and use. These device implications or guidelines were presented in a tabular format organized and indexed according to relevance for (1) specific members of a nineteen category task/behavior classification system, and (2) types of general design problems, e.g., stimulus presentation, performance feedback, or operator output.

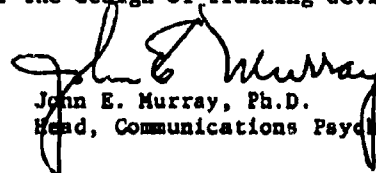
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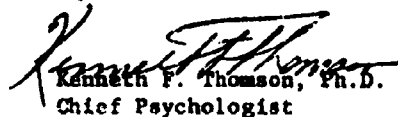
Over the past decade, a considerable amount of information underlying consideration of human factors in the design, development and utilization of training devices has been accumulated. Most of these data have been obtained from a wide variety of isolated experimental studies and, thus far, only limited formulations of general principles for training device design have emerged. What has been lacking is information of a preceptive and systematic nature which can be used in translating more of the available knowledge of the learning process into training equipment features.

The need for extension and amplification of the kinds of information which must underlie the design of training devices can be fulfilled, to a great extent, on the basis of explanations and appraisals of the functions of the training device in the basic learning process. Current theories of learning provide comprehensive explanations of the learning process and related phenomena, and application of these theories to training situations can make possible the formulation of guiding principles. Thus, from the vast potential contained in current learning theories, a means for systematizing and integrating large quantities of experimental findings can be provided.

In the present study, contemporary learning theories have been reviewed, compared and recast in the light of the unique features of the training situation. From this analysis has resulted a number of generalizations which serve as a basis for formulating the desired guidelines. The guidelines presented are in check-list form and should be of considerable value to personnel concerned with training device development and utilization.

Because of the large amount of material presented as well as the possible varied interests in the subject matter, two other reports have been prepared separately. Technical Report 784-2 contains a detailed description of the methodology employed in the development of the guidelines; Technical Report 784-3 presents an extensive compilation of specific principles formulated by each of a representative group of contemporary learning theorists and upon which the guidelines for the design of training devices are based.


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INTRODUCTION

This report represents the major product of a study designed to develop criteria for the design, development, and use of training devices on the basis of information contained in contemporary psychological theories of learning. The rationale underlying this study was the possibility of extending and amplifying present human factors guidelines for training device design and use by means of an application of learning theory principles to the training device situation. The set of guidelines presented in this report constitute the results of a first attempt at such an application.

A. Related Reports

A detailed description of the methodology employed in the course of this study is presented in a separate report entitled "Deriving Training Device Implications From Learning Theory Principles, Volume II: Methodology." Another related report, entitled "Deriving Training Device Implications From Learning Theory Principles, Volume III: Specific Learning Principles," presents an extensive compilation of specific principles formulated by each of a representative group of contemporary learning theorists. This large compilation undoubtedly contains many specific principles which relate only indirectly, if at all, to the "Guidelines" of the present report. Thus, Volume III may be considered a potential source of additional implications or criteria for the design and use of training devices.

B. Intended Use of Guidelines

The set of guidelines presented in this report may be used as a type of check-list to be consulted by the training device designer/user as an aid in developing or utilizing training devices. These guidelines, of course, must be regarded as tentative recommendations since experimental verification of each principle, under the wide range of conditions which may be appropriate, is not available. However, until the necessary verification is obtained, a given guideline may be considered sufficiently plausible to serve as a "rule" or "guiding principle" of practice.

Obviously, the set of guidelines must not be used as if it were an infallible source of solutions to all practical training device problems. Certain guidelines, particularly when carried to extremes, may actually be contradictory; hence, the designer or user of the device must make the necessary trade-offs on some basis other than the set of guidelines. The fact that the present set of guidelines presumably represents only a core or group of the more prominent members of the possible set of training device implications derivable from learning theory principles also would argue strongly against exclusive reliance upon these guidelines.

In addition to use as a check-list, the present set of guidelines should serve as a basis for (1) extending and broadening the amount of systematic, preceptive information available to training device designers and users, and (2) experimental investigations of specific learning theory implications.

C. Organization of Guidelines

The guidelines are presented in two major groups. The first and largest group consists of implications derived from one or more "common" learning principles, i.e., principles common to most learning theories. The second group consists of implications derived from a small selected sample of principles characteristic of, or particularly emphasized by, specific theorists. Both groups are intended to be fairly illustrative rather than exhaustive. Although the first group of guidelines is relatively large, it must be considered, likewise, as a sample or portion of the total set of possible device implications which might have been derived. The criteria used in determining these samples are discussed in the Volume II report on methodology.

An index is provided to permit ready access to certain groups of guidelines. All guidelines relating to each of nineteen types of task or classes of behavior are identified in this index. Moreover, within each of these nineteen task/behavior categories, guidelines are sub-indexed according to the general design problem involved (e.g., displays, performance feedback, operator output, etc.).

D. Tryout

Examples of application of the guidelines to two specific practical training situations are presented in APPENDIX B. These examples were designed to illustrate (1) the feasibility of specific applications of the generalized guidelines, (2) the manner in which the guidelines may be applied, and (3) the type and variety of results obtainable from such specific applications.

E. Format and Terminology*

Each guideline is presented on a separate page in two forms. The first form is essentially a summary tabular presentation while the second is a complete statement of the guideline in a paragraph below the summary table.

*The reader may wish to refer to one of the guidelines on page 5 for following while reading this discussion of format.

The first column of the summary table presentation merely identifies the "Type of Task" and "Design Problem" with which the guideline is primarily concerned. The "Design Problem" terms are relatively standard and unambiguous. In contrast, the terminology employed to describe "Type of Task" may need some clarification. Included in APPENDIX A, therefore, is a set of examples of operational situations in which the nineteen types of task are, respectively, prominent. The hard core of the guideline is presented in the second column headed "RECOMMENDED DESIGN FEATURE." A third column is included for presentation of additional details or clarifying comments. Again, some of the terminology used in these columns may not be entirely meaningful, especially to readers unfamiliar with technical psychological terms. The simplest solution in this case appeared to be a "Glossary of Terms," which is presented in APPENDIX C of the present report.

The paragraph statement of the guideline, presented below the tabular summary, is followed by a source code. This code is merely one or more pairs of numbers which permit identification of the particular combination(s) of task/behavior category and learning principle from which the guideline was derived. It is necessary, however, to refer to Volume II on methodology for a complete interpretation of these code numbers.

GUIDELINES BASED ON "COMMON" PRINCIPLES

The training device guidelines which follow immediately on pages 5 through 48 are based on principles which are common to most, if not all, contemporary learning theories.

The guidelines are presented in tabular format, one guideline on each page. The table for each guideline highlights the more important aspects of the guideline. Below the table is the complete statement of the guideline.

For the user of the guidelines, the following aids are provided:

- a. Task/behavior categories are illustrated in Appendix A, beginning on page 59.
- b. Sample applications of the guidelines are presented in Appendix B, beginning on page 61.
- c. Terms or expressions which may need explanation or clarification are defined in the Glossary in Appendix C, beginning on page 73.
- d. The Index to the guidelines is presented in Appendix D, beginning on page 77.

Design Guide No. 1

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Non-Verbal Detection or Making Decisions-Alternatives Given, Unspecified, or Unknown/ Stimulus or Cue Presentation	Capability of presenting information, which must be accepted at a high rate and used as a basis for making decisions, in such a way as to facilitate reception and evaluation by the trainee. Data on stereotypes or "natural" modes of response should be obtained and used as a basis for optimum presentations.	1. Frequently much of the information is visual in nature. 2. A new technique that may be of value in determining optimum methods of presenting visual information is the method of recording eye movements in performance developed by Mackworth (of Dunlap & Associates), viz., the Mackworth portable eye motion camera.

In complex tasks involving the acceptance of information at a high rate and making decisions on the basis of the information received, it is important to present the information in such a way as to facilitate reception and evaluation of the information by the trainee. Frequently much of the information is visual in nature. Provision should be made for obtaining and/or utilizing data on stereotypes or "natural" modes or methods of response. A new technique that may be of value in determining optimum methods of presenting visual information is the method of recording eye movements in performance developed by Mackworth, viz., the Mackworth portable eye motion camera.
(Source: 1-1, 1-2, 1-12, 9-1, 9-2, 9-12, 10-1, 10-2, 10-12, 11-1, 11-2, 11-12)

Design Guide No. 2

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Detection: Non-Verbal Cues/ Feedback on Performance	Omission of performance feedback on some training trials. This feedback omission should be variable over a range from zero to the level characterizing the post-training operational situation.	Feedback omission should be programmable according to stage of training.

In training for detection of non-verbal cues, provision should be made for omission of knowledge of results feedback on some training trials. Preferably, this feature should be variable over a range from zero feedback omission (i.e., total, continuous, or uniform feedback) to a level at least equivalent to that characterizing the operational situation toward which the training is directed. (It is assumed that a substantial amount of feedback omission is actually characteristic of the operational setting.) The potential for variation of feedback omission over the indicated range would permit the determination of possible optimal amounts of feedback for different stages of training.

(Source: 1-10)

Design Guide No. 3

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Detection: Non-Verbal Cues/ Personal Environ- ment: Fatigue/Boredom Conditions	Reducing undesirable motivational effects such as fatigue and boredom, especially in early stages of training. Final stages of training should involve extended time intervals during which the student must keep alert if he is to perform adequately on the detection task.	Fatigue/boredom effects might be reduced by: 1. Adjustable seating. 2. Use of auxiliary sense modalities. 3. Changing temporal pattern of required "peaks" of attention. 4. Special instructions.

In training for detection of non-verbal cues, provision should be made for maintaining adequate motivation or alertness over required periods of performance. The final stages of training should involve extended time intervals during which the student must keep alert if he is to perform adequately on the detection task. Provision should be made to offset or decrease undesirable motivational effects such as fatigue and boredom which are likely to result from the protracted time intervals.
(Source: 1-11)

Design Guide No. 4

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Identification: Verbal or Non- Verbal Cues/ Stimulus or Cue Presentation, i.e., Displays	Variable combinations or ratios of relevant and irrelevant (transient) cues, presentable according to requirements of various stages of training.	If possible, increments (or decrements) in relevant cues should be manipulable independently of increments/decrements in irrelevant cues.

In training for identification of either verbal or non-verbal cues, provision should be made for presenting gradually decreasing amounts of relevant cues and gradually increasing amounts of transient or irrelevant cues during training. Operational contexts frequently require identification on the basis of minimal cues embedded in a context of irrelevant cues. Training under such conditions in the initial stages of learning may be highly inefficient. Maximum training efficiency may require that varying combinations or ratios of relevant and irrelevant cues be presented according to stage of training. (Sources: 2-2, 4-2)

Design Guide No. 5

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Identification: Verbal or Non- Verbal Cues/ Stimulus or Cue Presentation	Cue stimuli in training should be as nearly identical as possible to cue stimuli which will be encountered in subsequent transfer to job conditions.	Positive transfer, or performance, is maximized by minimizing differences in training and job cue conditions.

In training for identification of either verbal or non-verbal cues, the cue stimuli presented to the student should be as nearly identical as possible to the cue stimuli which the student will encounter in subsequent transfer to job conditions. The greater the degree of similarity between the cues presented in the training situation and cues encountered in the operational situation, the greater will be the positive transfer from training to job conditions. (Sources: 2-3, 4-3)

Design Guide No. 6

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Identification: Verbal or Non- Verbal Cues/ Stimulus or Cue Presentation	1. Maximize the number of cues which elicit mediating (or helper) responses. 2. Minimize the number of cues which elicit interfering and competing responses.	Examples of classes of mediating, or helper, responses which might be emphasized are: 1. Self-instructions. 2. Stereotypes. 3. "Natural" associations.

In training for identification of either verbal or non-verbal cues, provision should be made for (1) emphasizing the presentation of cues which elicit mediating responses (e.g., self-instructions, population stereotypes or "natural" associations), and (2) minimizing the number of cues which elicit interfering and competing responses. (Sources: 2-12, 4-12)

Design Guide No. 7

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Verbal Detection/ Stimulus or Cue Presentation	Similarity between physical characteristics (such as intensity, frequency, timbre, rates of change, etc.) of verbal cues presented in the training situation and physical characteristics of verbal cues previously overlearned - at least in the earlier stages of training.	Typically, verbal detection responses have been tremendously overlearned through years of practice of communicative skills. The training situation should utilize this previous overlearning by providing cues sufficiently similar to the overlearned stimuli to permit adequate generalization.

In training for detection of verbal cues, provision should be made for presenting verbal cues which, at least during the earlier stages of training, are sufficiently similar in physical characteristics (intensity, frequency, timbre, rates of change, etc.) to previously overlearned stimuli to permit adequate generalization. In other words, the training situation should take advantage of the fact that verbal detection responses, typically, have been tremendously overlearned through years of practice of communicative skills. (Source: 3-3, 3-5)

Design Guide No. 8

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Identification: Verbal Cues/ Operator Output	Extensive response repetition or practice by the operator/trainee.	1. Learning to identify a stimulus is generally more difficult than simply learning to detect its presence. 2. Verbal cues are typically more abstract than non-verbal ones. 3. Hence, assuming other factors constant, more opportunity for response repetition would seem to be indicated for discrimination learning of the identification/verbal type than for the detection/non-verbal type.

In training for verbal identification learning, provision should be made for relatively heavy emphasis on response repetition or practice as compared to that allocated to non-verbal identification or to verbal detection training. (Source: 4-5)

Design Guide No. 9

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Facts, Principles, Procedures/ Operator Output	Measurement of occurrence of recall response. This feature requires that the trainee must be enabled to give direct, overt evidence of recall, e.g., written or oral verbalization of the fact, principle, or procedure.	Recognition (i.e., identification) training may strengthen the recall response, but for maximizing accurate description and control of recall learning, measurement of the occurrence of the response is essential.

In training for recall of facts, principles, or procedures, provision should be made for measurement of the occurrence of the recall response. This requires that the trainee must be enabled to give direct, overt evidence of recall such as written or oral verbalization of the fact, principle, or procedure. Recognition, i.e., identification, training may strengthen the recall response, but for maximizing accurate description and control of recall learning, measurement of the occurrence of the response is essential. (Source: 5-4, 6-4, 7-4)

Design Guide No. 10

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Principles/ Stimulus or Cue Presentation	Acquisition and subsequent use of readily available facilitating or supporting responses. The set of variables involved in any given principle constitute a ready source of cues capable of facilitating recall of the principle.	Any cues serving to elicit recall of variables involved in the principle would tend to facilitate recall of the principle itself.

In training for retention/recall of principles, provision should be made for the acquisition and subsequent use of mediators (facilitating or supporting responses) potentially available in the set of variables involved in the particular principles. Presentation of any cues serving to elicit recall of such variables would tend to facilitate recall of the principle(s) relating these variables.
(Source: 6-12)

Design Guide No. 11

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Stimulus or Cue Presentation	Development of redundant or supplementary habit systems (cue-response patterns) based upon available components of the total cue context. Such components include: 1. "Specific step" external (equipment) cues. 2. "Response-produced" cues arising from the immediately preceding response. 3. "Temporal/sequential" cues correlated with proportion of total procedure previously completed.	Procedures which must be recalled are often sufficiently difficult or lengthy that considerable habit redundancy or duplication may be required for successful performance.

In training for recall of lengthy or difficult procedures, provision should be made for development of redundant or supplementary habit systems based on such potential components of the total cue context as (1) "specific step" cues - the external cues for each individual step or basic unit of the procedure, (2) "response-produced" cues - those cues which arise from the immediately preceding response, (3) "temporal/sequential" cues - i.e., cues which are based on the proportion of the total procedure previously completed. (Additional habit systems may be developed on the basis of symbolic equivalents of these three types of cues.) (Source: 7-2)

Design Guide No. 12

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Operator Output	Extensive response repetition or practice by the operator/trainee.	Response repetition is not only essential to overlearning and maximal retention, but is essential to the development of recall-facilitating "redundant" habit patterns based on (1) "response-produced" cues arising from the immediately preceding response and (2) "temporal/sequential" cues based on the proportion of total procedure previously completed.

In training for recall of lengthy or difficult procedures, provision should be made for heavy emphasis on response repetition or practice. This emphasis is critical not only to overlearning but also to the development of recall-facilitating "redundant" or supplementary habit systems based on (1) "response-produced" cues arising from the immediately preceding response and (2) "temporal/sequential" cues based on the proportion of total procedure previously completed. (Source: 7-5)

Design Guide No. 13

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Operator Output	Varying the temporal interval between adjacent response steps. If adjacent responses are permitted to occur sufficiently close in time to become practically contiguous, then both responses will be impartially associated with the contiguous stimulus context.	Later in training, i.e., after each adjacent step is relatively well associated with its specific cue, the temporal gap between adjacent responses can be reduced with less possibility of response interference effects.

In training for recall of lengthy or difficult procedures, provision should be made for varying the temporal interval between adjacent response steps, especially during the early stages of training. Permitting adjacent responses to occur sufficiently close in time to become essentially contiguous would, in the early stages of training, result in impartial association of both responses with the contiguous stimulus context. (Source: 7-6)

Design Guide No. 14

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Operator Output	Development and use of mediators (helper responses) in the form of anticipatory symbolic responses. One potential component of the total response context is the symbolic equivalent or concomitant of the overt response. Being symbolic in nature, this response may readily become anticipatory and serve as an additional cue for the overt response.	1. The likelihood of occurrence of such symbolic responses in human learning situations is considerable. 2. Special instructions may be necessary to provide some measure of control over these symbolic responses.

In training for recall of lengthy or difficult procedures, provision should be made for development and use of mediators in the form of anticipatory symbolic responses. The symbolic equivalent or concomitant of the overt response is one potential component of the total response context. Being symbolic in nature, this component may readily become anticipatory, i.e., occur prior to the actual overt response, and thus possibly serve as a mediator or additional cue for the overt response. If such symbolic responses are not controlled and turned into effective mediators, they may actually interfere with performance of the overt response. (Source: 7-6)

Design Guide No. 15

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Operator Output; Stimulus or Cue Presentation	Mental ("in-the-head") rehearsal of sequential steps readily codable in symbolic form. Recall of a procedure may be facilitated by presentation or recall (in appropriate sequence) of mediators for the component steps of the procedure.	One set of potential mediators is available whenever the component steps of the procedure are readily codable in symbolic form.

In training for recall of lengthy or difficult procedures, provision should be made for mental or symbolic rehearsal of sequential steps readily codable in symbolic form. (Source: 7-12)

Design Guide No. 16

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Operator Output	Gradual decrease in number/amount of guidance or "artificial" components of total response context during the course of training. Early in training it may be desirable to provide substantial amounts of guidance, i.e., restrictions or limitations on operator output. If such guidance is too prolonged, irrelevant aspects of the response context may be overly strengthened.	Since these guidance components of the response context acquire cue value for subsequent responses in the procedure, performance under on-the-job (non-guided) conditions may be weakened by abrupt removal of such cues.

In training for recall of lengthy or difficult procedures, provision should be made for gradually decreasing the guidance or "artificial" components of the total response context during the course of training. Otherwise, the student may become so dependent on the cues provided by those aspects of the response context which are specific to the guided or artificial training conditions that removal of such cues under on-the-job (non-guided) conditions will result in decreased performance. (Source: 7-6)

Design Guide No. 17

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Feedback on Performance	Minimizing delay of reinforcement (or feedback on adequacy of performance) following each "single-step" or "basic unit" response, especially during early stages of learning.	Immediacy of reinforcement (feedback) is not so critical in later stages of training when individual response steps are relatively well-established and the problem is primarily one of integrating the individual steps into the total procedure.

In training for recall of lengthy or difficult procedures, provision should be made for minimizing delay of reinforcement (or feedback on adequacy of performance) following each "single-step" or "basic unit" response, especially during the early stages of training. (Source: 7-7)

Design Guide No. 18

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Feedback on Performance	Reinforcement of any given single step (or basic unit) of the procedure prior to execution of next step.	Effectiveness of the reinforcement would be diminished by the altered cue and response contexts resulting from the interpolated second step.

In training for recall of lengthy or difficult procedures, provision should be made for reinforcing (giving information on adequacy of performance) any given single step or basic unit of the procedure prior to execution of the next step. (Source: 7-7)

Design Guide Nr. 19

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Feedback on Performance	Gradual increase in delay of reinforcement (knowledge of results feedback) of single cue-response steps as training progresses. In later stages of training for recall of procedures, adjacent responses may have to be executed with increasing speed so that reinforcement of single cue-response steps becomes less and less feasible.	Reinforcement delay may also be imposed by the necessity of transferring to on-the-job conditions involving long chains of responses with no intermediate reinforcements.

In training for recall of lengthy or difficult procedures, provision should be made for gradually increasing the delay of reinforcement (i.e., feedback on adequacy of performance) of single steps or basic units of the procedure as training progresses from one stage to the next. (Source: 7-7)

Design Guide No. 20

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Procedures/ Feedback on Performance; Operator Output	Mental ("in-the-head") rehearsal of sequential steps readily codable in symbolic form. Delay of reinforcement may be less in symbolic than in overt rehearsal. This is particularly likely to be the case in later stages of procedural training when the occurrence of a given response may serve as a reinforcement or indication of the adequacy of the preceding response.	Symbolic rehearsal is typically much more rapid than the corresponding overt rehearsal.

In training for recall of lengthy or difficult procedures, provision should be made for mental rehearsal of sequential steps readily codable in symbolic form as delay of reinforcement may be less in symbolic than in overt rehearsal, particularly in later stages of procedural training when the occurrence of a given response may serve as a reinforcement or indication of adequacy of the preceding response. (Source: 7-7)

Design Guide No. 21

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Using Principles, Inferring/ Stimulus or Cue Presentation; Operator Output	Variation of stimulus context during practice (response repetition) by means of a large number of illustrations or examples of application of the principle.	1. Monotonous effects of repetition are reduced by varying the stimulus context. 2. Trainee is provided with opportunity to acquire new and finer discriminations, i.e., "understanding" of the principle is facilitated.

In training in the use of principles, provision should be made for a large number of illustrations or examples of application or use of the principle. By varying the stimulus context of repetition through use of examples, the potential aversive or monotonous effects of repetition are reduced while at the same time the trainee is provided with the opportunity to acquire new and finer discriminations, or in other words the subject's "understanding" of the principle is increased.
(Source: 8-5, 8-2, 8-11)

Design Guide No. 22

Type of Task/ Design Problem.	RECOMMENDED DESIGN FEATURE	Comment
Using Principles, Inferring; Making Decisions - Alternatives Given, Unspecified, or Unknown/ Operator Output	Measurement of degree to which performance improvement is independent of initial (or reference) level of performance. Identical performance among given trainees is not necessarily indicative of identical learning; hence, the need for a better measure of the extent to which trainees are profiting from the training situation. Special analytic techniques may be appropriate, e.g., residual gain scoring as proposed by Dubois. ¹	Because of possible individual differences in ability as well as prior experience, trainees demonstrating equivalent performance must not be assumed to be profiting or learning equally well. Performance differences which are due to individual differences in ability tend to be magnified as a function of increasing task difficulty. Hence, the present feature is particularly important for such difficult tasks as using principles, inferring, and making decisions.

In training for decision-making, using principles, and inferring, provision should be made for measurement of the degree to which performance improvement is independent of initial (or reference) level of performance. Because of possible individual differences in ability as well as prior experience, trainees demonstrating equivalent performance must not be assumed to be profiting or learning equally well. The uncritical assumption that identical performance is indicative of identical learning could lead to ineffectiveness in guidance, in feedback, or in matching of trainees for mutual or team training. Special analytic techniques may be appropriate, e.g., residual gain scoring as proposed by Dubois.¹ Such techniques may involve, as a minimum, both pre- and post-testing of trainees. (Source: 8-13, 9-13, 10-13, 11-13)

¹ Dubois, P. H., and Manning, W. H. (Eds.) The measurement of learning. A report of a conference held at Washington University, Saint Louis, Missouri on February 27, 1958. (Technical Report No. 6 Office of Naval Research Contract No. Nonr 816(02) Naval Air Technical Training, May 1958.)

Design Guide No. 23

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Given/ Stimulus or Cue Presentation	Presentation of ramifications or logical implications of alternatives, whenever possible, as contiguous parts of the alternative (choice) context.	This feature may require time compression such as might be provided by film or diagram techniques. "Gaming" techniques might also be useful here.

In training for decision-making under conditions in which the alternatives are given, provision should be made for presentation of ramifications or logical implications of alternatives, whenever possible, as contiguous parts of the alternative context. This may require time compression such as might be provided by film or diagram techniques or gaming techniques. (Source: 9-2)

Design Guide No. 24

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Unspecified or Unknown/ Stimulus or Cue Presentation	Flexibility in temporal presentation of cues - from time compression to time expansion.	1. This feature permits variation of amounts of relevant and irrelevant cues for identification of possible alternatives. 2. Useful techniques for implementing the feature may include diagrams, films, or "gaming" techniques.

In training for decision-making under conditions in which alternatives are unspecified or unknown, provision should be made for flexibility in temporal presentation of cues from time compression to time expansion. This permits variation of amounts of relevant and irrelevant cues for identification of possible alternatives. Techniques such as diagrams, films, or "gaming" techniques may be appropriate. (Source: 10-2, 11-2)

Design Guide No. 25

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Unknown/ Stimulus or Cue Presentation	Acquisition and subsequent use of mediators such as stereotypes, self-instructions, or "natural" associations. Such mediators might be largely semantic or verbal in nature, e.g., instructions as to what constitutes the general class of events known as "alternatives", or rules for implicit testing of alternatives.	Mediators would facilitate identification of response alternatives and reinforcement of such identification responses when they occur.

In training for decision-making under conditions in which the number of possible alternatives is practically innumerable or in which a substantial proportion of the alternatives are unknown, provision should be made for the development and use of mediators (stereotypes, self-instructions, or "natural" associations) both for facilitating identification of response alternatives and for reinforcement of such identifying responses when they occur. Such mediators might be largely semantic or verbal in nature, e.g., instructions as to what constitutes the general class of events known as "alternatives," or rules for implicit testing of alternatives. (Source: 11-12)

Design Guide No. 26

Type of Task/ Design Problem.	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Unknown/ Feedback on Performance	Minimal delay of reinforcement (feedback on adequacy of performance) following the identification or determination of any given relevant alternative.	1. A critical portion of the task is the identification of a set of alternatives from which to make a choice or "final" decision. 2. Reinforcement may depend upon a relative ranking or choice among the set of identified alternatives, or upon the consequences of some final decision. Thus, substantial amounts of delay may be involved in the reinforcement of these critical responses.

In training for decision-making under conditions in which the number of possible alternatives is practically innumerable or in which a substantial portion of the alternatives are unknown, provision should be made for minimizing delay of reinforcement (feedback on adequacy of performance) following the identification or determination of any given relevant alternative. (Source: 11-7)

Design Guide No. 27

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making decisions - Alternatives Unknown/ Feedback on Performance	Capability for varying amount or level of performance feedback during training. Feedback omission should be variable over a range from zero to the level characterizing the post-training operational situation.	Level of feedback, i.e., amount of feedback omission, should be programmable according to stage of training.

In training for decision-making under conditions in which the number of possible alternatives is practically innumerable or in which a substantial proportion of the alternatives are unknown, provision should be made for varying amount or level of knowledge of results feedback during training. Preferably, this feature should be variable over a range from maximal feedback to a level at least equivalent to that characterizing the operational situation toward which the training is directed. (It is assumed that a substantial amount of feedback omission is actually characteristic of the operational setting.) The capability for varying feedback level would permit the determination of possible optimal amounts of feedback for different stages of training. (Source: 11-10)

Design Guide No. 28

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Positioning Movement/ Operator Output	Sufficient response repetition (practice).	Practice is essential for elimination of non-essential components of the movement, or for simplified swing (ballistic) movements to be developed.

In training for positioning movements, provision should be made for sufficient practice by trainees. Such practice is important, even on simple positioning movements, for the elimination of non-essential components of the movement or for the development of simplified swing (ballistic) movements. (Source: 12-5)

Design Guide No. 29

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Repetitive Movement/ Operator Output	Extensive response repetition or practice by the trainee.	The task consists largely (almost by definition) of response repetition.

In training for simple repetitive movements, provision should be made for emphasis on response repetition or practice, since this is an essential feature of the task. (Source: 13-5)

Design Guide No. 30

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Repetitive Movement/ Operator Output	Extensive response repetition or practice by the trainee.	Response repetition or practice makes possible the development of an effective, continuous series of mediators in the form of muscular responses producing kinesthetic cues (i.e., cues based on "muscular feel") for the successive components of the given movement.

In training for simple repetitive movements, provision should be made for emphasis on response repetition or practice in order to develop the kinesthetic cues (cues based on "muscular feel") essential to skilled performance. (Source: 13-12)

Design Guide No. 31

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Repetitive Movement; Serial Movement/ Feedback on Performance	Extensive response repetition or practice by the trainee.	1. Simple repetitive movements may be "automatically" reinforcing, i.e., feedback is essentially a natural consequence of the movement. 2. In serial movements, particularly in later stages of training, the occurrence of a given component response (step) may serve as a reinforcement or indication of the adequacy of the preceding component (step) of the response series.

In training for repetitive or serial movements, provision should be made for extensive response repetition or practice by the trainee. The purpose of this feature is to take advantage of the "built-in" feedback properties of these types of task. Simple repetitive movements may be "automatically" reinforcing, i.e., feedback is essentially a natural consequence of the movement. In serial movements, particularly in later stages of training, the occurrence of a given component response (step) may serve as a reinforcement or indication of the adequacy of the preceding component (step) of the response series. (Source: 13-8, 15-8)

Design Guide No. 32

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Stimulus or Cue Presentation	Presentation of appropriate target-stimulus cues to the trainee either continuously or at appropriate points in time during the execution of the task.	The learner will not be able to respond correctly (except by chance) to changes in the appropriate target-stimulus context if such changes are not perceived at the appropriate points in time.

In training for continuous movement or tracking tasks, provision should be made to insure that the appropriate target-stimulus cues are available to the student either continually or at appropriate points in time during the execution of the task. (Source: 14-1)

Design Guide No. 33

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Stimulus or Cue Presentation; Operator Output	Capability of presenting target-cursor relations extrapolated into the immediate future on the basis of current response characteristics, thus enabling the trainee to avoid potential errors before such errors actually occur by simply modifying what is predicted according to what is required.	Techniques for providing such predictions or extrapolations may range from self-instructions to complicated computerized arrangements.

In training for continuous movements, provide for presentation of target-cursor relations extrapolated into the immediate future on the basis of current response characteristics. Thus, the trainee can avoid potential errors before they actually occur by simply modifying what is predicted according to what is required. Techniques for providing such predictions or extrapolations may range from self-instructions to complicated computerized arrangements. (Source: 14-11)

Design Guide No. 34

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous or Serial Move- ment/ Stimulus or Cue Presentation	Capability of presenting stimulus cues in fast time (time compression as in speeded films, diagrams, etc.), real time, and slow time (time expansion as in slow-motion films).	Fast time permits emphasis on continuity of movements that may not be readily apparent in real time. Slow time may facilitate guidance or critique of the trainee's performance during critical or difficult phases of performance by revealing details not detectable at real time speeds. The real time presentation is essential for maximizing positive transfer from later stages of training.

In training for continuous or serial movements, provide for flexibility of temporal relationships in presenting stimulus cues. Specifically, stimulus cues should be presentable in fast time (time compression as in speeded films, diagrams, etc.), real time, and slow time (time expansion as in slow-motion films). Fast time permits emphasis on the dynamic continuity of movements that may not be readily apparent in real time. On the other hand, slow time may facilitate guidance or critique of trainee's performance during critical or difficult phases of the performance. Slow time may reveal details (errors, etc.) of performance which are not detectable during normal or "real time" speeds of response. The real time condition is, of course, essential to maximum positive transfer to operational conditions. (Source: 14-2, 15-2)

Design Guide No. 35

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Operator Output	Measurement of trainee performance throughout the course of training in such a manner that data diagnostic or indicative of the important elements of the response as compared to skill factors may be obtained. Possible useful techniques include infra-red and closed loop video, X-Y plotters, direct recording of error signals (voltages) on magnetic tape, analog and digital computers, or even simple event counters.	1. It is desirable to detect shifts in the elements or components of response as training progresses. 2. Also valuable are data reflecting motivational as well as "skill" aspects of behavior. In tracking tasks, for example, frequency measures may be useful in indicating amount of effort expended in achieving a given amplitude or error score.

In training for continuous movements, provision should be made for measurement of performance in such a manner that analytic or diagnostic indicators of behavior may be obtained throughout the course of training. It is important to detect shifts in the elements or components of response as training progresses, e.g., relative shifts in emphasis from motor to perceptual or mediational aspects of performance. Also valuable are data reflecting motivational or emotional factors as well as "skill" factors. In tracking tasks, for example, frequency measures may be useful in indicating the amount of effort expended in achieving a given amplitude or error score. If the response involves both periodic and random components, it is highly desirable that these be separable for purposes of analysis. Techniques that may be of value in this regard include infra-red and closed loop video techniques, X-Y plotters, direct recording of error signals (voltages) on magnetic tape, analog and digital computers, or even simple event counters. (Source: 14-6)

Design Guide No. 36

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Operator Output	Measurement of occurrence of response and changes in response context throughout the course of training.	This feature may involve continuous measurement of both frequency and ampli- tude of error in tracking performance.

In training for continuous movements, provision should be made for measurement of frequency and type of errors and changes in total error pattern throughout the course of training. This may require continuous measurement of both frequency and amplitude of error in tracking performance.
(Source: 14-4, 14-6)

Design Guide No. 37

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Feedback on Performance	Performance feedback not only in terms of the ultimate performance criterion but also whenever the performance of the trainee is within some specified intermediate accuracy limits. Such augmented feedback may be provided by a clock for displaying cumulative time on target or by a counter for displaying discrete units of time-on-target or error.	The important point here is to provide feedback for small increments of performance, i.e., for achievement of relevant sub-goals during the gross performance.

In training for continuous movements, provision should be made for presenting performance feedback not only in terms of the ultimate performance criterion but also whenever the performance of the trainee is within specified accuracy limits. Such augmented feedback may be provided by a clock for displaying cumulative time on target or by a counter for displaying discrete units of time-on-target or error. The important point here is to provide feedback for small increments of performance, i.e., achievement of relevant sub-goals during the gross performance. (Source: 14-9)

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Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Serial Movement/ Operator Output	Extensive response repetition or practice by the trainee.	Response repetition or practice is essential to the development of an effective series of response produced or kinesthetic cues capable of mediating successive steps in the serial movement.

In training for serial movements, provision should be made for emphasizing response repetition or practice in order to (1) strengthen individual or component steps of the movement series and (2) integrate these steps into a smooth sequence. (Source: 15-12)

Design Guide No. 39

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Serial Movement/ Operator Output	Extensive response repetition or practice by the trainee.	Response repetition or practice is essential in order to (1) strengthen individual or component steps of the movement series and (2) integrate these steps into a smooth sequence.

In training for serial movements, provision should be made for emphasizing response repetition or practice in order to (1) strengthen individual or component steps of the movement series and (2) integrate these steps into a smooth sequence. (Source: 15-5)

Design Guide No. 40

Type of Task/ Design Problem:	RECOMMENDED DESIGN FEATURE	Comment
Static Reaction: Personal Environ- ment: Fatigue- Boredom Condi- tions; Stimulus or Cue Presenta- tion; Operator Output	Minimizing undesirable motivational effects, such as fatigue and boredom, over the required period of performance. Fatigue/boredom effects might be reduced by: (1) adjustable seating, (2) use of special support for body member(s) involved in static reaction, (3) mechanical features designed to reduce tremor by resisting movement of body member(s), or (4) position- ing of body member(s) - e.g., hand tremor is less when hand is positioned within eight inches above or below the heart level.	Fatigue/boredom effects might also be reduced by special instructions or by changing the temporal pattern of required "peaks" of attention.

In training for difficult or prolonged static reactions (tasks in which body member(s) must be maintained in a precise "immovable" position), provision should be made for maintaining adequate motivation over the required period of performance. Particular attention should be given to the problem of minimizing fatigue and boredom effects. This may require special device features such as (1) adjustable seating, (2) use of special support for body member(s) involved in static reaction, (3) changing temporal pattern of required "peaks" of attention, (4) special instructions, (5) mechanical features in equipment to reduce tremor by resisting movement of body member(s), (6) positioning of body member(s) involved in the static reaction (e.g., hand tremor is less when hand is positioned within about eight inches above or below the heart level.) (Source: 16-11)

Design Guide No. 41

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Oral Verbaliza- tion/ Operator Output	Appropriate recording of response in context. Since the response is typically a complex involving subtle relations among components, the technique of measurement should provide for recording the total complex in a manner permitting analysis of such subtle relationships.	Some of the newer multiple-channel tape recording devices may be appropriate.

In training for oral verbalization, provision should be made for appropriate recording of responses in context. Since the response is typically a complex involving subtle relations among components, the technique of measurement should provide for recording the total complex in a manner that permits analysis of such subtle relationships. Some of the newer multiple-channel tape recording devices may be useful in this regard. (Source: 17-4, 17-6)

Design Guide No. 42

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Written Verbalization/ Stimulus or Cue Presentation; Operator Output	Extensive symbolic response repetition (or mental rehearsal) in terms of the symbolic equivalents of the visual cues presented. Development of the symbolic equivalents of the visual cues would be facilitated by optimal units and schedule of presentation of the visual cues.	Written verbalization provides stimuli that are readily and rapidly accessible, by means of visual inspection, and which provide a ready-made continuous series of mediators to facilitate symbolic or mental rehearsal.

In training for difficult written verbalization tasks, provision should be made for emphasis upon symbolic response repetition or mental rehearsal. This "in-the-head" practice should be in terms of the symbolic equivalents of the visual cues presented by the material to be mastered. Special consideration should be given to the problem of developing these symbolic equivalents by optimal units and schedule of presentation of the visual cues. (Source: 18-5)

Design Guide No. 43

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Other (Overt) Verbalization/ Stimulus or Cue Presentation	Addition of relevant supplementary visual cues to the stimulus context. For example, in training in the use of conventionalized gestures or specialized sign languages such as the semaphore or deaf-mute systems, relevant visual cues may be added to the stimulus context by means of various optical arrangements - a simple mirror may suffice in cases where reversal of left-right relations in the mirror image is irrelevant. This feature may not be appropriate until later stages of learning when trainee's motor performance is relatively well developed.	The purpose of this feature is to provide for the development of supplementary habit systems (or cue-response patterns) based on both muscle movement cues and potential visual cues determined by the muscle activity.

In training for non-oral, non-written verbalization, provision should be made for the development of redundant or supplementary habit systems based on both muscle movement cues and potential visual cues determined by the muscle activity. For example, in learning to use conventionalized gestures or specialized sign languages such as the semaphore or deaf-mute systems, relevant visual cues may be added to the stimulus context by means of various optical arrangements - a simple mirror may suffice in cases where reversal of left-right relations in the mirror image is irrelevant. (Source: 19-2)

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Other (Overt) Verbalization/ Operator Output	Appropriate recording of response.	Film techniques may provide the most effective recording of responses of this type.

In training for non-oral, non-written verbalization, provision should be made for appropriate recording of responses. Responses of this type are illustrated by gestures, hand signals, etc. Film techniques may provide the most effective recording of such responses. (Source: 19-4)

GUIDELINES BASED ON "SPECIFIC" PRINCIPLES

The training device guidelines which follow immediately on pages 51 through 57 are based on principles characteristic of, or particularly emphasized by, specific learning theorists.

The guidelines are presented in tabular format, one guideline on each page. The table for each guideline highlights the more important aspects of the guideline. Below the table is the complete statement of the guideline.

For the uses of the guidelines, the following aids are provided:

- a. Task/behavior categories are illustrated in Appendix A, beginning on page 59.
- b. Sample applications of the guidelines are presented in Appendix B, beginning on page 61.
- c. Terms or expressions which may need explanation or clarification are defined in the Glossary in Appendix C, beginning on page 73.
- d. The Index to the guidelines is presented in Appendix D, beginning on page 77.

Design Guide No. 45

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Recalling Facts, Principles, or Procedures/ Stimulus or Cue Presentation; Feedback on Performance	Maximal control of stimulus and reinforcement conditions.	"Teaching machines" or "programmed learning" techniques may be required for maximal control of both stimulus and reinforcement variables during the course of training.

In training for recall of facts, principles, or procedures, provision should be made for maximizing control of the stimulus or cue conditions and the reinforcement (performance feedback) conditions. Maximal control of these critical learning variables may require the use of "teaching machines" or "programmed learning" techniques. (Source: Skinner)

Design Guide No. 46

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Using Principles, Inferring/ Stimulus or Cue Presentation	Emphasis on the relationship of specific applications (parts) to the general principle (whole) on which the applications are based, i.e., the logical routes from principle to applications.	The unique, specific features of each application should be minimized while the common relationships to the general principle should be emphasized.

In training in the use of principles, provision should be made for emphasizing the logical relationships which exist between specific applications of a principle and the general principle itself, i.e., the relationship of the "parts" to the "whole." The unique, specific features of each application should be minimized while the common relationships to the general principle should be emphasized. (Source: Tolman)

Design Guide No. 47

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Given/ Stimulus or Cue Presentation; Operator Output; Feedback on Performance; Personal Environment	<u>Maximize for correct and minimize for incorrect response:</u> 1. Number of previous occurrences of the response. 2. The extrinsic and/or intrinsic motivation attending the response. 3. The "incentive motivation" (i.e., anticipation of the goal or satisfactions presumably attainable by the response) <u>Minimize for correct and maximize for incorrect response:</u> 1. Number of non-reinforced occurrences of the response.	1. Cues for the alternative responses must be received by trainee at the point of choice (spatial or temporal decision point). 2. Also desirable to maximize control of trainee's receptor orientation or "data intake," particularly by eliminating possibility of picking up extraneous or irrelevant cues.

In training for decision-making under conditions in which the alternatives are given or presented in such a manner that one or more decision points confront the trainee, each involving a correct and an incorrect alternative (response), provision should be made for maximizing the following variables for the correct response(s): (1) number of previous occurrences of the response, (2) the extrinsic and/or intrinsic motivation attending the response, and (3) the "incentive motivation" or anticipation of the goal, i.e., anticipation of satisfactions presumably contingent upon, and attainable by, the response. In addition, the number of non-reinforced occurrences of the response should be minimized for correct and maximized for incorrect response(s). It is also important to insure that (1) the cues for both alternatives (responses) are received by the trainee at each choice point (spatial or temporal decision point) and (2) the trainee's "data intake" is carefully controlled to eliminate extraneous or irrelevant cues. (Source: Spence)

Design Guide No. 48

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Making Decisions- Alternatives Given/ Feedback on Performance; Operator Output	Capability of manipulating probability of reinforcement such that a given response can be reinforced with some fixed probability and alternative responses reinforced on the remaining trials. This feature permits control of both the rate and asymptote (limit) of learning.	1. Probability of response will change gradually from beginning value to a stable, final asymptote approaching the probability of reinforcement. 2. Rate of learning will depend upon extent to which probability of reinforcement deviates from chance, i.e., from .5 if there are two alternative responses, from .33 if there are three alternatives, etc.

In training for decision-making under conditions in which the alternatives are given or presented in a discrete-trial fashion, provision should be made for manipulating probability of reinforcement such that a given response can be reinforced with some fixed probability and alternative responses reinforced on the remaining trials. This feature permits control of both the rate and asymptote (limit) of learning. (Source: Estes)

Design Guide No. 49

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement/ Stimulus or Cue Presentation; Operator Output; Feedback on Performance	Emphasis upon "thinking ahead" or anticipating target-stimulus conditions and appropriate responses. Measurement of frequency of errors may be appropriate. Feedback could be provided in the form of instructions to make slower, low-frequency response movements while attempting to anticipate target-stimulus conditions, thus shifting the stimulus control from immediate external cues to anticipatory cues.	Appropriate pre-training and/or instructions could develop the anticipatory cues - prior to actual tracking performance.

In training for continuous movement or tracking tasks, provision should be made for emphasis on "thinking ahead" or anticipating target-stimulus conditions (and appropriate responses). Measurement of frequency of errors, in addition to amplitude, may be appropriate. Such measures might form the basis of feedback in the form of instructions to make slower, low-frequency response movements while attempting to anticipate target-stimulus conditions. Shifting from external stimulus control to control by anticipatory cues may be facilitated by training or instructions given prior to, or outside of, the actual tracking situation. (Source: Spence)

Design Guide No. 50

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Continuous Movement; Serial Movement/ Operator Output; Feedback on Performance	Capability of making reinforcement contingent upon properties of the trainee's response, so that by a process of "successive approximations" the final, desired response is "shaped up." Implies that emphasis is placed upon response differentiation rather than external stimulus discrimination.	1. The desired response may be virtually impossible early in training, yet be capable of gradual development by successive response approximations. 2. Extremely careful monitoring of trainee may be required.

in training for difficult, complex continuous or serial movements, provision should be made for making reinforcement contingent upon properties or characteristics of the trainee's response, so that by a process of "successive approximations" the final, desired response is "shaped up" or produced. Emphasis is on differentiation of response rather than on external stimulus discrimination. Extremely precise monitoring of trainee's responses may be required. (Source: Skinner)

Design Guide No. 51

Type of Task/ Design Problem	RECOMMENDED DESIGN FEATURE	Comment
Serial Movement; Recalling Procedures/ Stimulus or Cue Presentation	Programming demonstrations of lengthy serial or sequential performance according to the amount of demonstration which can be assimilated or apprehended by the trainee, i.e., the proportion of the sequence which can be correctly recalled or reproduced at a given point in training. As training progresses and the trainee's ability to assimilate increases, the demonstration should be lengthened appropriately.	Continuing a demonstration of a lengthy sequence beyond the "saturation point" will result in the association of responses with incorrect cue contexts, i.e., stimulus contexts involving errors of recall of temporal/sequential cues.

In training for lengthy serial movements or for recall of lengthy or difficult procedures, provision should be made for programming demonstrations of the lengthy serial or sequential performance according to the amount of demonstration which can be assimilated or apprehended by the trainee, i.e., the proportion of the sequence which can be correctly recalled or reproduced at a given point in training. As training progresses and the trainee's ability to assimilate increases, the demonstration should be lengthened appropriately. Continuing a demonstration beyond the "saturation point" will result in the association of responses with incorrect cue contexts, i.e., stimulus contexts involving errors of recall of temporal/sequential cues. (Source: Guthrie)

APPENDICES

APPENDIX A: Task/Behavior Categories with Examples of Operational Context

1. Non-Verbal Detection: Detection of some critical physical signal such as (1) a target on a radar scope, (2) an auditory signal of equipment malfunction, or (3) a visual cue for starting an operating procedure.
2. Non-Verbal Identification: Identification of equipment configurations.
3. Verbal Detection: Monitoring communications equipment.
4. Verbal Identification: Identifying verbal stimuli or cues such as codes and diagrams or symbols such as those used in mathematical and natural languages.
5. Recalling Facts: Recall of information such as equipment nomenclature or function, codes, configurations, locations, etc.
6. Recalling Principles: Recall of information such as complex relationships between control inputs, output indications, and possible equipment malfunctions.
7. Recalling Procedures: Recall of information such as procedures involved in assembly or disassembly of a complex piece of mechanism, replacement of defective components, or fueling or arming a weapon platform.
8. Using Principles, Inferring: Application of complex relationships such as those involving control inputs, modes of operation, output indications, and possible equipment malfunctions; or use of principles in threat evaluation and weapon assignment.
9. Making Decisions - Alternatives Given: Certain types of complex equipment malfunction diagnosis, complex system check-out, or threat evaluation and weapon assignment.
10. Making Decisions - Alternatives Unspecified: Certain types of complex equipment malfunction diagnosis, complex system check-out, or threat evaluation and weapon assignment.
11. Making Decisions - Alternatives Unknown: Certain types of complex equipment malfunction diagnosis, complex system check-out, or threat evaluation and weapon assignment.
12. Positioning Movement: Handling of materials, operating controls.
13. Repetitive Movement: Turning a screwdriver or wrench, hammering, using a hand file or saw, etc.

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14. Continuous Movement: Tracking tasks such as following a target with a gun or with fire-control equipment, or operating the steering mechanism of a moving vehicle.
15. Serial Movement: Typing, radar set turn-on procedures, portions of system check-out routines.
16. Static Reaction: Maintaining proper sight-target relationship in aiming a rifle, holding an electrode in place when welding, or maintaining optimal postural adjustment when monitoring a radar scope.
17. Oral Verbalization: Person-to-person(s) vocal communication - either face-to-face or via electronic/mechanical transmission.
18. Written Verbalization: Writing in special codes or symbols or in new natural or mathematical languages.
19. Other (Overt) Verbalization: Use of conventionalized gestures or specialized sign languages such as the semaphore and the dactylological (deaf-mute) systems.

APPENDIX B: Examples of Application of Guidelines

Presented in this section are examples of application of the guidelines to two specific practical training situations. These examples serve to illustrate the manner in which these general guidelines may be applied and provide some indication as to type and variety of results obtainable from such specific applications. Briefly, the manner in which both applications were conducted involved the following steps:

Step 1. The specific training problem or situation was described and analyzed in sufficient detail to be meaningfully related to the nineteen task/behavior categories (cf. APPENDIX A) used in developing and stating the guidelines.

Step 2. On the basis of the above description of the specific situation, the index to the guidelines was checked for entries identical or similar to those aspects of the training situation which were identified as critical task behaviors.

Step 3. The guidelines identified in Step 2 were then reviewed in the light of the specific characteristics or circumstances of the situation.

Step 4. In the course of Step 3, a number of suggestions as to specific design features occurred. These suggested design features, based largely on the guidelines plus a knowledge of significant characteristics of the specific training situation, were recorded, refined, and then grouped according to relevance for particular design problems such as displays, feedback, etc.

Example No. 1: Adjustment of Telecommunications Relays

Brief Description of Tasks: Adjusting leaves of relays used in telecommunications systems, so that contacts make and break according to specifications. Requires positioning relay on mounted stand which connects it electrically; adjusting clearance between armature and coil by screw adjustment; using gauges to check clearance; inspecting clearances of contacts; using small tools to bend leaves of relay pile-up so that tolerances are met; diagnosing how contacts are out of adjustment and determining what adjustments are needed where to bring it into adjustment.

Additional Information: Relays are of several degrees of complexity with any or all of three types of contacts: make, break, and make before break. Electrical test stand is not diagnostic to the point of specifying which specific contact needs adjustment, when several similar contacts are involved. Written procedures are very brief and require much interpretation. Specifications are highly technical and much of the information is in coded form. Training currently requires about three months, during which time the trainee learns primarily by watching a skilled adjuster working.

Critical Task Behaviors: The major skills to be developed are related to the following behaviors:

- a. Inspecting: requiring careful visual inspection against a white background, to observe minute clearances, simultaneity of contact makes and breaks, and effects of adjustments for clearance and timing.
- b. Determining nature of needed adjustments: From the inspection, manipulation and gauging of the relay, diagnosing which segments of the relay require adjustments of the kinds the adjuster can make.
- c. Making manual adjustments: requiring use of small hand tools for bending or straightening leaves of the relay, including judging how much of a movement or adjustment is needed, essentially by "feel".
- d. Generalizing all skills among various types and complexities of relays: requiring the determination of additional interactions of contacts when different types of contacts are combined and when there are many of the same type of contact, and the judgment of how these interactions affect the component skills.

Suggested Design Features for Displays:

1. Actual relays do not provide many of the features suggested. For example, there are many irrelevant cues continuously present in actual relays. It is difficult to inspect an individual contact against a light background, because there are so many other contacts also visible and interacting. It would be desirable to provide a simplified relay with one or a few contacts easy to examine. These would still be realistic and provide transfer, and could be made more and more complex as training progresses.
2. If special training relays were to be designed, they should also be constructed so that the adjustments possible are fairly obvious to determine and so that the result of each possible adjustment can be demonstrated.
3. Several types of training relays should be designed, to insure generalization among types of pile-ups of leaves and among types of contacts.
4. Some training relays might be designed to be grossly out of adjustment, so that the cues which would suggest correct responses are obvious.

5. A checking routine might be developed to assist in training. This routine would break down the somewhat complex relationships among adjustment possibilities, perhaps suggesting priorities of checks and adjustments, somewhat as a troubleshooting routine does. The attempt would be to provide a fairly simple "mediator" for examining and working with the many possibilities facing the adjuster of a complex relay, presented to him as a "whole," without much of a procedure to follow.
6. As more complex relays are introduced, the training relays would vary in their timing of make and break.
7. Training relays should be constructed so that when the adjuster begins to make an adjustment, as in bending a leaf, he can see what will result from more or less of the same adjustment. This suggests that materials other than those used in actual relays may be desirable for some of the early training relays. On the other hand, the training relays should be capable of being re-set to any given inadjustment, after used in training, implying material which can be shaped and reshaped several times.
8. There might be an easy way for diagramming or for using a large-scale mock-up of a relay which very clearly points out what happens with contacts with each type and degree of adjustment. This method might facilitate the understanding of what happens when adjustments are made on either side of a fulcrum in a lever-type of arrangement, and the advantages of each type of adjustment.
9. For the fast, fairly repetitive types of adjustments, such as making very slight adjustments of each leaf in the relay in quick succession, a film in slow motion might help to show the action, although the value of such a film might not be worth the cost for production. A slowed-down demonstration might do as well.
10. In the analysis of where to make the adjustments, a simplified diagram with exploded views of adjustment areas might clarify and help encode the analysis process. For example, arrows could connect trouble and its correction in a "if this, then this" type of presentation. This might help to develop some geographical, physical associations more easily remembered than more logical or abstract relationships.

Suggested Design Features for Operator Output:

1. Obviously, extensive practice will be necessary, both to develop the manual skills of handling the tools and to develop the analyzing skills for determining what to adjust and where. To provide repetitive manual practice, some special training materials might be developed on which the operator can practice making bends of various

degree and which he can check with a standard of some kind. These would not necessarily be as parts of relays. The trainee might even take a long strip of metal which he must shape a certain way with his hand tools. The shaping must progress very gradually, and can be checked for accuracy at each of several stages.

2. Any training relays specially designed should provide for variations in operator response, so that in some cases, very small and few adjustments are necessary and, in other cases, much larger or more numerous adjustments are required.
3. The training equipment should provide a means for showing the trainee immediately the consequences of a given adjustment. It should first show him that something does happen when he responds (e.g., that there is a bend, however small, when he applies pressure with a small bending tool). Then it should show him that this "something" varies in proportion to his response (e.g., the more he applies pressure, the greater the bend). Finally, it should show him what will happen in the relay's action for one or more variations in this response (e.g., if too much, another contact will be affected; if too little, there is virtually no adjustment). With the simplified relays for early training, this type of consequences information should be easier to incorporate than with more complex relays.
4. The variety of training relays should provide a selection of lengths or materials in the leaves, if there is this variation in the actual relays, so that the trainee can learn to differentiate the responses required for each type of relay.
5. The armatures of the early training relays should be much more delicate or more nearly linear in response to applied force, so that the contacts can be made or broken slowly, instead of jumping as they do now with the amount of pressure on the armature which is needed to move the relays.
6. Perhaps, in early training, require the trainee to verbalize what he is doing and why, either aloud or on a "scrambled" checklist, so that his recall responses can be checked.

Suggested Design Features for Performance Feedback:

1. Perhaps the best type of feedback on a specific adjustment response would be that of an electrical check which would indicate that the relay is or is not now in adjustment. If possible, the test stand and the design of the relay should be such that contacts can be singled out for electrical checks, and that each of a pair of contact points can be isolated electrically. This might be done only with very simple training relays. It points up an advantage to starting with single point relay contacts, instead of having double points for each contact.

2. Early in training, feedback should be given quickly and often, after the response is made. As training progresses, feedback should be less quick and less complete. This would probably be compatible with an increase in the complexity of the relays during training.
3. There should be some means for reinforcing the learner in his analysis of the relay and in his selection of alternatives for adjustment, especially early in training. Perhaps he could analyze the problem, then select his alternative, and then check on a checklist. This would, of course, permit cheating, unless some form of self-teaching machine were used, requiring a written response first. This is perhaps too impractical and unrealistic, but worth some further thought.
4. Other design features suggest self-instruction, because of the emphasis on reinforcement. However, the checking of adjustment responses almost precludes any automatic way for reinforcement. For some bending tasks, the final bend might be checked against a standard of some kind, like a line which the edge of the leaf should conform to or a jig in which the leaf should fit easily.

Suggested Design Features for Personal Environment:

1. Vary training tasks at beginning to sustain interest. For example, the trainee might spend an initial bit of time on learning about different types of contacts, then work with his tools on a simple adjusting or shaping task, and then learn a little about analyzing what kind of adjustment is needed, etc. As training progresses, variations in types and complexity of relays will help sustain interest. Don't spend too much time on the visual discrimination at any one time.
2. A variety of teaching methods will help avoid fatigue also. For example, if self-instruction is possible for any part of the training, vary linear and branching materials. Intersperse the person-to-person instruction with demonstrations or other teaching media.

Discussion and Illustration of the Derivation of Design Features:

The steps leading to two of the above suggested design features are traced in order to illustrate in greater detail the manner in which the application was carried out:

Derivation of Suggested Design Feature No. 5 (for Displays):

Step 1. In the analysis of the specific training problem, one task was described as "diagnosing how contacts are out of adjustment and determining what adjustments are needed where to bring it into adjustment."

Step 2. The entry "Making Decisions - Alternatives Unknown" in the Index to the guidelines appeared to be sufficiently similar to the task or behavior described in Step 1 to warrant a follow-up. Several guidelines were grouped under this entry, including "Design Guide No. 27" which is presented on page 29. This guideline, stated briefly, is as follows: "In training for decision-making under conditions in which the number of possible alternatives is practically innumerable, or in which a substantial proportion of the alternatives are unknown, provision should be made for the development and use of mediators (stereotypes, self-instructions, or 'natural' associations) both for facilitating identification of response alternatives and for reinforcement of such identifying responses when they occur. Such mediators might be largely semantic or verbal in nature, e.g., instructions as to what constitutes the general class of events known as 'alternatives,' or rules for implicit testing of alternatives."

Step 3. Design Guide 25, identified in Step 2, was thus reviewed in the light of the specific characteristics of the situation, including the following: (1) "Electrical test stand is not diagnostic to the point of specifying which specific contact needs adjustment, when several similar contacts are involved," (2) "Written procedures are very brief and require much interpretation."

Step 4. In the course of Step 3, the following design feature was suggested: "A checking routine might be developed to assist in training. This routine would break down the somewhat complex relationships among adjustment possibilities, perhaps suggesting priorities of checks and adjustments, somewhat as a troubleshooting routine does. The attempt would be to provide a fairly simple "mediator" for examining and working with the many possibilities facing the adjuster of a complex relay, presented to him as a 'whole', without much of a procedure to follow."

Derivation of Suggested Design Feature No. 1 (for Personal Environment):

Step 1. One critical task behavior identified in analysis of the specific training problem was "Inspecting: requiring careful visual inspection against a white background, to observe minute clearances, simultaneity of contact makes and breaks, and effects of adjustments for clearance and timing."

Step 2. The Index entry "Non-Verbal Detection" appeared relevant. One of the guidelines covered by this entry was "Design Guide No. 3" which is presented on page 7. In brief, this guideline is as follows: "In training for detection of non-verbal cues, . . . provision should be made to offset or decrease undesirable motivational effects such as fatigue and boredom which are likely to result from the protracted time intervals."

Step 3. Design Guide No. 3, identified in Step 2, was then reviewed in the light of specific characteristics of the situation, including the following: (1) "Relays are of several degrees of complexity. . ." (2) "Training currently requires about three months," and (3) ". . . trainee learns primarily by watching a skilled adjuster working."

Step 4. In the course of the Step 3 review, the following design feature was suggested: "Vary training tasks at beginning to sustain interest. For example, the trainee might spend an initial bit of time on learning about different types of contacts, then work with his tools on a simple adjusting or shaping task, and then learn a little about analyzing what kind of adjustment is needed, etc. As training progresses, variations in types and complexity of relays will help sustain interest. Don't spend too much time on the visual discrimination at any one time."

Example No. 2: Operating Portion of Communications System

Brief Description of Task: Advances call to station: selects appropriate outgoing circuit; plugs in; performs necessary operations of dialing, key pulsing, ringing, or requesting; if necessary, monitors to determine that connection is complete to station; determines call status.

Additional Information: The selection of appropriate circuit is dependent upon the type of call and the equipment capabilities. There are specific procedures and practices to cover these alternatives. Once selected, the plug-in is made, and again depending upon the type of call and circuit, the operator has several alternatives for the next step: to key pulse a number, to dial a number, to ring on a ringing key and remain cut in until party answers, or to wait for an answer. She may pass information on to another operator in order to build up a connection, in which case she may have to clear the circuit verbally when the call is finished. If the call cannot be completed, she determines why not and selects an alternative course of action or a report to be given to the customer.

Critical Task Behaviors: Although there are many things involved here, the major skills are as follows:

- a. Recalling procedures and principles: She must remember specific steps to be followed for specific situations and conditions, and she must remember principles or rules governing some of these procedures and steps.
- b. Making decisions/alternatives known: She generally has a procedure to follow or a principle to use as a guide.
- c. Identification/non-verbal cues: She must quickly search the switch-board circuits for appropriate locations, and she must watch her supervision lights, two very crucial search and monitoring skills.

Suggested Design Features for Displays:

1. It seems most likely that call advancing should be trained substantially on a piece of equipment very much like the actual switchboard. This will maximize transfer to actual equipment. The main questions then become ones of how much simulation of advancing capabilities to provide, with necessary feedback.
2. Alternatives for selecting outgoing circuit groups can be grouped into a relatively few types. These categories can be set up to be more easily remembered than each of the many specific alternatives.
3. Alternatives for advancing are in large part dependent upon the type of route to be used for the call, e.g., whether the call can be advanced directly to a telephone or whether it must be passed through one or more other operators. These call types can easily be grouped for easy remembering. For example, direct to telephone routes will be listed in the reference guide with a + or 7D on the end. All routes through other operators do not end in + or 7D. This grouping is easier to remember than all the specific combinations of routes and codes.
4. A training board should provide a broad enough selection of outgoing circuits to allow application of principles to selection of alternatives. Therefore, there should be a jack for each general type of circuit. For example, if there are three "tandem" circuits with several jacks each, there should be one active jack for each tandem on the training board. However, if there are two or more areas for one type of tandem, there need not be an active jack in each area. The active jacks in the tandem should not always be the first in the row, but perhaps in the first five. It should have an idle-indicating lamp as on an actual switchboard. If there are several specific city groups of jacks on the actual switchboard, such as to New York, Boston, Philadelphia, etc., or more local areas such as Glenshaw, Evans City, and Oakmont, the training board should have an active jack in a few of these areas, but not necessarily in all of them. Calls in training can be limited to those areas represented on the training board. This can be generalized to the other areas with brief practice and drill on the actual board.
5. The selection of area jacks discussed above should include a sample of each type of advancing procedure. For example, if there are circuits direct to a ringdown (meaning that the operator has to ring the telephone herself), a few of these should be included.
6. In early training, when the trainee is concentrating on a specific type of advancing, the switchboard can be marked with tape, for example, to limit her search and the number of alternatives available to her. As training progresses, this can be eliminated.

7. When the advancing requires several steps, sometimes drawn out over several minutes because of waits, in early training these can be time-compressed, so that the sequence becomes clear. This will permit greater drawing of parallels between these procedures and those for more direct calls.
8. In early training, the call information can be presented so that the "heart" of the call is obvious, so that the decision and alternatives are clear. As training progresses, the call information presentation can vary as widely as customers tend to present it.
9. Where the operator has alternative methods of advancing for different types of calls, these alternatives can be presented so that they are associated with the consequences of each alternative. For example, you can do either A or B. If you do A, this is what happens; if B, this is what happens. Which do you want to happen here?
10. The call advancing procedures can be supported by a "supplementary habit system" which emphasizes on one hand the logical order required by the steps (e.g., you have to connect yourself to a telephone before you can ring it) or on the other hand the physical relationship among the steps (e.g., the information from the calling party comes in on one cord and has to go out on the other cord to some place before you can talk or ring at the called party's telephone or another operator).
11. In the early learning of sequences, numbered tags could be affixed to critical points of the equipment in accordance with the sequence to be followed. For example a 1 could be put at the incoming jack; a 2 at a point indicating the operator or her earphones; a 3 at the outgoing jack; a 4 at the ringing key or on the monitoring key; a 5 on the cord clips; and a 6 on the supervision lights. This would make the sequence physically obvious and easy to follow without initial error.
12. The various types of call status conditions should be carefully simulated, to develop discrimination between various frequencies of flashing lights, for example. Early in training, these differences can be exaggerated, so that a regular flashing is easily discriminable from an irregular flashing, for example.

Suggested Design Features for Operator Output:

1. Provide plenty of examples of the same type of call for extensive practice.

2. Space out the steps of the sequence to be followed so that each single cue can be associated with its specific response. For example, when the supervision light comes on at the end of conversation, the operator may remove cord clips, release the circuits verbally to another operator, and then disconnect. This sequence should be divided so that the cord clip removal is a cue to ring the other operator and clear, and that, in turn, is the cue to disconnect.
3. As training proceeds, reduce the amount and kind of special cueing from step to step.
4. Encourage the operator to go through the steps of the call advancement mentally. For example, while the call is up, the operator can rehearse in her mind the final steps to be carried out when the supervision light comes on.
5. Provide a large number of illustrations of calls with slight differences but which require the same principle to be applied. For example, there are several types of calls on which the operator remains cut in until the called party answers. A variety of these will help to generalize the principle of remaining cut in.
6. Early in training, the instructor may wish the student to state what action she will perform next, so that accuracy of recall can be measured.
7. Develop training sequences so that content is in most logical order, in appropriately small steps, and with adequate explanation at each point, so that there is minimal dependence on initial level of performance. Initial training design should probably be evaluated by checking on how effective it is for students with differing abilities at beginning.
8. Early in training, the student might be permitted to plug into only a few specific areas of the board, thus controlling her response somewhat. This would be broadened as training progresses until she is permitted to use the entire board.

Suggested Design Features for Performance Feedback:

1. Early in training, students can be reinforced after each step of the sequence and immediately. This is especially true if self-instructional methods are applied. Sequence recall might be trained and practiced through a branching type of program, so that if the student makes a wrong response, she is told it is wrong and why, before going on to the next step.

2. Later in training, the student would be reinforced primarily after completing the advancement of the call. This is more typical of the operational situation.
3. If the student is required to mentally rehearse the sequence, she should be reinforced, corrected if necessary, as she goes along. Later in training, the reinforcement will be primarily at the end of the sequence.

Evaluation of Applicability of Guidelines

On the basis of the previous examples, it appears that the present set of guidelines are capable of fruitful application to specific practical training situations. This is not to say that the results of the applications presented would have been unobtainable, in whole or in part, without the guidelines. It is not possible to separate exactly the contribution of the guidelines from the contribution played by knowledge of the specific practical situation and knowledge of, and creativity in, the general area of training methods, techniques, equipment, etc. Nevertheless, it seems likely that the set of guidelines may play a particularly useful role as a "memory jogger" or check-list to complement the memory of the training device designer or user.

Perhaps a substantial factor contributing to the apparent usefulness of the guidelines is the organization in terms of categories of tasks or behaviors and, secondarily, categories of general design problems. With this type of organization (and indexing), it becomes unnecessary to read through large quantities of material unrelated to the specific problem of the moment in order to find isolated bits of relevant information.

In conclusion, the set of guidelines appear to be capable of useful application to specific practical training situations, at least if applied in the manner summarized below:

- Step 1. Prepare, or otherwise obtain, a descriptive analysis of the specific training problem or situation in sufficient detail to be meaningfully related to the nineteen task or behavior categories used in developing and stating the guidelines. (cf. APPENDIX A)
- Step 2. Check Index to guidelines for entries identical or similar to those aspects of the training situation which are considered critical task behaviors.
- Step 3. Review guidelines identified in Step 2 in the light of the specific characteristics, requirements, or circumstances of the training situation.

Step 4. Record and refine suggestions as to specific design features, details, etc. which occur in the course of Step 3. This is, perhaps, the most critical step, depending heavily on the knowledge and creativity of the reviewer.

APPENDIX C: Glossary of Terms

alternative (choice) context - Stimulus context in which the stimuli consist of alternatives or choices in a decision-making situation. These alternatives or choices must be presented or perceived at approximately the same point in time in order to be considered portions of the same context.

analytic (diagnostic) indicators - Data capable of facilitating analysis of performance in terms of various meaningful aspects of the underlying learning process. Such data may reflect, for example, rate as well as level of learning, motivational as well as skill level, or projected points of maximal response interference or difficulty. Implies data providing a more "fine-grained" account of trainee performance than is required for simple evaluation in terms of typical performance criteria.

anticipatory symbolic response - Covert (i.e., mental, "in-the-head," not directly observable) equivalent or concomitant of an overt (directly observable) response, the symbolic equivalent occurring prior to its corresponding overt response.

codable in symbolic form - Expressible or representable in words or other symbols.

cue-response pattern - A learned combination and/or arrangement (spatial and/or temporal) of specific responses and associated cues or initiating signals. See habit system.

cue-response step - Portion of a required procedure or performance which entails the execution of a specific response (or appropriate substitute) to a given cue (or appropriate substitute).

feedback - Information presented or otherwise made available to trainee indicating adequacy of performance. Sometimes termed "knowledge of results." See reinforcement.

generalization (Stimulus generalization) - Tendency of a given cue to elicit or produce a given response solely on the basis of similarity to another cue (or to other cues). Implies at least partial equivalence of different cues in evoking a learned response.

guidance or "artificial" components of total response context - Refers to aspects of response which occur primarily, if not exclusively, because of special guidance features which are introduced, usually early in training, to limit or control trainee's response in some desired respect. See total response context.

habit system - A set of interrelated habits (learned cue-response relationships). See cue-response pattern.

implicit testing of alternatives - Refers to symbolic evaluation of alternatives (or choices) in a decision-making situation. Implies a simulated try-out of alternatives, i.e., estimating probable consequences of given courses of action as opposed to actually determining alternative consequences.

Individual differences - Variation with respect to abilities (or other characteristics) among individuals.

Interfering and competing responses - Responses which are to some extent incompatible with the to-be-learned response. Occurrence of such (i.e., interfering) responses implies a lowered probability of occurrence of the desired or to-be-learned response. Complete extension of one's arm, for example, is incompatible with complete flexion of the same arm, i.e., one response precludes or prevents the other at any given point in time.

Irrelevant cues - Extraneous cues which, because of their transient nature, are inappropriate or inadequate as signals for the desired or to-be-learned response.

kinesthetic cues - Cues based on "muscular feel," i.e., stimuli which occur as the result of muscular activity. Such cues have their origin in muscle tissue, tendons, or joints.

mediator - Response which facilitates the development of an association between some other response and a given cue by serving as a sort of "go-between" or "link" between the given cue and the other response. Implies that the given cue is fairly capable of eliciting the mediating response, and that the mediating response then serves as a more adequate, i.e., stronger, signal for the desired response than does the given cue which originally elicited the mediating response. For example, the cue "1" is fairly capable of eliciting the response "2" which, in turn, is a more adequate or stronger signal for "2" r".

(assuming this is the desired response) than is the original cue "1." In this example the response "2" is the mediator or link between the given cue "1" and the desired response "2 r."

"natural" association - Highly overlearned cue-response relation. Implies high probability of response upon presentation of given cue. May be useful as a mediator.

overlearning - Practice or response repetition carried beyond the point of mastery.

positive transfer - Facilitating effects of previous learning experience upon subsequent learning performance.

"programmable" according to stage of training - Refers to capability of organizing and scheduling one or more features of the training situation according to the stage of training or relative progress of the trainee.

redundant or supplementary habit system - A habit system or cue-response pattern characterized by the following features: (1) usually superfluous, i.e., non-essential to successful performance as long as some other habit system remains adequate, (2) capable of producing successful performance in the event that another, usually adequate, system breaks down, as might occur, for example, under stress or in the case of particularly difficult or complex tasks.

reinforcement - The action of some event upon a response such that the response is strengthened. In human learning "knowledge of results" or performance feedback is usually considered to act as a reinforcement. See feedback.

relevant cues - Appropriate or adequate signals for the desired or to-be-learned response. Those cues to which the trainee should attend or respond in order for the most efficient learning performance to develop.

response-produced cue - Stimulus or cue produced or determined by a given response. Implies that the response itself is a cue or signal for some other response.

self-instructions - Instructions which trainee provides himself through recall or other symbolic responses. Cues for such responses may be either symbolic (covert, "in-the-head," not directly observable) or overt (directly observable).

sense modalities - Methods or classes of sensory input, e.g., visual, auditory, tactual, etc.

"single step" or "basic unit" response - See cue-response step.

"specific step" external cue - Stimulus or signal for a given response, the stimulus being presented by some source (e.g., equipment, instructor, materials, etc.) other than the trainee himself. Also implies that the response in question is only a portion of some performance sequence or procedure.

stereotypes - Common cliches, movements, gestures, postures, or other highly standardized responses.

stimulus reception - Activation or arousal of sensory receptors (sense organs) by a stimulus. Implies that the stimulus becomes an actual input to the trainee.

symbolic (mental) rehearsal - Repetition (practice) of symbolic response(s). See symbolic response.

symbolic response - Covert (i.e., mental, "in-the-head" not directly observable) equivalent or concomitant of an overt (directly observable) response.

temporal/sequential cues - Cues based on the proportion of a total procedure or sequence of responses which has been previously completed. Implies that such cues indicate to the trainee "where he is" in the procedure or sequence, and thus provide an indirect indication of the appropriate next response.

total cue context (stimulus context) - The entire set of cues or sensory inputs occurring simultaneously with some specified single cue. Implies that the set of accompanying cues is complete, i.e., includes every other sensory input regardless of origin, relevance, etc.

total response context - The entire set of response occurring simultaneously with some specified single response. Implies that the set of accompanying responses is complete, i.e., includes every other response irrespective of origin, relevance to the to-be-learned performance, etc.

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