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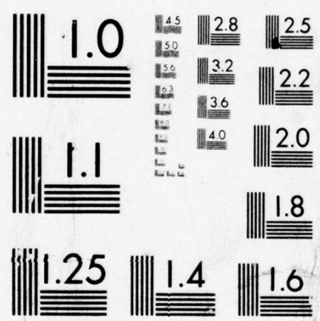

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STUDIES IN SYSTEMATIC INSTRUCTION AND TRAINING

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THE ROLE OF VERBAL CONTROL IN COMPLEX SKILL TRAINING

James L. Eubanks

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THE ROLE OF VERBAL CONTROL IN COMPLEX SKILL TRAINING

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Rule Learning and Systematic Instruction in Undergraduate Pilot Training

Vernon S. Gerlach, Principal Investigator

THE ROLE OF VERBAL CONTROL IN COMPLEX SKILL TRAINING

James L. Eubanks

Technical Note #60115

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Acknowledgments

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I. The Problem

Man's ability to communicate through verbal behavior is a characteristic that clearly sets him apart from lower animals. Verbal instruction facilitates his acquisition of complex skills which would otherwise be learned very slowly or not at all. Verbal descriptions or rules often shield man from environmental factors that would diminish his survival chances. For instance, the pilot is spared the aversive consequences that could result from flying in inclement weather by following rules. One could hardly argue for allowing the pilot to directly experience such hazardous situations in order to ascertain that "he really knows how to handle himself under adverse conditions."

From the perspective of the present paper, however, what needs to be reconsidered in education and training is the extent to which verbal control is frequently emphasized--often to the exclusion of sufficient opportunities for the learner to perform under the actual contingencies operating in the environment. One problem is the inability to accurately and exhaustively describe the intricate relationships between the behavior of the learner and the existing environmental conditions under which he or she is expected to perform. In training parlance, the student pilot may learn a number of procedures to follow in executing, for instance, a Vertical S-A, through studying a manual, listening to a briefing, or watching an instructor pilot perform the maneuver. In actual practice, however, the skilled pilot acquires a number of techniques for performing the maneuver proficiently. Such techniques, which result from the pilot's experience, are often difficult to convey verbally. Indeed, the distinction between procedure and technique permeates pilot training (Reiser, Brecke, and Gerlach, 1972).

Skill learning theoreticians tend to emphasize the role of verbal control during the initial stages of acquiring complex skills. Fitts and Posner (1967), for instance, postulate that the trainee first tries to "understand" the task at hand by constructing verbal mediators or rules to describe what he or she is supposed to do. This initial cognitive stage is followed by an intermediate or associative stage, and, finally, by an "automatization" stage during which performance is essentially automatic and not under the control of verbal mediators. More recently, Posner and Keele (1973) have reduced this process to a two-stage model in which the trainee relies on conscious or verbal control and external feedback, followed by automatic control with heavy reliance on task-intrinsic feedback. Adams (1971) describes a similar two-stage sequence involving an initial verbal motor stage and a motor stage with a minimum of verbal control.

Although the learning of rules, or cognitive pretraining, is clearly at the heart of systematic training, instructional psychologists have not defined rule in a manner that either avoids unsubstantiated generalizations (Haygood, 1973) or clearly links the use of rules to subsequent trainee behavior (skilled performance). The present paper is an attempt to bridge this gap. The objectives are (1) to provide a framework for viewing methods that emphasize verbal control in training complex skills, (2) to describe different uses of the term rule within this framework, and (3) to suggest some implications of this framework for subsequent training research efforts. Research is cited only to clarify a point at issue; consequently, the review of the literature is selective rather than exhaustive.

II. Training for Complex Skills through Verbal Control

A number of approaches to training complex motor skills have been studied rather intensively during this century. Research paradigms have emphasized many different forms of verbal control, at least during the initial stages of skill acquisition. Figure 1 provides a summary of these approaches organized according to the descriptors of methods most frequently cited in the experimental literature.

Mental Practice

In the typical mental practice experiment, trainees are provided with a brief verbal description of the task to be performed. Subsequently, they are instructed to mentally picture themselves performing the task. The trainees are generally required to repeat this mental task for a number of trials. In a comprehensive review of mental practice research spanning some 30 years, Richardson (1967) concluded that methods involving mental practice generally produce a considerable amount of positive transfer to performance on the actual task. Although the studies reviewed by Richardson involved simple motor skills that were easily managed in a conventional laboratory setting (cf. Figure 1), a recent study by Prather (1973) suggests that mental practice on landing a T-37 aircraft can result in significantly better trainee performance of this task as evidenced by higher instructor pilot ratings.

Verbal Pretraining

A second verbal control approach to training skills emphasizes the preliminary establishment of stimulus-response pairings, much in the manner of that employed in the traditional paired associates learning paradigm. In this type of experiment, the trainee is presented with pairings between stimuli that are to be used in a subsequent motor task and words or phrases that describe the correct motor response to be made to each stimulus. McAllister (1953) evaluated the effects of a number of variations of this paradigm upon subsequent performance on the Star Discrimeter, a simple motor task which involved the correct positioning of a wobble-stick in the presence of a particular colored light stimulus configuration. The results of this early study indicated that the preliminary learning of associations between color cards and naming the corresponding correct response significantly enhanced subsequent performance on the criterion task which involved a motor response substituted for the verbal descriptor and colored lights substituted for the color cards. Similar studies by Gagnè and his associates, sometimes conducted under the rubric "stimulus predifferentiation," produced substantial positive transfer to a somewhat more complex task involving the correct placement of four levers in the presence of four distinctive stimulus light configurations (Baker and Wylie, 1950; Gagnè and Baker, 1950; Gagnè and Foster, 1949a, 1949b; reviewed in Gagnè, Baker, and Foster, 1950). Significant verbal pretraining enhancement effects on subsequent perceptual motor performance have been noted by numerous other investigators using similar tasks (Arnoult, 1957; Battig, 1956; Cantor, 1955; Goss, 1953; Goss and Greenfield, 1958). And, a recent study by Wood (1973) showed significant transfer from pretraining sequences with an

Approach	Stimulus Conditions Presented to Learner	Response Required of Learner	Applications
Mental Practice	Verbal description of the task and directions to think about performing the task.	Imagining or thinking about performing responses involved in the task.	Dart throwing, basketball throwing, card sorting, minor drawing, substituting digits, moving pegs on a pegboard, landing a T-37 aircraft.
Verbal Pretraining (Stimulus predifferentiation)	Stimuli or descriptions of stimuli that are similar, but not identical, to those involved in the criterion task.	Response descriptions or verbal labels that are similar, but not identical, to those involved in the criterion task.	Finger positioning task, manipulating switches, stick positioning task (Star Discrimeter), flight simulator maneuver, lever manipulation.
Directions (Experimental Instructions)	Verbal description of what activities are to be performed with respect to the stimuli and the goals or objectives to be achieved.	Responses specified in verbal description.	Dart throwing; rotary pursuit tracking; tasks involving a series of discrete motor responses to a series of discrete stimulus presentations; discrimination reaction time tasks.
Instructional Cues	Information needed in order to acquire or emit behavior specified in a given instructional objective.	Response described in given instructional objective.	Academic tasks; flight simulator maneuver.
Rule learning	Verbal description of responses involved in the task, and the conditions or stimuli for which those responses are appropriate.	Criterion response described in rule.	Concept learning; academic tasks; problem-solving.

Figure 1. Verbal control approaches to facilitating complex skill acquisition

audiovisual pretraining device to performance in a light aircraft instrument trainer with simulated motion.

Experimental Directions or Instructions

Experimental directions or instructions are not frequently manipulated in experimental studies. In this approach, a brief verbal description (oral and/or written) is provided subjects prior to their engaging in the experimental task. These directions or instructions generally indicate the activities to be performed with respect to the stimuli and the goals to be achieved. Such experimental instructions in perceptual motor studies rarely involve the explicit stimulus-response pairings that are an integral part of the verbal pretraining methods described above. However, conflicting results have been obtained in experiments designed to evaluate the effects of various levels of instructions on subsequent motor performance. An early study by Judd (1902) showed that preliminary instructions regarding the principle of refraction enhanced performance on a task in which boys threw darts at targets underwater. Renshaw and Postle (1928), on the other hand, found that subjects who received explicit task-related instructions demonstrated poorer performance than subjects who were given only the task objective, or who were instructed to generate written descriptions of the task. More recent studies by Noble and his associates (Noble, Alcock, and Farese, 1958; Noble, Alcock, and Frye, 1959) have obtained a facilitative effect for specific task-related instructions. Although the Noble et al. data suggest that the negative findings of Renshaw and Postle may be attributable to poorly developed instructions, a recent study by Brecke (1975) designed to examine the effects of systematically designed instruction on complex skill learning showed superior performance for certain subjects who received only the objective. Data regarding the effects of verbal instructions on subsequent perceptual motor proficiency are clearly equivocal; we shall return to a more detailed analysis of this issue.

Instructional Cues

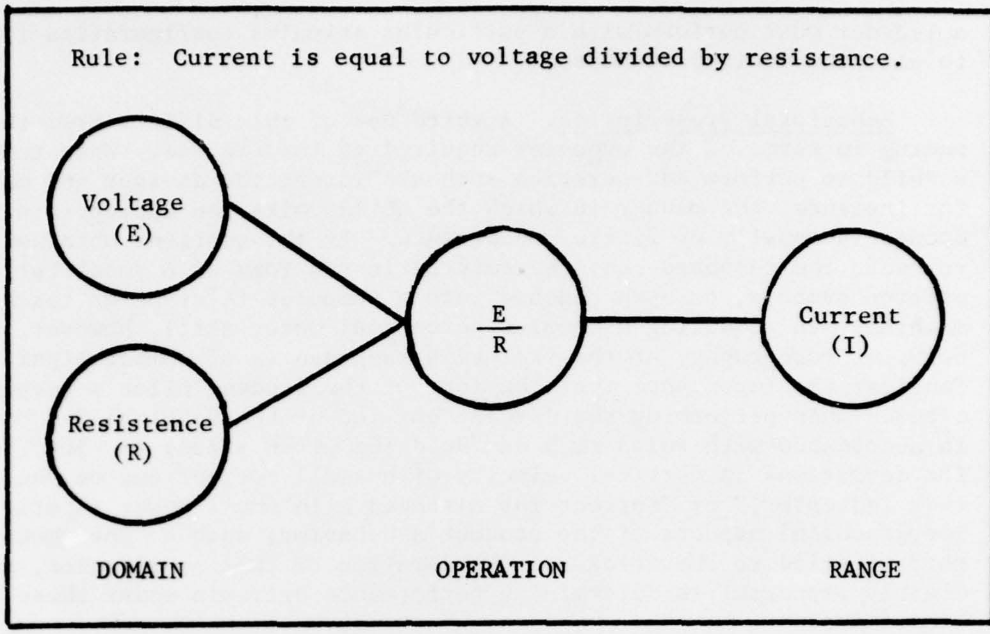
An instructional cue is the minimal information provided a learner or trainee to enable him to acquire or emit the behavior specified in a given instructional objective (Schutz, Baker, and Gerlach, 1964; Gerlach, Baker, Schutz, and Sullivan, 1967; Brecke, Gerlach, and Shipley, 1974). Instructional cues differ from the experimental psychologist's general conception of instructions for a particular research study. Instructional cues are written specifically for the intended trainee; they are evaluated and revised in accordance with the extent to which the trainee can perform the desired behavior after having mastered or memorized the cues to some preset criterion level (usually verbal). Experimental instructions or directions, on the other hand, may range anywhere from simple one-liners such as "Sit down and make yourself comfortable," or "Try to keep the stylus on this white dot on the revolving wheel as much as you can" to information provided subjects regarding how to actually perform the experimental task--as in previously described studies by Noble et al. (1958; 1959). Although the instructional cue has been applied primarily to instruction in academic skills such as reading and elementary mathematics, recent work by Gerlach and his associates (Brecke, 1975; Brecke, Gerlach, and Shipley, 1974) has convincingly demonstrated the utility of this approach for teaching student pilots complex perceptual motor skills--such as performing selected maneuvers in a flight simulator.

Rule Learning

The expression rule has been used in numerous ways. It is often equated with legal or ethical considerations, either written or nonwritten, pertaining to how a particular society prescribes appropriate behavior for its members. The folklore is replete with maxims such as "let sleeping dogs lie," or "early to bed, early to rise." Within the context of education and training, there appear to be three primary modes in which rule learning is emphasized.

Attribute identification. In this usage of rule, a symbol, object, or event is identified with, or defined in terms of, other symbols, objects, or events. That is, in defining a nonfamiliar entity for a student, instructors often refer to stimuli, or attributes of those stimuli, that are presumed to be more familiar to the student than the entity being defined. Upon first encountering the word lift, for instance, the industrious student pilot might immediately consult *Webster's Seventh New Collegiate Dictionary* and find it defined as "The component of the total aerodynamic force acting on an airplane or airfoil that is perpendicular to the relative wind and that for an airplane constitutes the upward force that opposes the pull of gravity." Similarly, in training a child to identify examples and nonexamples of peninsulas on a world map, the following rule might be presented: "A peninsula is any body of land that is surrounded by water on all but one side." However, both student pilot and the young child would have to be provided another set of objects, symbols, or events if the terms used in the above indicated verbal rules were not sufficiently familiar to these learners. When used for the purpose of enabling the trainee to identify stimulus attributes to a particular entity of interest, a rule is primarily definitional in function. Similar uses of rule in this context have been frequently emphasized by a number of prominent instructional psychologists (e.g., Anderson and Faust, 1973; Ausubel, 1968; DeCecco, 1968; Gagnè, 1970).

Operation specification. In a closely related context, rules have been associated with operations for combining or otherwise elaborating stimulus characteristics to determine the selection of an appropriate response. Merrill and Wood (1974), for instance, define rule as ". . . an ordered relation consisting of a set of domain concepts, an operation, and a set of range concepts" (p. 22). Figure 2 illustrates the relationship between domain, operation, and range emphasized by Merrill and Wood. Scandura (1970, 1972, 1974a, 1974b) makes similar use of domain, operation, and range in defining rule in terms of set theoretic language: ". . . a rule can be denoted by a function whose domain is a set of stimuli and whose range is a set of responses" (1974a, p. 12). Many of the rules of symbolic logic and mathematics, as well as those frequently used in concept identification studies (cf. Haygood and Bourne, 1965) fit this category, since they are verbal specifications of the operations



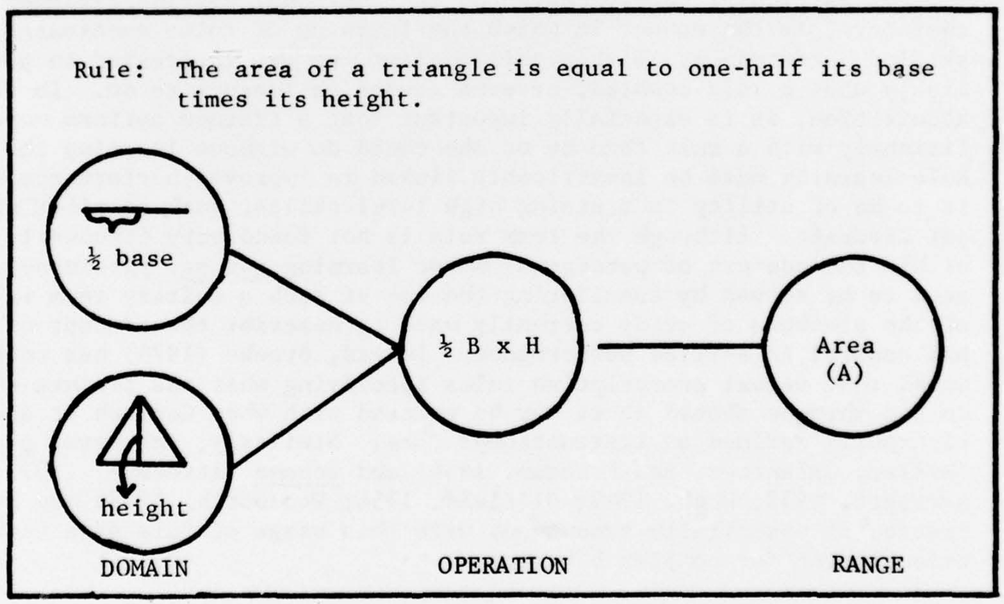


Figure 2. Two examples of operation specification rules expanded into Domain, Operation, and Range Components. (Adapted from M. David Merrill and Norman D. Wood, Instructional Strategies: A Preliminary Taxonomy. Ohio State University: ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, 1974.)

a learner must perform with a particular stimulus configuration in order to emit the desired response.

Behavioral prescription. A third use of rule differs from the preceding in terms of the behavior required of the trainee. When teaching a child to perform an operation such as "invert the divisor and multiply," for instance, the manner in which the child emits the appropriate response is usually of little consequence. If the quotient obtained is correct, the response could be emitted in the form of a vocalization, written symbols, or even punched into a computer teletype or teaching machine. In acquiring a complex perceptual motor skill, however, the form, or topography, of the trainee's response is of upmost significance. Consider the importance that the form of the student pilot's responses assumes when performing the descent portion of the Vertical S-A maneuver in accordance with rules such as "Hold the pitch steady at -50," "Adjust for deviations in vertical velocity with small corrections on the attitude indicator," or "Correct for airspeed with small power inputs." Topographical aspects of the student's behavior, such as the amount of force applied to the stick and the duration of that application, are clearly important in determining performance criteria under these latter conditions.

Of particular relevance to the instructional systems designer, therefore, is the manner in which the learning of rules eventuates in skilled performance. Within this context, we are interested in precisely what a rule enables, or even causes, a learner to do. In skill acquisition, it is especially important that a trainee perform more proficiently with a rule than he or she could do without learning the rule. Rule learning must be inextricably linked to improved performance if it is to be of utility in training high level skills, such as piloting a jet aircraft. Although the term rule is not found very frequently within the context of perceptual motor learning per se, parsimony would seem to be served by considering the use of such a unitary term in lieu of the plethora of words currently used to describe the concept of verbal control in skilled performance. Indeed, Brecke (1975) has recently noted that verbal prescriptive rules specifying what the trainee should do and when he should do it may be equated with what Gerlach et al. have rigorously defined as instructional cues. Similarly, the terms plan (Miller, Galantner, and Pribram, 1966) and schema (Attneave, 1957; Bartlett, 1932; Hebb, 1949; Oldfield, 1954; Woodworth, 1938) may be treated as essentially synonomous with this usage of rule as a verbal prescription for complex behavior.

III. Rule Learning and Skilled Performance

Rules and Instructional Cues

It is of interest to note a further similarity between rules and instructional cues. Although Brecke (1975) has suggested an identify between an instructional cue and the use of rule in the context of behavioral prescription, the earlier literature on instructional cues (cf. Schutz, Baker, and Gerlach, 1964) deals exclusively with academic tasks such as English and elementary mathematics--applications that might be more appropriately classified according to the categories attribute identification and/or operation specification. We might, therefore, consider the same classification scheme for instructional cues, or--more parsimoniously--opt for consistently using the more traditional term rule in place of instructional cue.

Algorithmization of Verbal Control

Gerlach, Reiser, and Brecke (1975) have recently described the potential of algorithms for problems of learning, teaching, and instructional design. According to Gerlach et al. ". . . an algorithm is a procedure which will produce the correct result when applied to any problem of a given class of problems" (p. 10). Just as rules may be classified according to their particular usage, different types of algorithms are required for different user requirements. Indeed, the possibility exists that each type of verbal control approach to shaping complex skills is amenable to algorithmization. The characteristics of each approach, described in Figure 1, differ according to the stimulus conditions presented to the learner and the response required of the learner. According to Gerlach et al., teaching algorithms provide a precise specification of the teaching procedure, or the manner in which stimulus conditions are arranged to ensure criterion performance by the learner. Learning algorithms specify a procedure for the learner to use in acquiring the appropriate response. In short, these two types of algorithms seem to hold particular promise as means of adapting verbal control approaches to enhancing the attainment of systematic training program objectives.

Rule-Governed and Contingency-Shaped Behaviors

Skinner (1969) distinguishes between behaviors that are shaped by environmental contingencies, largely without the use of verbal mediators, and behaviors that are primarily controlled by verbalizable rules that are usually conveyed through textbooks, manuals, or other forms of instruction (e.g., the briefing). The former are called "contingency-shaped" behaviors, while the latter are denoted "rule-governed." The close correspondence between Skinner's distinction and the procedure-technique difference (Reiser et al., 1972) is apparent; but little, if anything, is gained by simply exchanging one set of verbal labels for another. However, what is implied by Skinner's formulation is that the controlling variables are different for procedure and technique. It is possible that most skilled pilot behavior, as well as other skilled performance, is contingency-shaped. The dilemma of the instructor pilot lies in describing or instructing the student pilot on how to perform behaviors that are largely under the control of variables other than easily verbalized rules.

Judgment is a more-or-less undefined term used to refer to the rather global ability of producing appropriate responses rapidly, dependably, and rationally. The failure to consistently train pilots to acquire "good judgment" is evidenced by the high percentage of flight accidents attributable to pilot error. A pilot must be able to respond fast and effectively at the same time. The difficulty in training pilots to acquire this skill is closely related, if not identical, to the difficulties entailed in acquiring technique. "Good judgment," like technique, seems to be based largely on the skilled pilot's previous successful experiences in similar situations. Because judgment is also shaped by environmental contingencies, largely without the use of verbal mediators, it is difficult for the instructor to teach this to the student pilot.

The problem may be one of "proceduralizing technique." That is, it may be possible to infer rules by observing highly skilled instructor pilots perform difficult maneuvers. Functional rules might then be generated. However, if the controlling variables for acquiring procedure and technique are different, then we may actually interfere with or retard the student pilot's difficult task of attaining proficiency. For example, it is conceivable that once the basic procedures for a maneuver have been acquired by the student pilot, further attempts at providing verbal instruction are neither as efficient nor as effective as simply providing ample practice opportunities in the simulator. Refined performance may instead be acquired through training the student pilot to use the task-intrinsic feedback that occurs when he executes a maneuver in the simulator or actual aircraft. In short, acquiring strategies for "self-remediation" of one's own performance once the functional rules for performing the task have been mastered may constitute the optimal way to acquire technique or skill.

IV. Proposed Research Directions

Among the variables that seem most promising for study is a determination of the conditions under which verbal mediators, in the form of rules, facilitate the acquisition of skilled performance. The primary theme underlying the present paper has been the idea that excessive reliance on verbal control approaches may sometimes impede the development of the trainee's "feel" for the task at hand. This should not be confused with Skinner's (1966) suggestion that instruction *per se* interferes with an appropriate analysis of the contingencies maintaining behavior. Rather, it seems well established that verbal instruction can facilitate operant performance (*cf*. Kaufman, Baron, and Kopp, 1966). The instructional systems designer is particularly interested in determining the conditions and/or tasks for which the precise design of verbal information seems a realistic or feasible goal.

Methods need to be further refined and developed for standardizing in instruction technique; algorithmic or quasi-algorithmic approaches to the design of verbal information appear to be particularly promising in this area (Gerlach, Reiser, and Brecke, 1975). Training strategies can also be developed which rely less heavily on the trainee's learning of verbal rules in acquiring proficiency with a given task. For instance, learning algorithms might be developed for processing task-intrinsic feedback.

Potential approaches to shaping skilled repertoires, perhaps varying along a dimension of verbal control, might then be compared and evaluated in terms of a number of dependent measures, such as training time or number of trials to criterion, or number of errors in posttreatment assessment. Another relevant variable in assessing the trainee's development of proficiency concerns the extent to which he or she can identify deviations from correct performance of the desired task. Indeed, this is precisely what a highly skilled instructor pilot must do in evaluating the performance of a trainee.

In this context, it would appear to be highly worthwhile to investigate the effect of providing simulator training under a variety of instructional conditions on the development of the trainee's proficiency in correctly identifying performance deviations. In addition, such research should also assess the effects of algorithms or other systematic approaches on the development of the trainee's piloting technique, as evidenced both in the simulator and in the aircraft.

Appropriate control or baseline procedures also need to be established for contrasting and evaluating various levels of the independent variable *rule*. One potential method would involve a trial and error procedure in which the trainee is asked to perform, given only the objective for a specified task. That is, the trainee is told *what* he is to accomplish, but he receives no systematic instruction on *how* to perform (*cf*. Brecke, 1975). Incorporating such control procedures should permit an assessment of the extent to which the learning of verbal rules enhances the acquisition of skill on any given task. Repeated application of this design to a range of psychomotor tasks should enable us to begin drawing some conclusions regarding the types of tasks that are facilitated by systematic verbal instruction.

The personnel selection literature provides a number of approaches to the problem of characterizing various types of tasks that human operators perform. Fleishman (1975) has described four major approaches to task description and classification behavior description, behavior requirements, ability requirements, and task characteristics. In the behavior description approach, tasks are classified on the basis of observations and descriptions of what operators actually do while performing a task (McCormick, 1964). The behavior requirements approach systematically catalogs behaviors that are assumed to be required in order to achieve criterion proficiency (cf. Annett and Duncan, 1967; Gagne and Bolles, 1963; Miller, 1962). This approach emphasizes inferred processes that are assumed to intervene between stimulus and response (e.g., short-term memory, long-term memory, and decision making)--as opposed to the exclusive reliance on descriptions of overt behaviors emphasized by the behavior description approach. In the ability requirements approach, tasks are described and compared in terms of the abilities that a given task requires of the operator. The ability concepts are derived primarily through factor analytic studies (cf. Fleishman, 1972; 1975).

In the task characteristics approach, tasks are described in terms of a number of task-intrinsic properties that elicit performance, e.g., the goal toward which the operator works, relevant task stimuli, instructions, procedures, and characteristics of the responses required. Figure 3 depicts the conceptual scheme of task characteristics employed by Farina and Wheaton (1973). In describing a task, characteristics are rated on a 7-point scale by judges with a human factors background in accordance with the extent to which the task is typified by each characteristic shown in Figure 3. An exemplary task characteristic scale is presented in Figure 4; studies described by Farina and Wheaton (1973) indicate a high degree of inter-rater reliability across a number of task descriptive scales.

In the present research program, we are interested in classifying tasks or complex skills in a manner such that each category or class has specific training requirements associated with it. In particular, we need to determine the skill classes that are enhanced by the training methodologies employing various degrees of verbal control (cf. Figure 1). Once a framework is established for determining what skills are enhanced by these methods, we can begin designing alternative instructional modes for the remaining skills that are not readily acquired through verbal pretraining. Observational learning techniques, for example, may prove particularly useful in this area. Such methods have been found to be effective in teaching a variety of generalized language rules, abstract concepts or principles, Piagetian conservation responses, problem solving strategies, and creative responses (Zimmerman and Rosenthal, 1974).

Another potentially promising instructional modes involves the use of imagery by trainees to enhance their acquisition of technique.

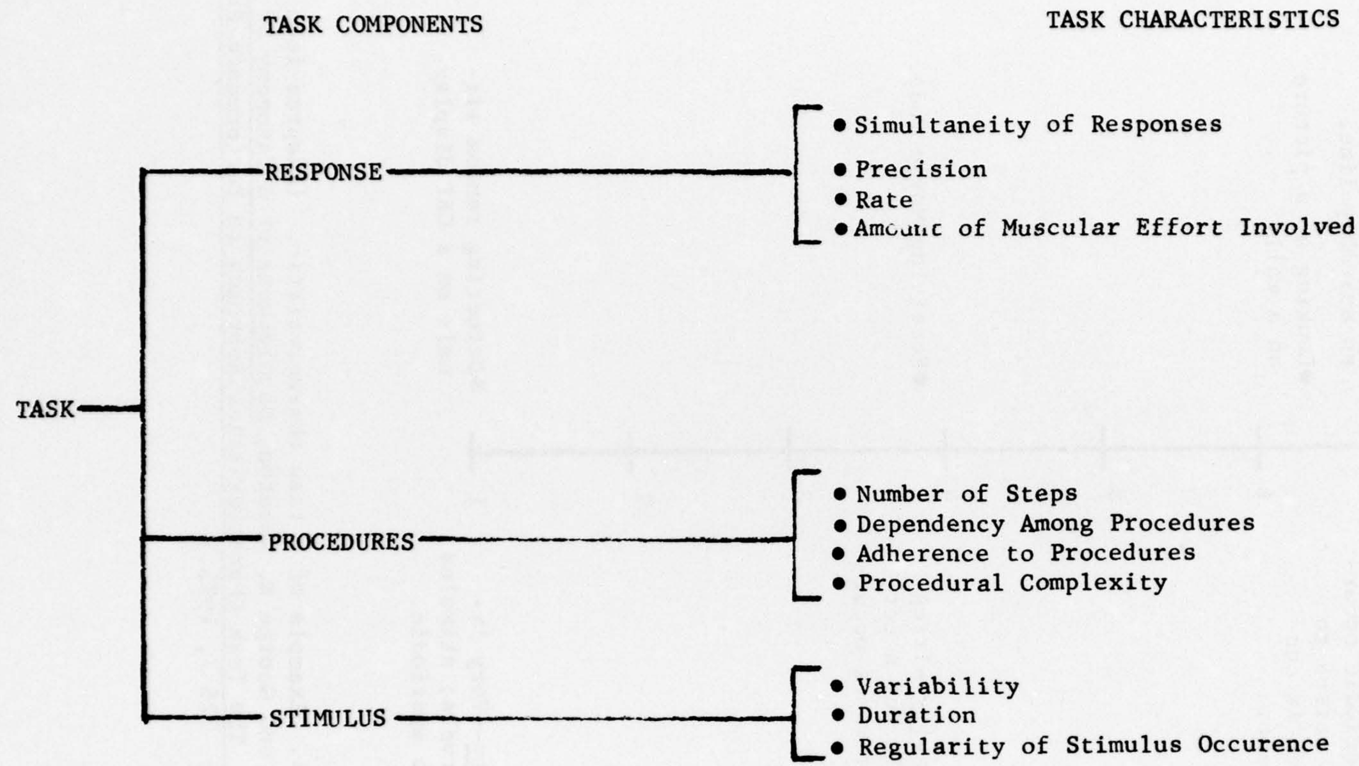


Figure 3. Conceptual scheme of task characteristics: Relationship among the terms task, components, and characteristic. (Adapted from Alfred J. Farina, Jr., and George R. Wheaton, Development of a Taxonomy of Human Performance: The Task Characteristics Approach to Performance Prediction, AIR Tech. Rep. 726-7, 1973.)

Rate the present task on this dimension.

Definitions	Scale	Examples
High regularity—Regular intervals, periodic occurrence. Also refers to stimulus which is constantly present.	7	•Responding to units on an assembly line. •Looking at a picture on a wall.
	6	
	5	
Medium regularity—Irregular intervals but a perceivable pattern of occurrence.	4	•Receiving Morse code.
	3	
	2	
Low regularity--Very irregular intervals; stimulus occurrence is aperiodic.	I	•Detecting random signals on a CRT display.

Figure 4. Example of a task characteristic. (Adapted from Alfred J. Farina, Jr., and George R. Wheaton, Development of a Taxonomy of Human Performance: The Task Characteristics Approach to Performance Prediction, AIR Tech. Rep. 726-7, 1973.)

Jacobsen (1973) has demonstrated that many individuals produce very small muscular responses as measured by an electromyograph when they are asked to imagine themselves performing a task, such as pumping a bicyle tire. These responses tend to occur in the same muscle groups that are employed by the individual in overtly performing the task. Of particular interest is the variety of individual differences exhibited in producing these "covert" responses. When directed to imagine themselves peforming a given psychomotor task, some subjects begin with minute stereotyped eye movements that correspond to subjective reports of visual imagery. Individuals who demonstrate the most pronounced eye movements tend to show few, if any, concomitant muscular responses that can be detected by currently available instrumentation. Conversely, individuals who demonstrate considerable skeletal muscle involvement in thinking about the task differ widely with respect to corresponding eye movements and reports of visual imagery.

What is the relevance of these data for systematic training applications? Individual differences in the ability to imagine or "imagize" oneself performing a task may be directly related to the extent to which proficiency is enhanced through training methods involving verbal instruction. That is, attempts to establish verbal control over subsequent motor responding may be less successful for individuals who are not skilled imagizers. Perhaps some of the previous studies involving mental practice or other verbal control approaches would have obtained more pronounced effects if these individual differences had been taken into account.

Two potential research thrusts are suggested. Given a well established relationship between UPT performance and the ability to imagize, methods for screening potentially successful program applicants could be investigated. Alternatively, both motor and visual imagery may constitute skills that can be acquired through systematic training methods. In this instance, the use of imagery training as a supplement to the repertoire of cognitive pretraining methods currently used in UPT could be investigated.

V. Summary and Concluding Comments

Of prime importance is a precise determination of the relationship between rule learning and the subsequent attainment of highly refined skills. During the course of our investigations, the tentative framework for viewing verbal control approaches to training complex skills may be refined or discarded in favor of a more workable model for the context of training applications. Regardless of the course dictated by these initial research efforts, the prime objective in our program is to develop and validate efficient methods for establishing skills that are currently difficult to train, such as "good judgment" and pilot techniques.

References

Adams, J. A. A closed-loop theory of motor learning. Journal of Motor Behavior, 1971, 3, 11-150.

Anderson, R. C., and Faust, G. W. Educational psychology: The science of learning. New York: Dodd, Mead, and Company, 1973.

Annett, J., and Duncan, K. D. Task analysis and training design. Occupational Psychology, 1967, 41, 211-221.

Arnoult, M. D. Stimulus predifferentiation: Some generalizations and hypotheses. Psychological Bulletin, 1957, 54, 339-350.

Attneave, F. Transfer of experience with a class-schema to identification learning of patterns and shapes. Journal of Experimental Psychology, 1957, 54, 228-237.

Ausubel, D. P. Educational psychology: A cognitive view. New York: Holt, 1968.

Baker, K. E., and Wylie, R. C. Transfer of verbal training to a motor task. Journal of Experimental Psychology, 1950, 40, 632-638.

Bartlett, F. C. Remembering: A study in experimental and social psychology. Cambridge, England: Cambridge University Press, 1932.

Battig, W. F. Transfer from verbal pretraining to motor performance as a function of motor task complexity. Journal of Experimental Psychology, 1956, 51, 371-378.

Brecke, F. H. Transfer from selected pretraining variables to a complex perceptual motor task. Unpublished doctoral dissertation, Arizona State University, 1975.

Brecke, F. H., Gerlach, V. S., and Shipley, B. D. Effects of instructional cues on complex skill learning. (Technical Report No. 40829, Project No. AFOSR 71-2128) Arlington, VA: U. S. Air Force Office of Scientific Research, 1974.

Cantor, J. H. Amount of pretraining as a factor in stimulus predifferentiation and performance set. Journal of Experimental Psychology, 1955, 50, 180-184.

DeCecco, J. P. The psychology of learning and instruction. Englewood Cliffs, NJ: Prentice-Hall, 1968.

Farina, A. J., Jr., and Wheaton, G. R. Development of a taxonomy of human performance: The task characteristics approach to performance prediction. JSAS Catalog of Selected Documents in Psychology, 1973, 3, 26-27.

Fitts, P. M., and Posner, M. I. Human performance. Belmont, CA: Wadsworth, 1967.

Fleishman, E. A. On the relation between abilities, learning, and human performance. American Psychologist, 1972, 27, 1017-1032.

Fleishman, E. A. Toward a taxonomy of human performance. American Psychologist, 1975, 30, 1127-1149.

Gagnè, R. M. The conditions of learning. New York: Holt, 1970.

Gagnè, R. M., and Baker, K. E. Stimulus predifferentiation as a factor in transfer of training. Journal of Experimental Psychology, 1950, 40, 439-451.

Gagnè, R. M., Baker, K. E., and Foster, H. On the relation between similarity and transfer of training in the learning of discriminative motor tasks. Psychological Review, 1950, 57, 67-79.

Gagnè, R. M., and Bolles, R. C. A review of factors in learning efficiency. In E. Galanter (Ed.), Automatic teaching: The state of the art. New York: Wiley, 1963.

Gagnè, R. M., and Foster, H. Transfer of training from practice on components in a motor skill. Journal of Experimental Psychology, 1949a, 39, 47-68.

Gagnè, R. M., and Foster H. Transfer to a motor skill from practice on a pictured representation. Journal of Experimental Psychology, 1949b, 39, 342-354.

Gerlach, V. S., Baker, R. L., Schutz, R. E., and Sullivan, H. J. Defining instructional specifications. Inglewood, CA: Southwest Regional Laboratory for Educational Research and Development, 1967.

Gerlach, V. S., Reiser, R. A., and Brecke, F. H. Algorithms in learning, teaching, and instructional design. (Technical Report No. 51201, Project No. AFOSR 75-2900) Bolling AFB, DC: U. S. Office of Scientific Research, 1975.

Goss, A. E. Transfer as a function of type and amount of preliminary experience with task stimuli. Journal of Experimental Psychology, 1953, 46, 419-428.

Goss, A. E., and Greenfield, M. Transfer to a motor task as influenced by conditions and degree of prior discrimination training. Journal of Experimental Psychology, 1958, 55, 258-269.

Haygood, R. C. Toward a definition of the expression "cognitive rule." Paper presented at the Annual Meeting of the Rocky Mountain Psychological Association, Las Vegas, Nevada, May 1973.

Fitts, P. M., and Posner, M. I. Human performance. Belmont, CA: Wadsworth, 1967.

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Fleishman, E. A. Toward a taxonomy of human performance. American Psychologist, 1975, 30, 1127-1149.

Gagnè, R. M. The conditions of learning. New York: Holt, 1970.

Gagnè, R. M., and Baker, K. E. Stimulus predifferentiation as a factor in transfer of training. Journal of Experimental Psychology, 1950, 40, 439-451.

Gagnè, R. M., Baker, K. E., and Foster, H. On the relation between similarity and transfer of training in the learning of discriminative motor tasks. Psychological Review, 1950, 57, 67-79.

Gagnè, R. M., and Bolles, R. C. A review of factors in learning efficiency. In E. Galanter (Ed.), Automatic teaching: The state of the art. New York: Wiley, 1963.

Gagnè, R. M., and Foster, H. Transfer of training from practice on components in a motor skill. Journal of Experimental Psychology, 1949a, 39, 47-68.

Gagnè, R. M., and Foster H. Transfer to a motor skill from practice on a pictured representation. Journal of Experimental Psychology, 1949b, 39, 342-354.

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Goss, A. E. Transfer as a function of type and amount of preliminary experience with task stimuli. Journal of Experimental Psychology, 1953, 46, 419-428.

Goss, A. E., and Greenfield, M. Transfer to a motor task as influenced by conditions and degree of prior discrimination training. Journal of Experimental Psychology, 1958, 55, 258-269.

Haygood, R. C. Toward a definition of the expression "cognitive rule." Paper presented at the Annual Meeting of the Rocky Mountain Psychological Association, Las Vegas, Nevada, May 1973.

Haygood, R. C., and Bourne, L. E., Jr. Attribute- and rule-learning aspects of conceptual behavior. Psychological Review, 1965, 72, 1975-195.

Hebb, D. O. Organization of behavior. New York: Wiley, 1949.

Jacobsen, E. Electrophysiology of mental activity: An introduction to the psychological process of thinking. In F. J. McGuigan and R. A. Schoonover (Eds.), The psychophysiology of thinking. New York: Academic Press, 1973.

Judd, C. H. Practice and its effects on the perception of illusions. Psychological Review, 1902, 9, 27-39.

Kaufman, A., Baron, A., and Kopp, R. M. Some effects of instructions on human operant behavior. Psychonomic Monograph Supplements, 1966, 1, 243-250.

McAllister, D. E. The effects of various kinds of relevant verbal pre-training on subsequent motor performance. Journal of Experimental Psychology, 1953, 46, 329-336.

McCormick, E. J. The development, analysis, and experimental application of worker-oriented job variables. (Final Report: ONR 1100) Lafayette: Purdue University, 1969.

Merrill, M. D., and Wood, N. D. Instructional strategies: A preliminary taxonomy. Columbus: ERIC Information Analysis Center for Science, Mathematics, and Environmental Education, The Ohio State University, 1974.

Miller, R. B. Analysis and specification of behavior in training. In R. Glaser (Ed.), Training research and education. Pittsburgh: University of Pittsburgh Press, 1962.

Miller, G. A., Galanter, E., and Prebram, K. H. Plans and the structure of behavior. New York: Holt, 1960.

Noble, C. E., Alcock, W. T., and Farese, F. J. Habit reversal under differential instructions in compound trial-and-error learning. Journal of Psychology, 1958, 46, 253-264.

Noble, C. E., Alcock, W. T., and Frye, R. L., Jr. The joint influence of practice and instructions on discrimination reaction time. Journal of Psychology, 1959, 48, 125-130.

Oldfield, R. C. Memory mechanisms and the theory of schemata. British Journal of Psychology, 1954, 45, 14-23.

Posner, M. I., and Keele, S. W. Skill learning. In R. M. W. Travers (Ed.), Second Handbook of Research on Teaching. Chicago: American Educational Research Association, 1973.

Prather, D. C. Prompted mental practice in a flight simulator. Journal of Applied Psychology, 1973, 57, 353-355.

Reiser, R. A., Brecke, F. H., and Gerlach, V. S. On the difference between procedure and technique in pilot instruction. (Technical Report No. 21128) Tempe, AZ: Arizona State University, Instructional Resources Laboratory, 1972.

Renshaw, S., and Postle, D. K. Pursuit learning under three types of instruction: Journal of General Psychology, 1928, 1, 360-367.

Richardson, A. Mental practice: A review and discussion. The Research Quarterly, 1967, 38, 95-107.

Scandura, J. M. Role of rules in behavior: Toward an operational definition of what (rule) is learned. Psychological Review, 1970, 77, 516-533.

Scandura, J. M. What is a rule? Journal of Educational Psychology, 1972, 63, 179-185.

Scandura, J. M. Structural learning, I. Theory and research. New York: Gordon and Breach, 1974a.

Scandura, J. M. Human problem solving: A synthesis of competence, psychological, and measurement approaches. Proceedings of the Fifth Annual Interdisciplinary Conference on Structural Learning, 1974b.

Schutz, R. E., Baker, R. L., and Gerlach, V. S. Measurement procedures in programmed instruction. Tempe, AZ: Arizona State University, Classroom Learning Laboratory, 1964.

Skinner, B. F. Operant behavior. In W. K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton, 1966.

Skinner, B. F. Contingencies of reinforcement: A theoretical analysis. New York: Appleton, 1969.

Wood, M. E. Transfer from audiovisual pretraining to an instrument flight task. Unpublished doctoral dissertation , Arizona State University, 1973.

Woodworth, R. S. Experimental psychology. New York: Holt, 1938.

Zimmerman, B. J., and Rosenthal, T. L. Observational learning of rule-governed behavior by children. Psychological Bulletin, 1974, 81, 29-42.

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The role of verbal control during the initial stages of acquiring complex perceptual-motor skills has been frequently emphasized by instructional psychologists. Although the learning of verbal rules, or cognitive pretraining, is clearly at the heart of systematic training, the term rule has not been defined in a manner that either avoids unsubstantiated generalizations or clearly specifies the manner in which the learning of rules eventuates in skilled performance. A framework for viewing methods that emphasize verbal control in training complex skills is provided, along with (Cont. on back)

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20. Abstract (Continued)

a description of different uses of the term rule as it relates to skill acquisition. Implications of this framework for subsequent training research are discussed, suggesting methods for empirically verifying the idea that excessive reliance on verbal control approaches may actually impede the trainee's progress in attaining certain skills, such as piloting technique. In short, the primary objective of the proposed research program is to develop and validate efficient methods for establishing skills that are difficult to train using state-of-the art instructional design technologies.