The Design of Stimulus Materials in Response-Oriented Programs[1]

GEORGE L. GROPPER

STIMULUS- VS. RESPONSE-ORIENTED MATERIALS

Evidence from a decade of research on programed instruction and evidence from earlier decades of research on film-mediated instruction provide ample support for the behavioral view that *active responding* is a necessary condition for learning. Sharing this view, this paper will propose and offer some evidence to support the collateral view that the impact of response practice on learning effectiveness and efficiency can be heightened by the systematic organization of *stimulus* materials that control such practice. This is an historical account of the development of techniques for the *spatial* organization of stimulus materials in response-oriented programs. It will provide some preliminary evidence concerning the efficiency of the

[1] This paper was prepared as part of a contract with the Bureau of Naval Personnel, Contract #N-00022-68-C-0106.

George L. Gropper is principal research scientist at the American Institutes for Research, Pittsburgh.

techniques. It will demonstrate that the length of verbal programs and the time it takes to complete them can be substantially reduced; it will further show that this is possible without any ensuing loss of instructional effectiveness. And, indeed, it offers a rationale for the expectation of heightened effectiveness. It will attempt to support the proposition that the practice of, and therefore the acquisition of, discriminations, generalizations, and chains can be facilitated by the spatial organization of stimulus materials.

Discussions of instructional strategies have in recent years made clear that the differences between instructional approaches that are stimulus-oriented and approaches that are response-oriented rest on a fundamental distinction. The stimulus approach stresses the overriding importance of the design of the stimulus materials to be presented. It is the clarity and organization of these materials that make for effective learning. Those supporting the response approach, in contrast, insist that it is the character of response practice which is crucial. The student learns the responses he practices. No matter how well organized the instructional presentation is, to be optimally effective, instruction must provide for response practice.

Klaus (1965) has categorized programers according to their preferences for the two differing approaches. Gropper (1966) has similarly categorized audiovisual specialists with the same distinctions in mind. Most audiovisual specialists are concerned with the *presentation* of information and may, therefore, be dubbed stimulus-oriented. The most visible exceptions include a relatively small number of behaviorally oriented film and TV researchers whose work is summarized in the Lumsdaine (1961) volume on active responding. How do programers, audiovisual specialists, or behaviorally oriented instructional technologists who are *response-oriented* view the stimulus presentation problem?

Responses are not made in a vacuum. Even the harshest critics of S-R psychology admit that responses are made in the presence of appropriate stimuli. The automobile driver applies the brakes when the traffic light turns red. The student responds appropriately, composing a verbal answer when a test question is asked. The stimuli, whether visual or verbal, make up the criterion contexts in which or to which people respond. To be able to respond correctly, the novice in an automobile or a beginning student has to be able to: a) discriminate among stimuli (e.g., tell the difference among colored lights); b) generalize across stimuli (e.g., see the similarity among red lights, stop signs, the palm of a policeman's hand); and c) associate responses with stimuli (e.g., stop when the light is red). Because these are prerequisite skills for successful performance, the behaviorally oriented trainer or educator makes provisions for the learner to practice them. For that purpose, he devises practice situations containing criterion stimuli or contexts. Since the learner must *practice* discriminating among stimuli, generalizing across stimuli, and associating stimuli and responses, the response-oriented technologist does indeed have to organize (in some fashion) and present criterion stimuli in training.

Other stimuli, again visual or verbal, are built into practice situations. They serve as cues or clues. They assist the learner to make discriminations; they assist him to form generalizations; and they assist him to form simple associations or the long sequences of associations called "chains." The learner may be shown a demonstration of the connection of opposite and like poles between a power source and a semiconductor and then be asked to define forward and reverse bias. Or, the learner may be given visual or verbal examples of what happens to solids, liquids, or gases when heat is applied to them and may then be asked to state how heat affects matter. These varying types of cues are a second class of stimuli which find their way into practice opportunities to *assist* the learner in responding to the first class, the criterion stimuli. By the end of training or instruction, the cues or clues are withdrawn and the learner responds appropriately, and without help, to the criterion stimuli.

His theoretical position leads the response-oriented technologist to insist on practice of responses. But, as has just been described, he also goes to great lengths to organize stimulus materials to provide appropriate contexts for and to ensure the correctness of the responses that are practiced. How then does he differ from his stimulus-oriented counterpart?

It would be inaccurate to assert that the response-oriented instructional technologist does not share with the stimulus-oriented technologist a concern for the clarity of the verbal stimulus materials (whether as contexts or as cues) he presents to the learner. Nor would it be accurate to deny his like concern for selecting vocabulary, style, or grammatical complexity suitable for his target audience. The difference between them lies in the systematic approach the response-oriented technologist takes in organizing stimulus materials so that the practice of relevant discriminations, generalizations, and chains may be optimally facilitated. Contrast in contexts are heightened to facilitate the practice of difficult discriminations. Similarities in contexts are identified to facilitate the practice of generalizations. The practice of long chains is facilitated by careful selection of and variation in the size of the practice unit. Thus, it is not simply a question of how to present a context in the clearest possible way. It is a question of presenting the kinds of contexts and the kinds of cues that can contribute optimally to the acquisition of the skills that underlie all types of learning; i.e., discriminations, generalizations, and chains. This means arranging stimulus contexts so that the learner can practice *responding* appropriately to them, and it means arranging stimulus cues so that the responses practiced are correct responses.

Cue presentation is systematically varied at different stages of learning to assure the practice of correct responses. Cues are made strong in early stages of learning and gradually weakened as learning progresses. Ideally, no more cuing is offered at any stage than is required by the learner. By gradual withdrawal of support and the gradual stretching of the learner, response practice produces a learner capable of criterion performance.

This report concerns the recent development of new techniques for organizing and presenting stimulus materials (in response-oriented programs) that can contribute to the heightened effectiveness and efficiency of response practice.

A DEVELOPMENTAL HISTORY

The spatial arrangement of words or pictures easily lends itself to the organization of stimulus material to facilitate learning. Physically separate but adjacent material lends itself to the identification of differences on which discriminations rest. Grouped material, on the other hand, lends itself to the identification of similarities on which generalizations rest. Further, sequential ordering of material lends itself to the identification of connections on which associations and chains rest. These spatial variables (separation, adjacency, grouping, and ordering) have been applied for these purposes in a series of developmental, programing efforts. With each new application, the techniques have undergone modifications that sometimes merely reflected adaptation to new instructional goals but at other times reflected refinement. These applications will now be discussed and illustrated.

A Program to Train Trainers How to Develop Instructional Materials (Gropper & Short, 1969a; Short & Gropper, 1969)

The earliest application of "spatial organizing techniques" appears in a handbook that is part of a program designed to train trainers how to apply behavioral principles to the design of instructional materials. The program was prepared under the sponsorship of the Bell Telephone Laboratories.

The handbook accompanies, and is intended to serve as a guide to, a workbook in which trainers practice applying behavioral principles to the preparation of instructional materials. The handbook was designed to serve both as a training aid and, upon completion of training, as a job aid.

Several illustrative uses of spatial organizing techniques taken from the handbook follow. Each of the following diagrams illustrates how one or more of the spatial variables (separation, adjacency, grouping, or ordering) can be used to facilitate discriminations, generalizations, or chains.

FIGURE 1

An Example of the Use of Separate and Adjacent Squares to Teach Discrimination

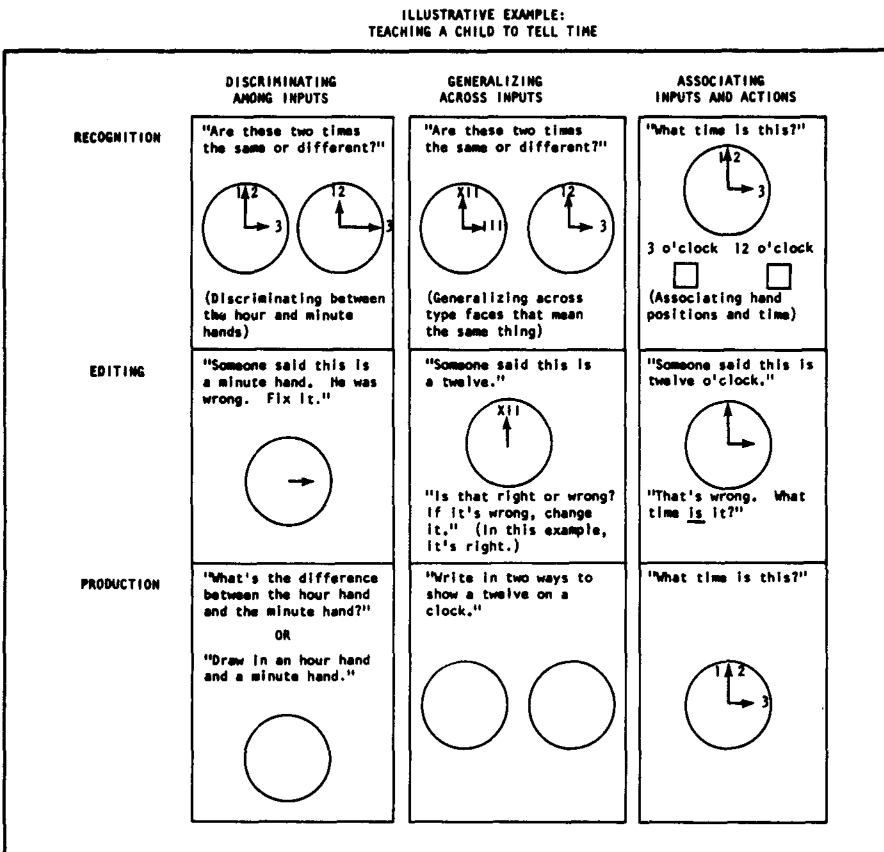


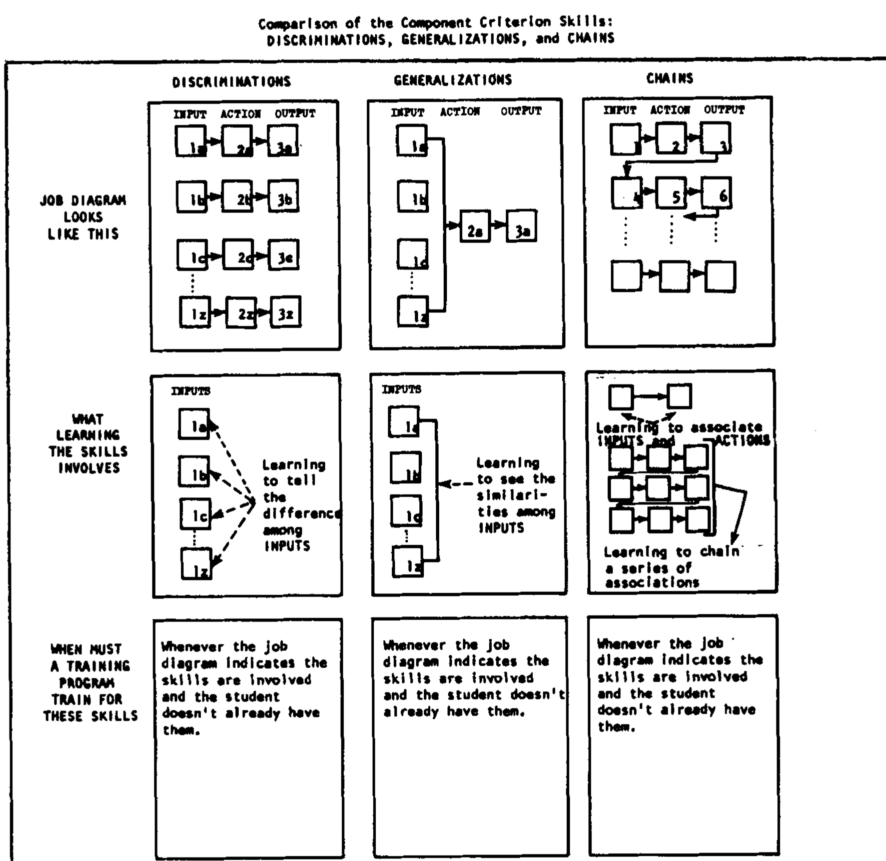
Figure 1 presents to the trainer a variety of types of practice items that he can use to teach a child how to tell time. Separate rows help him to distinguish between recognition, editing, and production items he can use. Separate columns help him to distinguish between the various instructional roles each of these types of items can play. The matrix comprehensively presents all the possible item types. Their display in physically separate, but adjacent squares helps the trainer learning about various types of practice to identify the key distinctions between them. Physically separate but adjacent display helps facilitate the acquisition of relevant discriminations.

Figures 2 and 3 provide further examples of the display of physically separate but adjacent materials the trainer must learn to identify as being different. Spatial organization makes for a direct, immediate confrontation, thereby facilitating the trainer's task of learning the essential distinctions. He can readily distinguish between job diagrams indicative of discriminations, generalizations, or chains he will have to teach *his own students.*

The two illustrations also provide examples of the use of sequential ordering to teach associations. Figure 2 probably uses this spatial variable less well than Figure 3. The former uses a vertical, downward order to identify elements to be associated.

FIGURE 2

An Example of Sequential Ordering to Teach Associations



For example, in the far left-hand column, the top square (a job diagram) is to be associated with the square below it (a verbal identification of a skill to be learned) and this square in turn is to be associated with the square below it (a verbal rule about providing appropriate practice). This latter association is better diagramed in the illustration in Figure 3. The more customary left-to-right order is used; and, in addition, connecting arrows leave no doubt as to what is to be associated with what. The spatial ordering of materials can facilitate not only the acquisition of simple associations, but also the acquisition of long chains.

FIGURE 3

An Example of a Different Sequential Ordering to Teach Associations

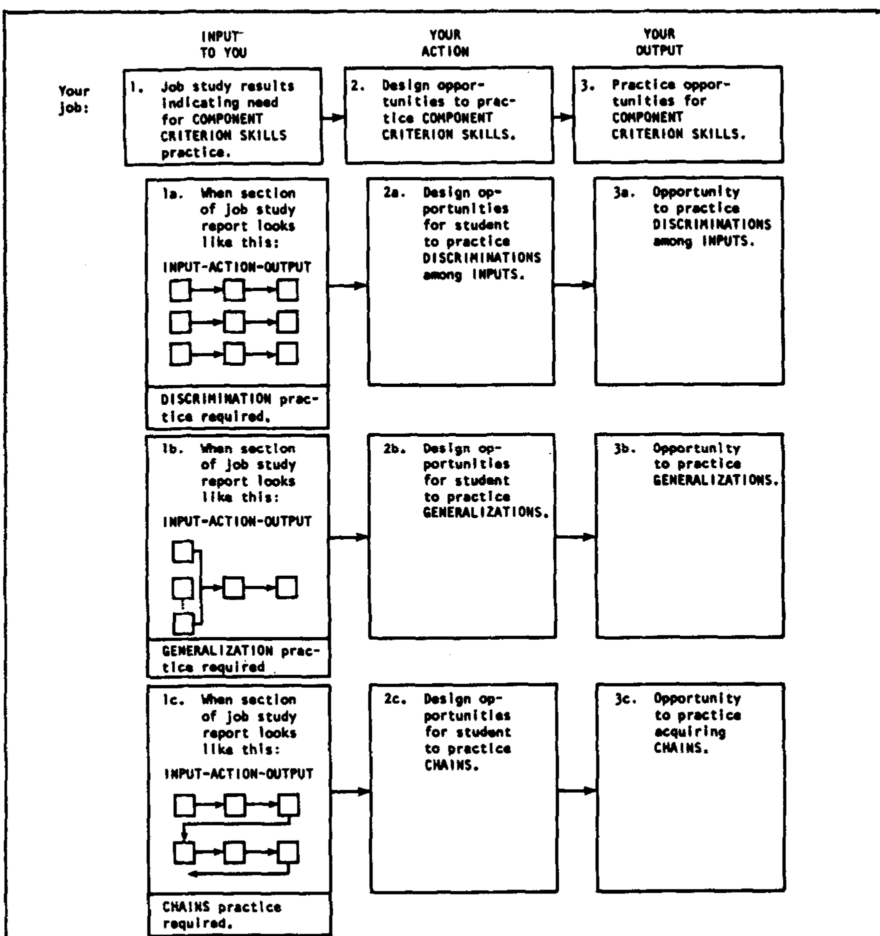


FIGURE 4

An Example of the Use of Spatial Separation, Adjacency, and Grouping to Teach Generalizations and Discriminations

SUMMARY RULES

	INPUT TO YOU		YOUR ACTION		YOUR OUTPUT
Your job:	INPUTS to students to be DISCRIMINATED.	→	Review INPUTS for three characteristics that create potential DIFFICULTIES in DISCRIMINATION.	→	Characteristics of INPUTS identified as posing DIFFICULTIES in DISCRIMINATION.

RULES ABOUT YOUR OUTPUT — EXAMPLES

When Inputs To Students Are To Be Discriminated	Positive Indication of Difficulty	Negative Indication of Difficulty
1. Determine whether inputs are highly similar (physically, conceptually, etc.) so that it is difficult to distinguish the differences among the inputs.	e.g., a musical note just slightly off pitch e.g., a soldering job virtually identical to a standard	e.g., a musical note markedly off pitch e.g., a soldering job amateurish and off the mark from the standard
2. Determine whether inputs have to be discriminated on the basis of more than one characteristic, so that it is difficult to distinguish among the inputs.	e.g., sorting produce on the basis of size, freshness, and firmness	e.g., sorting produce on the basis of freshness alone
3. Determine whether the number of inputs to be discriminated is large, so that it is difficult to discriminate or distinguish among the inputs.	e.g., the performance of 25 subordinates (inputs) to be ranked by a manager	e.g., the performance of 5 subordinates (inputs) to be ranked by a manager

One final illustration, Figure 4, provides an example of the use not only of physical separation and adjacency to facilitate discriminations, but also of grouping to facilitate generalizations. The last two columns provide the trainer, who has to determine when *his* students might or might not have learning difficulties, with adjacent, contrasting examples of such situations. In addition, grouping more than one example within a square helps the trainer to learn to generalize across situations that represent the same type of learning difficulty his students might experience. Separation, adjacency, and grouping are the spatial variables that heighten the effectiveness of presenting positive and negative examples.

The handbook used in the program to train trainers did not consist solely of diagrams of the kind just discussed. While the handbook was largely diagramatic, it also contained conventional textual material presented in paragraph form. Performance on workbook exercises thus was a joint function of the adequacy of both diagramed and nondiagramed materials. Results bearing on the effectiveness of the diagraming techniques per se had to wait for another project in which only diagrams were used.

A Program on Basic Electronics (Gropper, 1969)

The first opportunity to assess the impact that diagraming per se can have occurred in a project conducted under the sponsorship of the Bureau of Naval Personnel. A program was prepared on two topics from a course in basic electronics. Presented by means of conventional instruction, the two topics (covering semiconductors) take up four to six hours of the course. As will be noted below, the time required for the programed version that was developed was less than half the lesser of these two times.

The programed lesson consisted of a brief film sequence (requiring active responding), a reference booklet (comparable to a handbook), and a workbook. The reference booklet consisted solely of diagrams (one of which is shown in Figure 5). No textual material accompanied it. Following a recommended, careful study of a reference page, students (Navy enlisted men) were instructed to do workbook problems (examples of which are shown in Figure 6). Students solved problems first while still consulting the reference page, then without it. Final, criterion performance for most objectives consisted of production of a verbal chain (e.g., stating the principle that explains how the size of an atom influences its resistance to electrical current). Before discussing the role that the diagrams play and their advantages, results concerning their effectiveness and efficiency will be presented.

Evaluation of program effectiveness. A 68-item criterion test was developed to assess the effectiveness of the program. The test consisted of a mixture of multiple choice recognition items and production items (calling for definitions, statements of principles, identification of parts of circuit diagrams, etc.). The test was administered as a "before" test approximately two weeks before participating Navy enlisted men took the program. The test was administered not only to this group, the experimental group, but also to a control group which was to receive conventional instruction (prepared by nonproject Navy personnel and based on the same objectives). Included in both experimental and control groups was a group of men receiving instruction in the topic for the first time and a group of men repeating the topic (having had prior conventional instruction but having failed to meet qualification standards). All men were assigned at random to experimental and control groups.

The matrix below illustrates the distribution of repeaters and nonrepeaters within experimental and control groups.

	Experimental	*Control*
Repeaters	6	13
Nonrepeaters	17	9
Total	23	22

FIGURE 5

Example of Diagram from Reference Booklet

HOW THE SIZE OF AN ATOM
INFLUENCES RESISTANCE TO CURRENT

(1) Compare: a large atom in row "a" with a small atom in row "b" below.
(2) Relate each factor to the factor to its right.

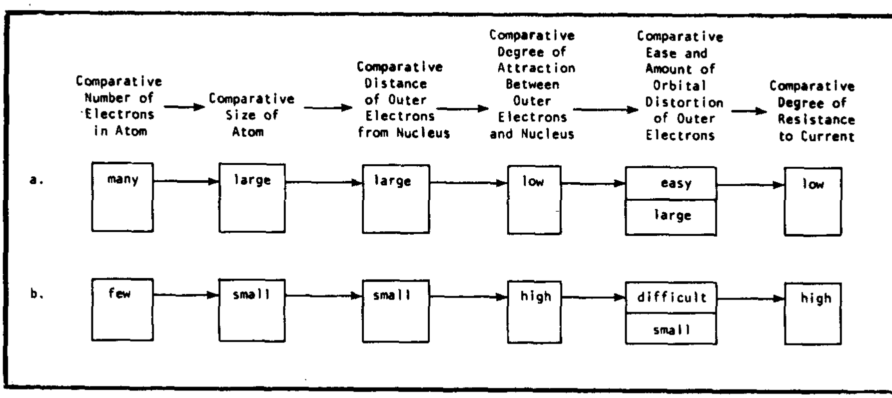


FIGURE 6

Sample Practice Problems from Workbook

You may refer to page 1 in the REFERENCE BOOKLET while answering the following questions:

1. Having more electrons in an atom makes the size of the atom — X larger ___ smaller
2. An atom being larger makes the distance between outer electrons and nucleus — X greater ___ smaller
3. The greater the distance an electron is from the nucleus makes the degree of attraction to the nucleus — ___ higher X lower
4. The higher the degree of attraction to the nucleus makes an electron — X harder to distort ___ easier to distort
5. The more difficult it is to distort an electron makes the resistance to current — X higher ___ lower

Table 1 presents means and standard deviations for error distributions on the criterion test. A comparison and statistical analysis of the differences between "after" scores for experimental and control groups reveal that the experimental group made significantly fewer errors than the control group. This was true for repeaters, nonrepeaters, and both taken together. Table 2 provides a frequency distribution of errors on the "after" test for the combined groups. The rectangles in each column contain the cases falling *below* the mean error score of the *control* group. They provide a graphic illustration, supplementing that provided by distribution means, of the difference in performance between experimental and control groups.

Achievement results for the experimental group may be summarized as follows:

Test Score	*Percentage of Students*
90% or above	78%
80% or above	96%

These results were obtained on the *first* field tryout of the

TABLE 1
Comparison of ERRORS on Criterion Test for Experimental and Control Groups

	BEFORE		AFTER	
	Experimental	Control	Experimental	Control
Non-repeaters				
$\bar{X}$	47.8	26.2	5.4*	12.1*
S.D.	12.1	9.5	5.5	12.0
N	17	9	17	9
Repeaters				
$\bar{X}$	23.3	18.2	4.0**	10.9**
S.D.	7.0	9.0	1.9	1.6
N	6	13	6	13
Combined				
$\bar{X}$	41.4	21.4	5.0***	11.4***
S.D.	15.3	7.6	4.9	2.4
N	23	22	23	22

*t = 3.27, P > 1% **t = 7.67, P > .1% ***t = 5.43, P > .1%

program (the program thus having undergone *no* revision based on large-scale field tryout).

More impressive than results of performance are *time* data. The conventional course (lecture, reading, demonstration) takes from four to six hours. The longest any student took on the programed material was 81 minutes. The range of time-to-complete was 42 to 81 minutes. The mean time was 64.1 minutes; the standard deviation was 12.2. There is no doubt that lecturers in the conventional course spent time dealing with additional content not identified in the statement of objectives. Even discounting as much as an hour or two for this "enrichment" material, the experimental group still required considerably less time.

Solicited comments from participating students produced descriptions of the experimental program by approximately two-thirds of them. Almost uniformly, their comments indicated that the program was clear and easy.

TABLE 2
Frequency Distribution of "After" Error Scores for Combined Group[a]

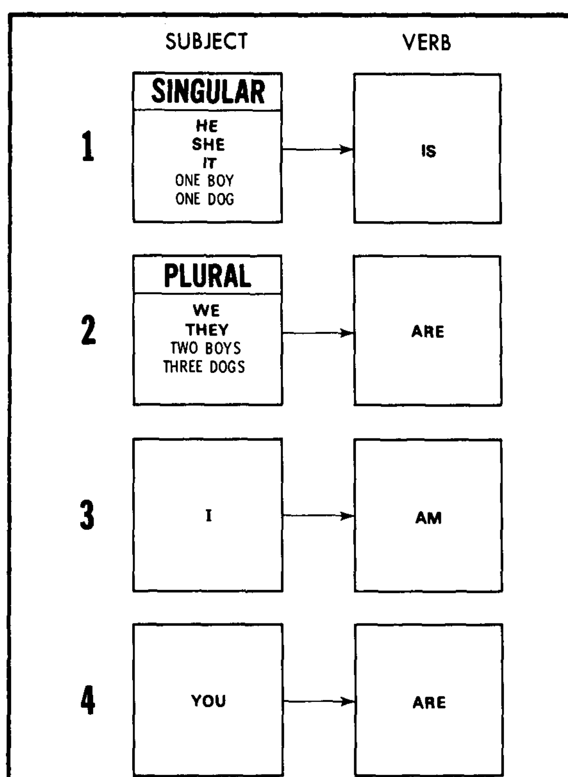
	EXPERIMENTAL	CONTROL
24-25	I	
22-23		
20-21		
18-19		
16-17		II
14-15		I
12-13		卌 II
10-11	I	卌 III
8-9	II	IIII
6-7	IIII	
4-5	卌	
2-3	卌 II	
0-1	III	

[a] Total possible number of errors is 68.

Discussion of results. It is granted at the outset that a comparison of a program with a conventional course leaves much to be desired. The only "variation" being assessed is the skill of the personnel who developed either set of materials. Nevertheless, they are the only data available. What can they tell us? Can they tell us anything about a specific feature of a program, for example, a variable such as spatial organization?

The reader should at this point review the workbook practice items in Figure 6. Practice items contain only criterion information. There are no clues as to what the correct answers are. The references pages alone supply them. Whatever success students had in solving workbook problems is due solely to the diagramed material in the reference booklet. Similarly, when students commented on the clarity of the program, it is unlikely that they are referring to the language of the *work-*

FIGURE 7
Example of Application and Advantages of Diagraming Technique



book problems. While their comments did not specifically identify the diagrams as the reason for the perceived clarity of the material, it is more likely that they were referring to the diagrams than to the workbook problems. As indicated by "before" test results, most problems could not have been solved without the diagrams.

Systematic variations of programs (e.g., with or without squares) undoubtedly would be more convincing than the evidence at hand. But the evidence at hand does suggest that the program was both effective and efficient; and the contingent relationship between reference pages and workbook problems identifies the diagrams as a major variable in producing such results.

A later section of this report will provide a more detailed discussion of the relationship between characteristics of reference pages, the type of response practice it makes possible, and the degree of learning effectiveness and efficiency they jointly make possible. But, first, examples of application of spatial organizing techniques to other types of learning tasks will be offered.

Teaching Standard English to Speakers of Nonstandard Dialects (Gropper & Short, 1969b)

The diagram in Figure 7 is part of printed materials, both visual and verbal, that accompany a taped, oral program developed for the Office of Economic Opportunity. The diagram, one of several, was built into the program following the successful use of the diagraming techniques in the Navy project just described.

The language diagram can serve as the prototype of the diagraming technique. It provides a highly clear-cut example of its application and advantages.

Spatial organization of stimulus materials. The language diagram provides an example of how spatial variables may be used to organize stimulus materials. Two purposes are served by placing squares in adjacent positions. In the *subject* column, the vertically adjacent squares help to focus attention on the contrasts between sentence subjects that have to be discriminated. Horizontal adjacency (in concert with connecting arrows) helps to identify subjects and verbs that have to be associated.

The enclosure of classes of subjects in squares and their physical separation facilitates discriminations among them and, in addition, helps to identify which subject goes with which verb. The grouping of subjects within the enclosure of a square facilitates generalizations (e.g., all singular subjects take *is*—with exception of *I* and *you*).

Amount of stimulus material in diagrams. The spatial variables (adjacency, separation, grouping, enclosure, or order) do not exhaust the properties of the diagrams that can account for their effectiveness. Effectiveness is also a function both of *how much* and *how little* material is in the diagram. The sparseness of material within each square (contrast it with the density of conventional paragraphs of material or even three or four lines of a program frame) makes for readier access to the material. Observing responses on which the learning of discriminations and discriminative responses themselves depend are both facilitated by the lean amount of material in the squares. On the other hand, the *total* inclusion within one diagram of all classes of stimuli and the responses to be associated with them also facilitates learning effectiveness. A big picture of the rules for using *is, are,* or *am* is provided in one "map" which, in addition, provides for easy access to any one location. With the whole rule before him clearly summarized, the learner can engage in practice involving any small part of that rule and not lose sight of its relationship to other parts. The diagram aids the learner to identify easily that part of the rule which applies to the practice problem at hand.

Training Teachers in the Use of Behavioral Principles to Manage Problem Behavior in the Classroom (Gropper & Kress, 1970; Kress & Gropper, 1970)

Under the sponsorship of United Mental Health Services of Allegheny County, Inc., a program was prepared to train teachers to apply behavioral principles to the management of problem behavior in the classroom. The program taught concepts and principles about such an approach, but it was designed primarily to teach how to implement the approach. The diagrams in Figures 8 and 9 are from a handbook that accompanies a revised version of the program. In Figure 9 the diagram's *ordering* of squares aids the discrimination between occasions to

FIGURE 8

Use of Spatial Ordering Used to Aid Verbal Chaining

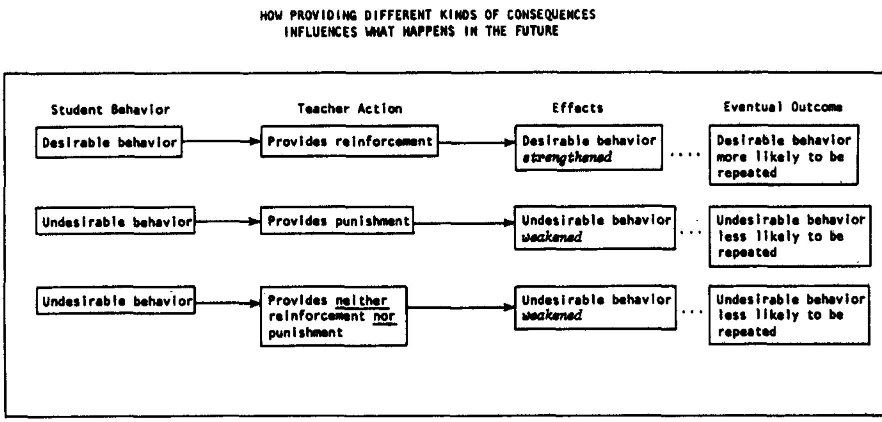
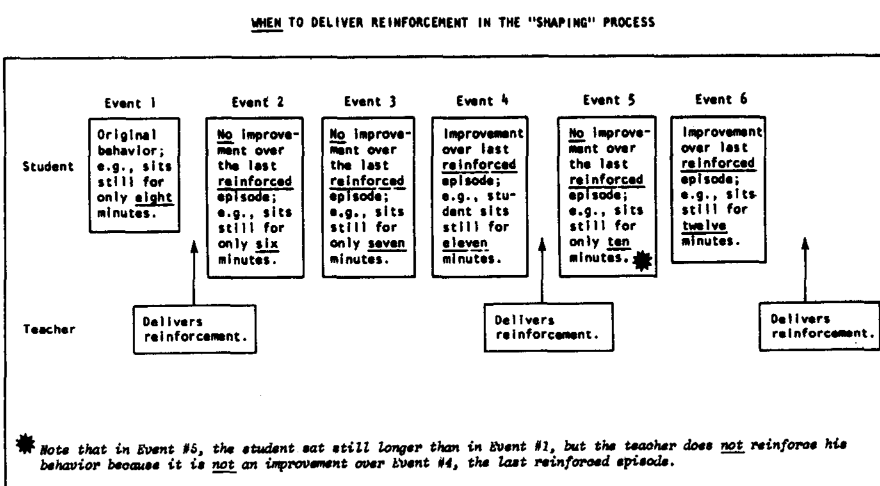


FIGURE 9

Sequential Ordering Used to Facilitate both Discriminations and Chaining

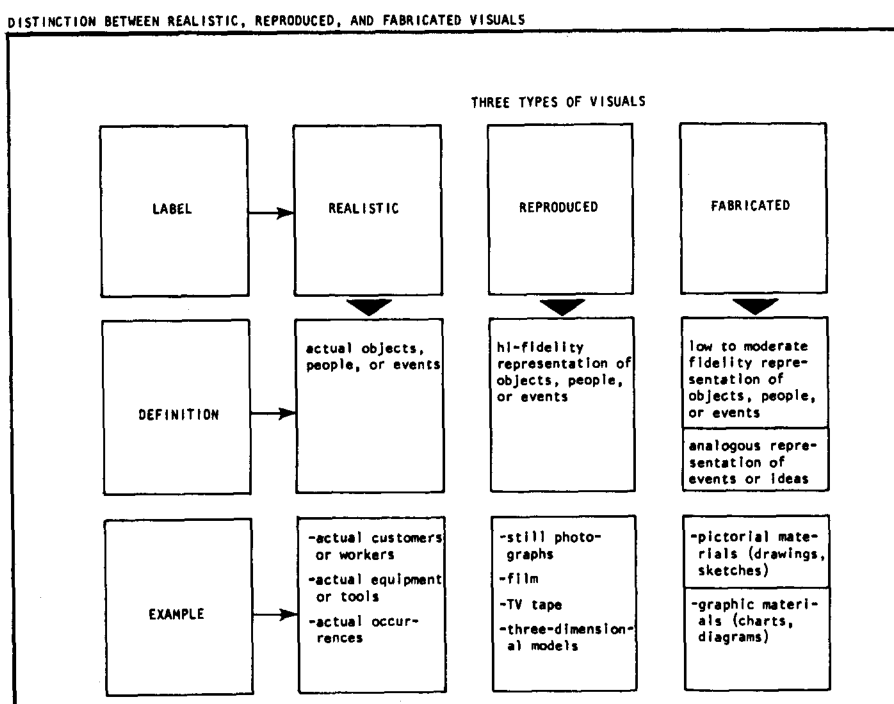


and not to deliver reinforcement. Both diagrams illustrate how the sequential ordering of stimulus materials (in squares) can be used to facilitate either verbal chaining (i.e., a verbal description of how the probability of responding is increased) or procedural chaining (i.e., delivering reinforcement at the appropriate time in the shaping process).

Providing Trainers or Audiovisual Specialists with Criteria for the Selection and Use of Visuals in Instruction (Gropper & Glasgow, 1969; Gropper, Glasgow, & Klingensmith, 1969)

A principal product of the Navy project described earlier was a program designed to train training personnel or audiovisual personnel in the selection and use of visuals in instruction. The program consisted of a handbook and a program. The concepts, principles, and application procedures covered overlap to a high degree with those covered in the training package developed for the Bell Telephone Laboratories (described previously). A primary difference resides in the emphasis on visuals in the Navy program. There are other differences, equally fundamental, in format. Although there was substantial reliance on clearly separate squares, the Bell handbook relied heavily on tabular formats and large amounts of accompanying textual materials. The Navy handbook, in contrast, is all

FIGURE 10
Page of Definitions from Handbook



squares. (Part of the content of this latter program deals precisely with the instructional functions served by the spatial organization of stimulus materials, obviously a *visual* issue.)

A typical page from the Navy handbook appears in Figure 10. Based on a reading of this definitional page and another page of additional examples, the student then proceeds to the

FIGURE 11

Practice Items in Workbook Accompanying Handbook

EXERCISE #1

I. Recognize

A. Classify the following types of visuals by checking the appropriate column.

Visual	Realistic	Reproduced	Fabricated
1. Chart showing net corporate earnings for twelve-month period			
2. Scale model of car			
3. Cartoons			
4. Airplane panel			
5. Flight simulator panel			
6. Outboard motor			
7. Job study diagram			
8. Automobile coming off assembly line			
9. Photograph of a computer keyboard			
10. Spare automobile parts			

type of practice problems shown in Figure 11. The types of problems shown, as well as those shown in Figures 5 and 6, illustrate the possible departures preparation of practice items can have from that used in most programs. The student is allowed to work on several problems with a reference diagram before him. He then is required to work on other problems without its aid. Unlike most programs which consist of a sequence of frames in which cuing strength is systematically varied from frame to frame, cuing in this program consists of a diagram applicable to a *series* of problems. Following completion of this first series of problems, the diagram is withdrawn and is not available as the student works on the same or a new series of problems. Cuing student responses thus becomes an all-or-none affair. The burden in program development thus shifts from the preparation of cues appropriate to individual practice items to the preparation of cues (i.e., diagrams) appropriate to multiple practice items.

Except for the language program described above, all the programs discussed consisted of a workbook containing practice problems and a handbook containing diagrams designed to facilitate (i.e., cue) practice in solving the problems. The handbook can also serve an important function upon completion of instruction. The properties that make it serve its cuing function well during training or instruction also allows it to serve the post-training reference function. Handbook pages can be used as job aids or as reference sources. Because diagrams can be used to present "the big picture," a single diagram may summarize all information bearing on *criterion performance* (for any part of a job or any part of a subject matter). Thus, the total number of pages summarizing a complete instructional unit can be small. Because the number of pages is small and because each page contains squares presenting condensed amounts of information, *access* to information in a diagramed handbook is facilitated. It is easier than access to the same information would be if it were presented either in a typical programed text or in a conventional text. Thus, the preparation of a diagramed handbook designed to accompany a consumable workbook results in an easily used, permanent reference source.

DISCUSSION

Since discriminations, generalizations, or chains in varying combinations and in varying degrees underlie all types of learning tasks, spatial organization of stimulus materials has the potential for diverse applications. The applications described in this report have included: a) language learning; b) learning facts, concepts, and principles (in physical science, behavior theory, and instructional technology); and c) learning procedures (using behavior theory-based management techniques in the classroom and using behavior theory-based techniques for developing materials in training or education).

In all their applications, the *effectiveness* of the techniques that were used appears to depend on two properties of diagrammatic presentation: spatial organization and the capacity to present the "big picture."

Spatial Organization of Stimulus Material

The use of two-dimensional blocks (if that is too square for some, circles are a possibility) permits the spatial arrangement of verbal or pictorial stimulus material. The enclosure of material within a square permits that material to be *compared* distinctively with or *related* arbitrarily, logically, sequentially, or causally to material in other squares. The amount of material within any one square is usually held to the minimum necessary so that observing responses can be facilitated (i.e., access made easy) and reading time kept short. The comparison and relating functions, as a result, proceed both effectively and efficiently.

Comparison of stimulus material in physically adjacent but separate squares is the basis for the identification of differences. The spatially separate squares facilitate the practice of discriminations. On the other hand, comparison of material within the same square is the basis for the identification of similarities. Spatial enclosure facilitates the practice of generalizations. *Comparison* of spatially enclosed and separated stimulus material thus forms the basis for the practice and acquisition of discriminations and generalizations.

Relating stimulus material in one square with that in others is the basis for learning simple associations or complex chains. Procedural or verbal chains may be diagramed by spatially ordered squares. In the case of procedural chains, spatial sequencing can be used to diagram the temporal or the sequential order of procedures. In the case of verbal associations or chains, spatial sequencing can be used to diagram the definition of terms or concepts (i.e., arbitrary relationships) or the statement of principles (i.e., causal or logical relationships). *Relating* stimulus material in one square to that in other squares thus forms the basis for the practice and acquisition of associations and chains.

Presenting the "Big Picture"

Practice and acquisition of discriminations, generalizations, and chains is further facilitated by big picture statements presented in a diagram appearing on a *single* page.

In typical small-step programs, each practice item deals only with discriminations involved in criterion response (however large or small) or only with the generalizations involved or only with the associations involved. Usually, each of these skills is dealt with only when its turn comes. Moreover, not all discrimination practice items identify all the stimuli to be discriminated; or, an item devoted to generalizations or to associations might not identify all the stimuli or all the responses involved in the criterion or subcriterion performance. The learner typically can identify the relationships among them all (i.e., the big picture) only when he has finished a complete series of practice items. While doing individual practice items, he remains in the dark about its relationship to other practice items bearing on the same total criterion performance.

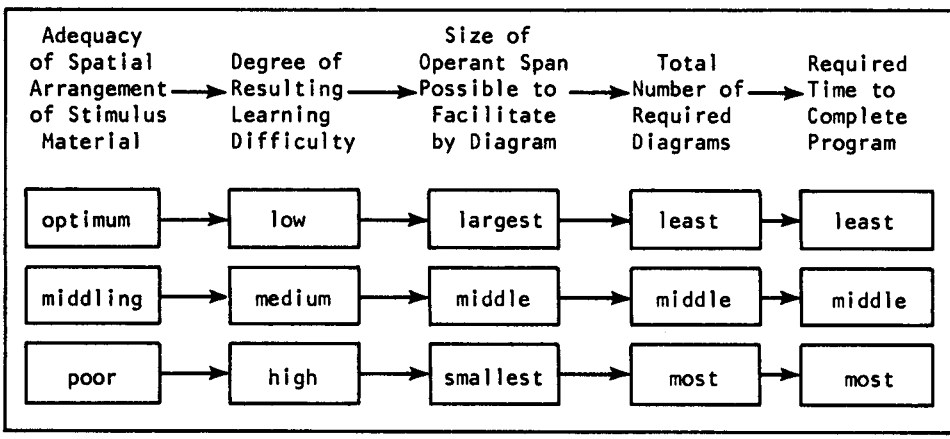
For example, in the usual kind of program, a learner working with the material in Figure 5 might deal with practice items having to do with, perhaps, only those variables identified in two of the columns. In the program of which the diagram in Figure 5 is a part, the learner may have dealt with individual small-step program items; but their relationship to the total picture was clearly before him. With the "big picture" available, both the verbal discrimination and the verbal chains involved are more readily learned.

Having the language "big picture" in Figure 7 in front of him enables the learner to practice associating the right verb with the right subject. When presented with *one giraffe* as a subject in a practice item, the big picture facilitates the correct response—saying *is*. The diagram facilitates the identification of the stimulus as singular and also the identification of the correct, singular response to be associated with it. Subsequent practice items can similarly be located within the total scheme or system. Correct responding is made possible because the learner has no more difficult a task than to compare stimulus or response elements in a practice item with the standard examples provided in a big picture diagram.

A comparison of the language big picture (Figure 7) and the science big picture (Figure 5) illustrates the further point that big pictures can vary in size and complexity. The science big picture, for example, might have contained just a portion of the information it now contains. How big a big picture is appears to be a joint function of the subject matter (i.e., the nature and size of criterion performance or subcriterion performance), its difficulty, and the prior background of the target population. Size can be geared to the learning problem at hand.

The size of the big picture (i.e., the size of the performance it is designed to facilitate) *is* related to the learning *efficiency* it makes possible. The larger the performance encompassed by a diagram, the fewer the diagrams necessary in the total program. A smaller number of condensed but comprehensive diagrams, in addition to making learning easier, reduces required reading time.

The evidence of considerable efficiency for the program on basic electronics (Gropper, 1969) cited above is, it is suggested, due to considerations involving big-picture size. Spatial arrangements *within* a diagram can reduce the difficulty of the material to be learned. This enables the size of the performance (i.e., the operant span) it was designed to elicit to increase. By having "larger" big-picture diagrams, the total number of diagrams required can be reduced, resulting in less reading time and in relatively short program completion times. These interrelationships can be illustrated by means of a diagram:



It is not only the number of diagrams that affects time-to-complete requirements. The use of limited numbers of words within squares makes access (observing responses) easier and reading-time requirements smaller. Also, as noted earlier, practice items in the workbook require no cuing beyond that provided by the diagrams in the handbook, thus reducing reading time still further. Moreover, it also appears, upon examination of the response part of the program, that response requirements were also reduced; that is to say, the number of practice items required to bring the learner up to criterion also appears to have been reduced from what it might be in a typical program. Overall, the efficiency of the diagramed handbook plus workbook appears to stem from this capability of producing criterion performance with a smaller amount of stimulus material and reduced amounts of response practice than is found in typical programs.

These conclusions are based on: a) the quantitative results taken from the assessment of just one program; b) an empirical description of program characteristics; and c) a rational analysis of the sources of instructional effectiveness and efficiency. The conclusions are sufficiently promising to warrant further applications and the further assessment of techniques for the spatial arrangement of stimulus materials and for presenting these materials in "big pictures."

This has been a detailed and lengthy discussion of techniques for organizing stimulus materials. No inference should be drawn from its length that any lesser role is being recommended for response practice. Indeed, the techniques for organizing and presenting stimulus material are intended to facilitate response practice. The effectiveness and efficiency of instruction, in the end, rests on the type of responses practiced and on the amount of practice. It is only with this goal in mind that spatial diagrams and big pictures are recommended. They are not meant to provide a clear and succinct presentation that need merely be read. They are meant to be used in response-oriented programs.

SUMMARY [See diagrams, pp. 156-158.—Ed.]

SUMMARY

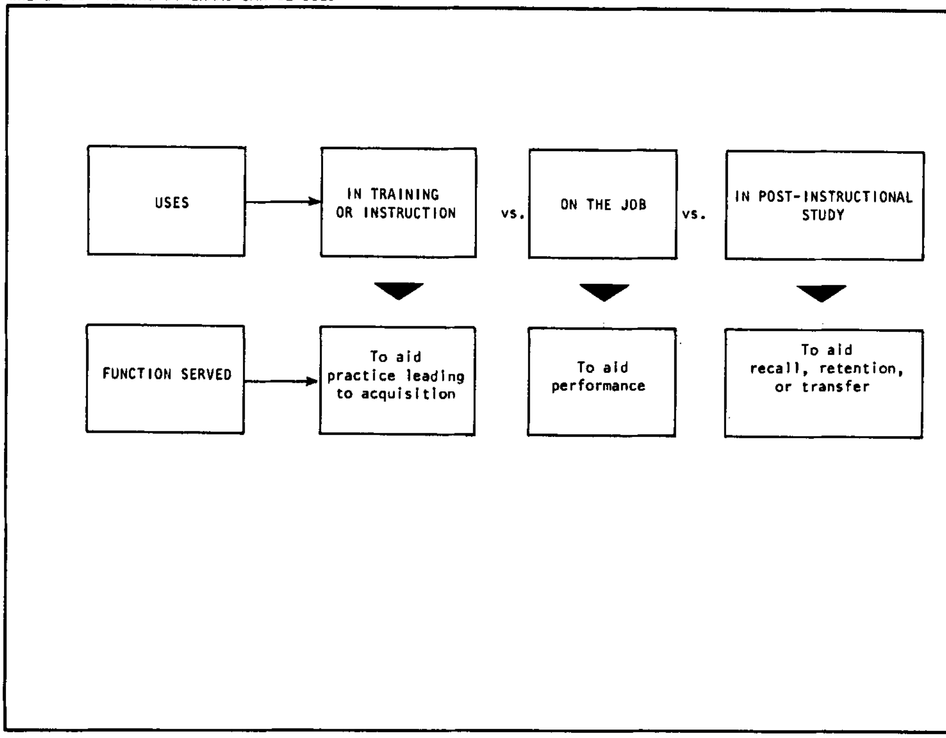
HOW SPATIAL ORGANIZATION OF STIMULUS MATERIALS FACILITATES ACQUISITION OF CRITERION SKILLS

CRITERION SKILLS	DISCRIMINATIONS	vs. GENERALIZATIONS	vs. ASSOCIATIONS AND CHAINS
FACILITATED BY	Stimulus materials in squares that are spatially separate but adjacent	Stimulus materials enclosed and grouped in one square	Stimulus materials in squares that are sequentially ordered
RATIONALE	Facilitates comparison of stimulus differences	Facilitates comparison of stimulus similarities	Facilitates relating stimulus materials arbitrarily, logically, causally, or sequentially
EXAMPLE	SUBJECT: singular / plural / I / you; VERB	SUBJECT: Singular — he, she, it, one boy, one dog; VERB	SUBJECT → VERB: singular → is; plural → are; I → am; you → are

HOW "BIG PICTURE" DIAGRAMS INCREASE THE EFFECTIVENESS AND EFFICIENCY OF INSTRUCTION

	1	2	3	4
ADVANTAGES	IMPROVED CUING VALUE FOR PRACTICE OF SKILLS	+ INCREASED OPERANT SPAN	+ REDUCED AMOUNT OF STIMULUS MATERIAL	+ REDUCED AMOUNT OF RESPONSE PRACTICE
DEFINITION	Practice of discriminations, generalizations, or chains is facilitated	The magnitude of sub-criterion performance possible at any learning stage is increased	The total number of diagrams required is small, reducing reading time	The number of practice items required before criterion performance is possible is reduced
RATIONALE	Facilitated by easy comparison of stimuli in big picture diagrams or of responses in practice items	Facilitated by -spatial organization -availability of the big picture	Made possible by larger operant spans	Made possible by -spatial organization -availability of the big picture
EFFECT ON INSTRUCTION	Increased effectiveness	Increased efficiency	Increased efficiency	Increased efficiency

WHERE BIG PICTURE DIAGRAMS CAN BE USED



REFERENCES

Gropper, G. L. Learning from visuals: Some behavioral considerations. *AV Communication Review*, 1966, *14*, 37-69.

Gropper, G. L. *A program on basic electronics.* Pittsburgh: American Institutes for Research, 1969.

Gropper, G. L. & Glasgow, Z. A. *Criteria for the selection and use of visuals in instruction: A handbook.* Pittsburgh: American Institutes for Research, 1969.

Gropper, G. L., Glasgow, Z. A., & Klingensmith, J. A. *Criteria for the selection and use of visuals in instruction: A workbook.* Pittsburgh: American Institutes for Research, 1969.

Gropper, G. L., & Kress, G. C. *Managing problem behavior in the classroom: A handbook; A programmed text.* New York: New Century, 1970 (in press).

Gropper, G. L., & Short, J. G. *Design of a training development system: A handbook; A book of forms; A final exercise.* Pittsburgh: American Institutes for Research, 1969. (a)

Gropper, G. L., & Short, J. G. *Development of a program to teach standard American English to speakers of non-standard dialects.* Pittsburgh: American Institutes for Research, 1969. (b)

Klaus, D. J. An analysis of programing techniques. In Glaser, R. (Ed.), *Teaching machines and programed learning, II: Data and directions.* Washington, D.C.: Department of Audiovisual Instruction, 1965. Pp. 118-161.

Kress, G. C., & Gropper, G. L. *Managing problem behavior in the classroom: A workbook.* New York: New Century, 1970 (in press).

Lumsdaine, A. A. (Ed.) *Student response in programmed instruction.* Washington, D.C.: National Academy of Sciences, National Research Council, 1961.

Short, J. G., & Gropper, G. L. *Design of a training development system: A workbook; An answerbook.* Pittsburgh: American Institutes for Research, 1969.