THE TEACHING AND TRANSFER OF SERIATION STRATEGIES USING NONVISUAL VARIABLES WITH FIRST GRADE CHILDREN

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ABSTRACT

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By

Michael James Padilla

Piaget and others have investigated and categorized children's visual seriation behavior, but few have studied the seriation of objects differing on nonvisual parameters. The intent of this work was to determine the degree of learning and transfer resulting from instruction on specific seriation strategies as compared to practice with outcome feedback only. The strategies and the seriation parameters (weight, texture, force) were conceived through and implemented within a curriculum model developed by Edward L. Smith which treated the seriation task as one of a vertical series of tasks in a possible curriculum. This model identifies an acquired strategy as a potential mechanism for transfer across related tasks and content.

Piaget's seriation stick task was individually administered to 120 first grade children. A group of thirty six Stage I (nonseriators) and Stage III (operational seriators) children were randomly chosen from those attaining

Stage I and III competency, and were randomly assigned to one of three treatments. The first treatment, the extreme value selection (EVS) strategy, emphasized finding the extreme valued object in a set and placing that object next in the seriation row until all the objects were ordered. The second treatment, the insertion (INS) strategy, emphasized placing randomly chosen objects relative to those previously placed until all objects were ordered. The last treatment, the control (CON) did not directly teach a seriation strategy, but rather provided practice with the task and outcome feedback.

The subjects were trained in three sessions followed by a post test session, all in a two week period. Each training session lasted about thirty minutes, began with a pretest, and used a different set of nonvisual materials. Data were collected during pretest, training and post test sessions through which task accuracy, strategy use and transfer could be inferred.

Unique sets of materials were used for each seriation variable. The "Weights" were cups of different weight, which the children lifted to ascertain relative heaviness. The "Feelies" were cups lined with different textured materials which the children felt and ordered on relative roughness. The "Pull Toys" were pipes with handles attached inside to different sets of rubber bands, which the children pulled to ascertain relative force.

Each object in each set of eight was exactly like every other object in that set, except for the variable of interest. And each object of each set was judged to be equidistant from the preceding and following objects on the appropriate variable.

Four major hypotheses were proposed. The first stated that at least 80 percent of each treatment/stage group taught a seriation strategy (EVS or INS) would use that strategy on the post test tasks. This hypothesis was supported. The second hypothesis, that the children taught a seriation strategy would perform more accurately on the post test tasks, was partially supported. No treatment differences were found among the Stage III seriators, although a ceiling effect was strongly indicated. Significant treatment differences ($p < .02$) were apparent among Stage I children, with post hoc analysis identifying the EVS as significantly higher ($p < .01$) than the CON. No significant difference existed between the INS and CON. The third hypothesis, that the treatment groups would show a higher degree of autotransfer on the pretests prior to each training session, was not supported. No significant differences among treatments for either stage were apparent. The last hypothesis, that the treatment groups would show a greater amount of facilitation of learning as reflected by trials to criterion, was partially supported. Again no significant differences were apparent among the

Stage III treatments. Stage I effects were significant ($p < .04$) with post hoc analysis showing the EVS Stage I children significantly ($p < .05$) better than the other two treatments while the CON was significantly better than the INS.

The results suggest several conclusions and implications. Teaching seriation strategies is feasible and for some children (Stage I) some strategies (EVS) produce more accurate seriators who transfer more during the learning process. Thus if the goal is to create accurate seriators in a short period of time, the EVS strategy seems to be the choice with Stage I children. Stage III children seem able to construct their own methods and achieve success. Also, the results with the Stage I children do not agree with Piaget's assertion that seriation ability cannot be altered with short term instruction. Nor do the results concur with Piaget's statement that operational nonvisual (weight) seriation develops at about age 8 or 9. The average age of all children in this study was 6 years 10 months and most performed the tasks with a high degree of competency, even the Stage I children. Too, the method of ordering content by similar intrinsic structure and the construct of a strategy as defined by Smith were at least partially upheld and warrant further study.

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By

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To Rosemary whose support and love provided a much needed inspiration.

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CHAPTER I

THE PROBLEM

The importance of human learning would be disputed by few. Before the first word is uttered by a young child, until the last minutes before death, humans are continually assimilating new bits of information into their stored, complex sets of information. Sometimes humans learn after one interaction with a phenomenon; other times they fail to learn after many direct attempts. Too, some capabilities are simple, others are very complex. Some things are learned in school, others outside of school. It is the knowledge that one gains in a school situation which is of interest in this thesis.

Specifically, the problem in this work revolves around the teaching and transfer of different methods of seriation task completion. These methods are called strategies and they are taught to children using materials differing on nonvisual parameters. It is hypothesized that the children taught a seriation strategy will complete the post tests with a higher degree of accuracy than a group given only practice with the materials. Too, it is thought that the strategy groups will show a greater amount of transfer in learning the task with new materials. Thus the major questions in this study involve task accuracy and relative transfer of strategy and placebo groups.

General Need for the Study

Much of a young child's time and energy is spent attending school, five days a week about forty weeks a year for at least ten or twelve years. What should our children be learning during this time? Should children be taught how to handle each and every situation or problem that will be confronted in later life? The obvious answer is "No, educators could never even think of each and every problem, much less supply solutions." What do we attempt to do in schools, then? We attempt to teach children certain basic skills such as reading, writing, and problem solving with which they can find their own solutions to problems. Certain classes of problems are stressed, again hoping that the solutions worked out by others will apply sometime in the future. In other words, we teach for transfer.

Transfer of Training Defined

Transfer can be defined as the use of diverse skills or knowledge in a problem situation, the result of which is the construction of a previously unlearned solution to the problem. A common example might involve the transfer of knowledge and skills learned in a school science unit on plants and gardening to a new problem, that of planting and raising a vegetable garden at home. While the types of plants grown, the conditions for growth (indoor vs. outdoor), and the watering regularity would differ considerably, much knowledge about the planting, germination, light, and soil characteristics could easily be transferred to the new problem. Other examples might involve the transfer of mathematical and computational skills to an income tax problem or a consumer problem of finding the best value for a dollar.

The Importance of Transfer

The importance of transfer is reflected in the objectives of formal education. Gagne (1970) says, "Knowledge transfer is frequently emphasized as a purpose of education. It is said that education should be concerned not simply with the acquisition of knowledge, but more importantly with the use and generalization of knowledge in novel situations" (p. 29). Jerome Bruner (1963) speaks of "learning how to learn," that is, learning that will make subsequent learning easier. Stephens (1965) states, "All learning and all teaching are based on the assumption that transfer works to some extent" (p. 213).

If in fact transfer does "work," then how might we organize school subjects so that we not only get transfer to future real life situations, but also get transfer from school subject to school subject as well as within a given school subject? Both Robert Gagne and Jerome Bruner have dealt with this question and the following short review of their significant work is appropriate and enlightening to this discussion of transfer.

Gagne (1970) distinguishes between horizontal transfer, across subject matter, and vertical transfer, intrinsic to subject matter, that is, from prerequisite skills to subsequent tasks. Although he does not discuss the conditions for horizontal transfer extensively, he does say that the most important conditions for this type of transfer seem to be internal to the learner. Some students seem better able than others to generalize across novel situations. He says that "the more broadly based a learned capability, the better chance it will have to transfer to new and different situations. Accordingly, the usefulness of any learned capability will be increased if it is practiced in as wide a variety of situations as possible" (p. 336). The conditions prescribed by Gagne for vertical transfer basically involve the learning of subordinate capabilities. If the learner has mastered the capabilities considered prerequisite to the terminal task, then the time taken to learn the terminal task will be less for that learner when compared to another who has not mastered the prerequisite capabilities.

Bruner (1963) speaks of specific and non-specific transfer. Specific transfer involves the generalization of skills. For example, "Having learned how to hammer nails, we are better able later to learn how to hammer tacks or chip wood" (p. 17). More important to Bruner is non-specific transfer or the transfer of principles and attitudes. "This type of transfer is at the heart of the educational process--the continual broadening and deepening of knowledge in terms of basic and general ideas" (p. 17). The basis for this second kind of transfer lies in the student's mastery of the structure of the subject matter. " . . . in order for a person to be able to recognize the applicability or inapplicability of an idea to a new situation and to broaden his learning thereby, he must have clearly in mind the general nature of the phenomenon with which he is dealing" (p. 18). A student who understands the structure of the subject matter as opposed to sets of unrelated facts and principles, will be better able to transfer principles and attitudes within that subject. Bruner would then propose that curricula stress the structure of a discipline by emphasizing the fundamental ideas of that discipline so that transfer could be enhanced.

Some Questions Relative to Transfer

Obviously, these two learning theorists do not speak to the same theoretical considerations when discussing transfer. Each emphasizes a different kind of transfer. Each looks at the same problem in a different way. Too, they differ substantially on such basic questions as what kind of knowledge transfers most and in what situations this transfer occurs. Possible mechanisms of transfer vary from Bruner's very general structure of the subject matter to Gagne's practice over a wide variety of tasks and his reference to prerequisite skills. And yet the views put forth by Bruner and Gagne represent much of the current thinking in learning and transfer. To say the least, it makes this area problematic and it is for this reason that these topics are the specific concern of this study.

The next section will attempt to provide a general overview of and rationale for this study. The particular problem will be developed relative to the model from which it stems. Following this will be a discussion of the task and the general procedure used in the experiment, including a list of the major hypotheses of interest.

The Problem Relative to the Chosen Curriculum Model

A model which enables the specification of objectives for curricula has been laid out by Smith (1974). This model deals with the analysis of content based on some shared general structure, the analysis of tasks, and the specification of strategies or ways of performing a task so that both horizontal and vertical transfer can be facilitated. Smith views the tasks and content as being related through a matrix (see Fig. 1). The strategy, or way in which a task is completed with a piece of content, is an important mechanism by which transfer can occur. If a child learns to do task 1 with content 1 by using one specific strategy, and if that strategy is a component of the strategy for task 2, then vertical transfer will occur. That is, task 2 will be learned in less time because the strategy for task 1 will facilitate its learning. Likewise, if a child learns to do task 1 with content 1 by using a specific strategy, then task 1 with content 2 will more easily be learned. In this case the child need only concentrate on the new content, not on how to do the task. Of course content 1 and content 2 must surely have a similar nature in order that the task and strategy be applicable to both.

	Content 1	Content 2	Content 3	etc.
Task 1				
Task 2				
Task 3				
Task 4				
Etc.				

Fig. 1.--A Task Content Matrix

The major questions involved in this thesis center around the learning and transfer of strategies for a task across different, but closely related, content areas. Will children be able to learn and retain a strategy for task completion when given specific short term instruction? Will task performance be improved by strategy instruction? Will children spontaneously transfer the taught strategy to new content areas and therefore perform the task with new materials more accurately? Will learning to do the same task with different content be easier or be accomplished in less time after a strategy has been learned with a previous content? These are the major general questions considered in this study.

The Seriation Task

The task for which a strategy was taught in this project is one called seriation. In this task a child is presented with a series of objects which differ on a named variable, and he is asked to put the objects in order according to the perceived values of that variable. This task was used because of its importance in elementary science curricula and secondarily because of its importance in the cognitive development literature.

Many different curricula including the Science Curriculum Improvement Study (1970) and the Modular Activities Program in Science (1974) include lessons involving seriation. Ordering objects on a named variable could be a preliminary task to studying the correlation of the named variable with a second variable. For example, ordering a set of plants on height could be a first step toward correlating height and amount of fertilizer applied. While this specific task is not one which is done in the programs named above, it is obvious from this example that the simpler seriation activities described in these programs could supply a basis upon which this more complicated task could be built.

In addition to the precedence cited above in curriculum projects, this task has been extensively studied as an indicator for cognitive development. While the main interest of this work revolves around the task as a component of a curriculum, the experimental literature available from the cognitive development area provided the basis for many specific decisions made. These decisions include the types of materials to be used, the particular values of each element, the specific instruction to be used with the materials, and other similar decisions.

An Overview of the Procedure

A group of first grade children were pretested and divided into two groups, those who could order a set of sticks on length (Stage III) and those who could not (Stage I). Twelve children from each group were randomly assigned to each of three treatment groups. Group 1 (EVS) was trained to seriate the materials using a strategy which focused on choosing the greatest element from the unordered elements and placing it next in a row until all the objects are ordered. Group 2 (INS) was taught to seriate the materials by choosing randomly from the unordered elements and inserting this selection into the proper place in the row. Group 3 (CON) was a control group which practiced the task with feedback on correctness. Three different sets of materials were used for training and testing. These include a set of eight different weights, a set of eight cups lined with different grades of sand paper, and a set of eight sticks with handles differing on the amount of force necessary to pull the handle. All of the materials differed on the named nonvisual variable only.

The treatment groups were taught in three separate sessions during which one of the three material sets were used and data was collected on the ease with which children learned the task. This data was used to infer one kind of transfer, facilitation of learning. A fourth session or post-test session was held during which one attempt to seriate each of the three sets of materials was given each child. Data was collected which allowed correctness scores and strategy-use scores to be computed. Additionally, each child was allowed to attempt to seriate each of the sets of materials once in a pretest before each strategy training session began. Task correctness and strategy-use scores were computed for each pretest. These scores were used to infer spontaneous or autotransfer.

The General Research Hypotheses

The first general research hypothesis in this work is that both strategy treatment groups will perform the post-test tasks using the taught strategy. A simple percentage of children using the taught strategy correctly was computed and an arbitrary level of 80 percent was used for deciding acceptance or rejection. The second general hypothesis is that the strategy groups will perform the post-test tasks more accurately than the control group as measured by an analysis of covariance. The third general hypothesis is that both strategy groups will show more transfer, both facilitation of learning, across trials, and autotransfer, across pretests, than the control group. Multivariate analyses of variance and covariance will be used to test these transfer hypotheses.

Assumptions and Limitations

Several assumptions and limitations relative to this study seem quite important and should be listed.

1. Transfer of training as defined in this chapter exists as a phenomenon and can be measured through proper test procedures and methods of analysis.

2. American elementary schools as they exist today will not drastically change in the near future.

3. A pretest involving the ordering of a set of sticks on the visual variable of length can be a

meaningful indicator of seriation ability with non-visual materials.

4. Most elementary school teachers will not be able to give individual training and feedback to every child in a class as was done in this study.

5. Piaget's findings with weight seriation apply equally well to most nonvisual seriation problems.

The brief outline of this thesis that has been presented in this chapter will be expanded greatly in the following chapters. Chapter II develops the theoretical argument for the task, the materials and the training procedures used, and further explicates the model within which the study was conducted. Chapter III describes the method including the treatments, the materials, the data collected, the design and the specific hypotheses and methods of analysis. Chapter IV presents the results of the planned analyses as well as some unplanned, post hoc analyses. Chapter V discusses the results and implications of the study.

CHAPTER II

REVIEW OF LITERATURE

This study probes some aspects of a general educational model which proposes a specific mechanism for transfer. The present chapter, a review of the literature, will first provide a substantial description of this specific model, preliminary to a thorough review of the seriation and training literature. The seriation review will describe the task and the kinds of materials used, as well as the materials variables which affect task difficulty. The training literature review will examine past attempts to teach seriation and other related and pertinent capabilities. Finally, as an attempt to integrate the model with the seriation task, one possible task-content matrix incorporating that task will be presented and the predicted transfer effects will be outlined.

The General Educational Model

Edward L. Smith (1974) has developed a model for instructional design which builds on the work of Kuhn (1962) and Schwab (1964) and their emphasis on the nature of the disciplines, the work of Gagne (1970) and his emphasis on task analysis and the work of Newell and Simon (1972) and their information processing models of human cognition. In Smith's model these three major aspects can be related to each other by a three dimensional matrix. Different pieces of content along the top axis are crossed with different tasks along the side axis (see Fig. 2). These content areas and tasks are identified by the processes of <u>content analysis</u> and <u>task analysis</u>. The third component, the strategy, is identified by the process of <u>skills analysis</u> and it is defined as the way in which a task is performed. Strategies are modeled by information

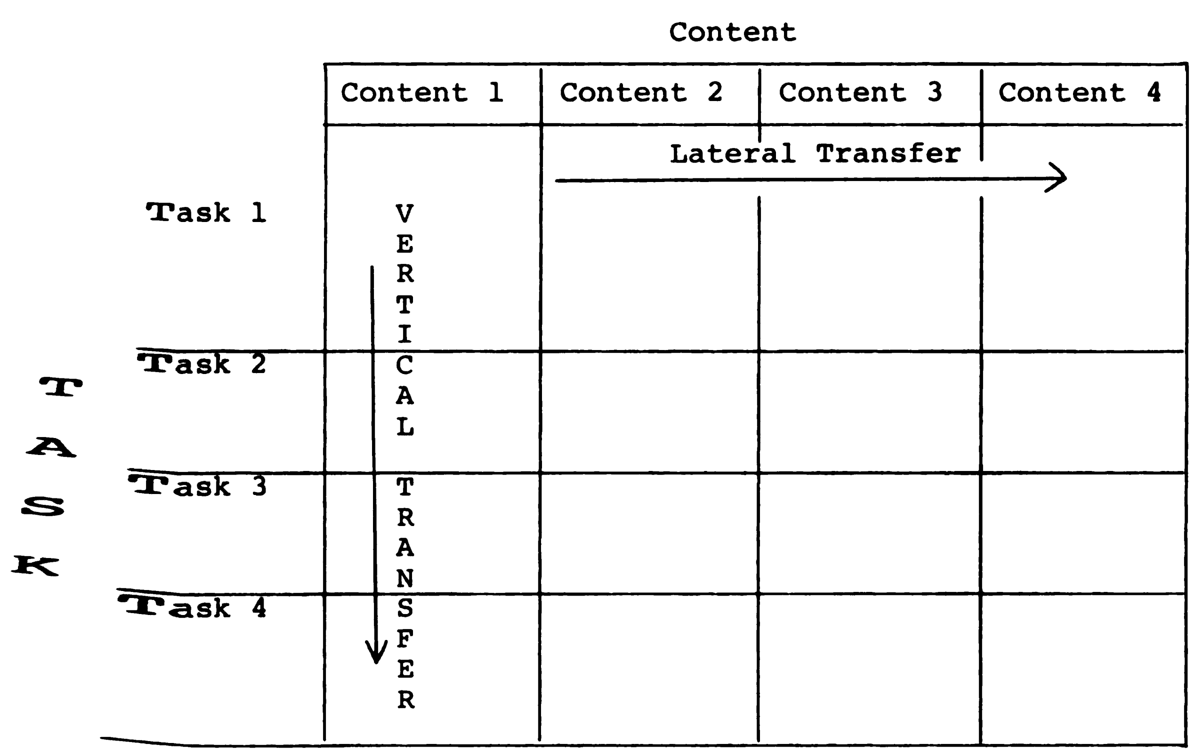

Fig. 2.--The Task-Content Matrix.

processing routines which make use of computer terminology in describing human thought processes. Smith contends that through proper use of content, task and skills analysis, instructional sequences may be planned which optimize both lateral transfer, from one piece of content to another, and vertical transfer, from task to task.

In order to better understand the relationships among content analysis, task analysis and skills analysis and in order to explain the power of Smith's model, the next sections will be devoted to a detailed description of these three processes. The entire model will then be reviewed and implications for its educational applications will be drawn.

Content Analysis

Smith (1974) sees content as an important aspect of a discipline and specifies that "the design of instruction for curriculum areas based on disciplines (natural and social sciences, history, mathematics, music, art, etc.) must systematically deal with the conceptual aspects of those disciplines" (p. 4). To this end, he devised a method of systematically analyzing content, the first phase of which " . . . involves identification of the types of conceptual systems characteristic of a discipline or subdiscipline" (Smith, 1974, p. 4). These types of conceptual systems are then grouped according to their shared general features and an abstract paradigm or what is called an analytic network is constructed of these shared abstractions. One example of a pervasive analytic network in the physical sciences is the variable-value analytic network. The general features of this analytic network are a variable name, variable values, an observation/measurement procedure and specific elements.

Each example within an analytic network will possess these features and each general example is given the name, systemic content. Weight is one such example within the variable value analytic network. Its variable name is weight; its variable values can take any amount and are expressed in pounds or grams (The gram is actually a unit of mass which under most common circumstances approaches or is the same as weight. Since this study deals with very young children, the term weight was used instead of mass.); its observation measurement procedure is the weighing of the elements on a scale or other device; its elements are the physical bodies to be weighed! Other systemic content examples of the variable-value analytic network include pitch, texture, force and length.

After the analytic networks have been identified within a discipline, they can be "used to identify and catalog the systemic networks in the area being analyzed" (Smith, 1974, p. 6). In this way an organized and systematic method of content analysis can be completed for a discipline and it can be based on the structure of the content within the discipline, not just on an intuitive approach to content organization.

The last level of content analysis is the choosing of what Smith calls the particular content or the specific examples of the already chosen systemic content. This step is completed only after a thorough analysis at the analytic and systemic levels has been completed. It involves the choosing of particular materials and the exact values for those materials. Smith states that "the time consuming and expensive task of identifying a sufficient quantity of particular content can be postponed until decisions have been made at the analytic and systemic levels. This order of decision making insures that particular content fulfills the design needs of the program and avoids wasted effort of identifying irrelevant particular content" (Smith, 1974, p. 6.).

Figure 3 is a diagrammatic representation of the different levels of content analysis.

Task Analysis

Task analysis is the process by which tasks are generated for a specific analytic network. One successful method of task generation involves the use and manipulation of the general features of an analytic network as Task Parameters. Various tasks can then be generated by changing the given input and desired output requirements.

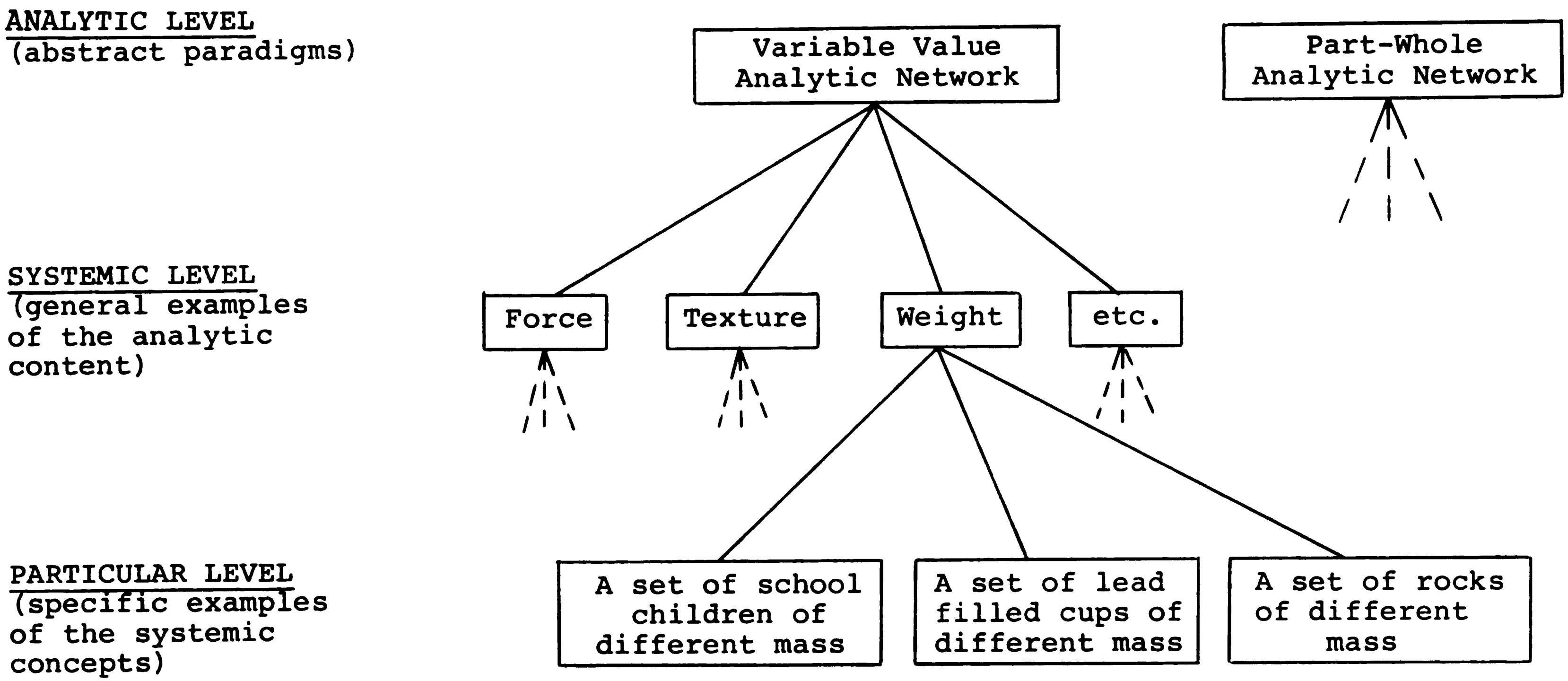

Fig. 3.--Diagrammatic Representation of the Levels of Content Analysis.

One variable value analytic network task thus created would take the following form:

given input: -variable name
-a series of elements
-an observation/measurement procedure
desired output: -a series of values for the elements

Various other tasks could be specified by rearranging the input and output conditions.

Each task produced using this method would have the advantage of being applicable to many different pieces of similar systemic content. This is true because the task was originated from the general features descriptive of each piece of systemic content within an analytic network. Since the above task was constructed from the general features of the variable value analytic network, it will be appropriate for many of the systemic variables, such as weight, length and force.

To be sure some of the tasks generated will be trite and a mitigating process of professional judgment will be necessary for each task, perhaps even for each task as it relates to each piece of content. But the end product of this process will be a series of tasks which relate to some, if not all, of the content in an analytic network. This relationship allows for many possibilities in curriculum design. One possibility might be transfer effects due to this unique task-content correlation, since one might be doing the same task with various pieces of similar content. Obviously the tasks must be carefully constructed and sequenced in order to promote learning and transfer.

Smith (1974) speaks to a common parallel often drawn, that of the relationship between content and tasks and the current content-process argument in science education. He states:

> Although the task analysis techniques might be thought of as dealing with the process aspect curriculum areas, the present approach brings a unity to the content-process distinction. It is assumed, and supported by the analyses to date, that similar operational requirements are relevant to each of a set of similar systemic networks. That is, operations or tasks relevant to a given systemic network (specialized conceptual system) are relevant to other systemic networks which are of the same type and are, therefore, represented by the same analytic network . . . .
>
> From this perspective, mastery of a process represents a type of mastery of a conceptual system. Conversely, any operational definition of concept mastery represents the specification of some process competency. Debate about content versus process becomes a question of what tasks should be mastered for what set of systemic networks.

Skills Analysis

Skills analysis is the process by which detailed psychological strategies, or how one performs a task, are specified. The end product, the strategy, is the inferred sequence of psychological processing steps that occur within the learner as he performs the task. This sequence is represented as a series of small, but specific information processing steps such as encode, decode, scan and choose. The use of these specific small entities to describe the logical thought processes of human beings allows a very detailed analysis of seemingly simple actions. In turn these detailed analyses allow some basis for logically sequencing both tasks and content so that maximum efficiency can be attained.

Smith (1974) argues that when strategies are not attended to, that "different individuals may learn to perform the same task in quite different ways" (p. 11). He cites Bruner's work with concept attainment strategies as proof of this condition, since four different strategies for task completion were found. He continues by saying, "The transfer effects of learning several tasks probably depend heavily on the strategies the student learns to use in performing both original and transfer tasks" (p. 11).

Since transfer is such an integral part of Smith's model, let us define the phenomenon and examine its relationship to the strategy.

Lateral and vertical transfer can be defined using the task matrix in Figure 1. Lateral transfer occurs when the learning of a task in a specific content area is facilitated by prior learning of the same task in a different content area. For example, if a child masters Task 1 with systemic content 1, and subsequently learns to do Task 1 with systemic content 2 in less time or with less effort, then one could infer that lateral transfer (across content) has occurred. Likewise, vertical transfer involves a facilitation of learning. This occurs when a task is learned with a specific systemic content and subsequently a different task is learned in a shorter time or with less effort than had the original task not been learned first. An example of this might be a child learning Task 1 with systemic content 1 and subsequently learning Task 2 with systemic content 1 in less time or with less trials than had he not previously learned Task 1.

The mechanism by which both vertical and lateral transfer can occur is the strategy. After analyzing and constructing the information processing models of the strategies, one turns to the tasks and systemic content which are

> . . . sequenced to promote systematic development of the strategies in the learner. It is assumed that instruction developed on the basis of such models will result in behavior consistent with the models and produce substantial transfer effects. As a student learns to use a strategy to perform a task with a series of similar systemic networks, a representation of the strategy becomes available in long term memory thus facilitating subsequent learning with additional systemic networks. This represents lateral transfer and is analogous to the phenomenon of learning set acquisition studied in experimental psychology (e.g., Bessemer and Stollnitz, 1971).
>
> Strategies are potentially a mechanism for vertical transfer as well. Once a strategy for a task has acquired some degree of stability, it can function as a subroutine in a larger strategy for performing a more complex task. Obviously, the utility of the simpler strategy depends on its compatibility with the higher level strategy. It is assumed that something like this occurs whether or not it is planned. This explains the importance attached to careful selection of strategies and sequencing of tasks in the present approach. One task may or may not be prerequisite to another, and thus facilitate its

> learning, depending on the compatibility of the strategies an individual learns to perform (Smith, 1974, pp. 11-12).

For a detailed description of the strategies used in this study as well as a description of the elementary processes used to construct the strategies, see Appendix H.

The Seriation Literature

The detailed review of the seriation literature will begin with an outline of Piaget's contribution to this body of knowledge, including some replications of his work. This will be followed by a systematic review of some of the major variables found to affect seriation difficulty as well as some of the content variables used in previous studies. The specific parameters reviewed will include the number of objects to be seriated, the size of the intervals between the elements to be seriated, the number of relevant and irrelevant variables, visually apparent seriation content and finally nonvisual seriation content.

Piaget and Replications of his Work

Any discussion of the seriation literature should start with the Swiss psychologist, Jean Piaget. Not only was Piaget one of the first to carefully attend to seriation, but he is the present source of stimulus for many of the studies being published by others in this area.

Because of his importance to seriation, he will be considered first.

Piaget (1965) studied children's seriation abilities using a set of ten sticks (A through K) which when lined up in a row, side by side, made a staircase configuration. Each stick differed from the next by 0.8 cm in length. The sticks were presented to the child who was asked to "form a series from the shortest (A) to the longest (K)" (p. 123). When this had been done, the child was told that the experimenter had forgotten to give him all of the sticks. The experimenter then handed the child ten sticks, one at a time. The sticks were to be inserted into the original staircase configuration. Each of the second set of sticks (a through k) fit in between two of the original set, so that the difference between a and A and a and B was 0.4 cm. The final order of the sticks, after all ten of the second set were inserted corresponded to the following: AaBbCcDdEeFfGgHhIiKk.

From this task Piaget described the following three stages in children's seriation abilities. Stage I children could not construct a set of sticks ordered from A-K. Configurations that were developed by children in this stage seemed to be perceptual and not logical in nature. For example, a number of children lined up the sticks, one next to the other so that the tops of the sticks formed a staircase. However, the bottoms of the sticks were completely ignored, so that in fact the sticks were completely disordered.

Stage II children were able to order the set of sticks A-K, but only through a trial and error method. A child may order the first three sticks BCA, but upon seeing that something seems wrong, begins to change the sticks around until they look right, i.e., ABC. In addition the Stage II child is unable to properly insert sticks a-k into the original set so painstakingly constructed. David Elkind (1964), in his review of the three stages states, "the child's trial and error behavior involves a beginning coordination of relations, inasmuch as the child eventually reaches a correct seriation, but the coordinations that lead to correct seriation are the <u>result</u> of the child's trial and error behavior and do not cause it" (p. 288). Later he states that the reason a child in Stage II cannot insert the sticks into the original configuration is that " . . . as soon as the child has completed his stairway, the child regards it as a completed figure or picture to which nothing more can be added" (p. 289).

Stage III children are both able to seriate the original set of sticks well and are able to do so systematically. The insertion task, also is easily concluded with few errors. Piaget (1965) states,

> . . . the difference in behavior with regard to the extra elements to be inserted is characteristic.

> Whereas children at the second stage consider these elements almost as foreign bodies, Sin and Ald (both Stage III seriators) react to them as to the others, compare them, measure them, if necessary, and place them in position keeping in mind simultaneously the relationships > and <" (p. 134).

In reporting his findings, Piaget (1965, 1964) did not use traditional statistical procedures, nor did he report the numbers of children able to perform at each stage. He reports his findings in a case study fashion, sometimes indicating the entire conversation between E and S verbatim, other times reporting only how a specific child placed sticks. He reports the average age of S's in Stage I to be four years, Stage II to be five years and Stage III to be six years. Because of the obvious problems concerning Piaget's findings, Elkind set out to replicate and possibly extend Piaget's experiments on discrimination, seriation and numeration.

Elkind's (1964) major thrust concerns the statistical verification of the development of Piaget's stages at the stated different ages. In addition he set out to study " . . . whether the perceptibility of size differences, in one dimensional, two dimensional, and three dimensional materials affects the ages at which stages appear" (p. 277). He also wished to amplify and explicate Piaget's explanations and discussion of seriation and numeration in terms more familiar to American psychologists.

In this study Elkind used three different sets of materials. The first set, <u>the blocks</u>, was a set of nine cubes, the smallest being a 1" cube with each succeeding block being 1/2" larger in all three dimensions. A second set of blocks, the smallest being a 3/4" cube with each succeeding block again increasing 1/2" in all three dimensions, was used for insertion. The second set of materials, the slats, were similar to the first set but differed in only two dimensions from slat to slat. The third set, the sticks, differed in only one dimension, length.

Elkind had his ninety subjects of 4, 5, and 6 years perform ordering and insertion tasks with each of the three sets of materials. If any S was unable to perform the ordering with nine objects, he was asked to order four elements. If unsuccessful he was terminated; if successful he was asked to order seven elements. If unsuccessful he was terminated; if successful he was asked to order the original nine elements. The children who were able to seriate nine elements were then asked to insert five elements into the ordered set of nine.

Elkind found that Piaget's data stood up under replication and statistical analysis. He found that the mean scores of subjects increased significantly with age from four to five to six. He also found that the more perceptible the differences in the materials (e.g., the three dimension differing cubes as opposed to the one dimension differing sticks), the easier the seriation task would be. This, too, is in agreement with Piaget's predictions. He found that while the absolute scores of the four, five and six year olds differed with regard to the material, the relative position of each group stayed static in each case.

One further point described by Elkind deserves some discussion. He states, "Item analysis revealed that the last item of the seriation test (the insertion problem) was the most difficult of the seriation problems" (p. 283). This does not exactly ring true. Since the insertion task was only given to those who correctly ordered nine elements, Elkind cannot have data which supports his inference that insertion was also more difficult for those unable to order the nine sticks. While it seems logical to accept Elkind's statement, particularly after reviewing Piaget's writings, it still stands as an unverified assumption that insertion comes only after ordering. If replication of this point is not borne out, it could lead to a new, slightly altered model of seriation development.

Variables Affecting Seriation Difficulty

As was seen in the review of Piaget's seriation and Elkind's replication study, a number of different variables may affect a child's seriation ability. These variables include the number of objects to be ordered, the size of the interval between objects in a set of materials, and the influence of relevant and irrelevant variables on the ease of completing a seriation task. It is the intent of this section to discuss these three variables, while continuing a systematic review of the seriation literature.

Number of Objects

In his replication study Elkind inferred that the number of objects to be ordered, significantly affects the success with which they are ordered. If a child is unable to seriate nine objects, Elkind gave him four to seriate. If successful, Elkind gave him seven. If successful again, the child is given the first nine objects again to re-order. If unsuccessful at either four or seven, he is terminated. The way the task is structured and presented leads one to believe that Elkind thought the number of objects to be a significant variable. Elkind does not state his results with regard to this variable, however. This leaves the reader to wonder whether there were significant differences. To be sure Piaget (1964) himself, states "Again we might have found a marked improvement in the seriation of length had we used fewer elements . . ." (p. 251).

Prentice (1963) also studied the affect of the number of objects to be seriated. In addition she investigated the effect of the magnitude of the increment between elements on seriation accuracy of young children, and she varied the materials and the instructions for the tasks. A sample of two hundred nursery school, kindergarten and second grade children were given tasks " . . . varying in: difficulty (number of elements: five, ten or fifteen) or increment between elements (small or large); materials (sticks of different lengths, pictures of objects that move at different speeds, pictures of sticks of different lengths); or instructions (I to seriate, II to insert elements, or III to successively choose the smallest element of the group)" (p. 3854, D.A. Vol. 24). Prentice's data disagree slightly with Elkind and Piaget with regard to number of objects. She found that series of five elements were easier than series of ten elements as expected. But she also found that series of fifteen elements were easier than series of ten elements, but more difficult than series of five elements (i.e., five easier than fifteen which are easier than ten).

Smith and Padilla (1975) conducted a study in which 96 first grade children were asked to seriate either a set of Piaget-like sticks or a set of weights. Each child was presented with either 4, 6, 8 or 10 objects differing on length or weight and each was asked to put the objects into a row. No significant differences were found relative to the number of objects. Even though the task proved easier for the children who used four objects, no significant differences were apparent between ordering four objects and ordering ten objects, statistically speaking. It is obvious from these and the other reported findings that further research is needed to firmly establish the effect of the number of objects on seriation behavior.

Size of Element Intervals

In addition to the number of elements in a set, Prentice and other authors have found differences in task completion scores when the task is done using a set of objects that may vary by small or large discrimination intervals. Prentice found that "it seemed that the larger increment made the tasks less difficult either by clarifying the nature of the problem, or by making easier the necessary size discrimination" (D.A. Vol. 24, p. 3854). Piaget (1964) himself sheds some light on the variable by stating "Again we might have found a marked improvement in the seriation of length . . ., if there had been greater differences between the elements" (p. 251). Piaget then states that this would change the nature of the task from one of operational reasoning to " . . . a perceptual adjustment to an intuitive whole" (p. 251). He is not explicit as to how or why this might occur, nor does he shed any light on how he set about choosing the proper increment with his materials.

Schafer (1972) attempted to advance a sample of seventeen kindergarten children from Stage II seriation ability to Stage III. Each subject was individually given approximately 30 minutes training, part of which was an insertion of one of a set of three or more sticks into an already ordered set of sticks. He decreased the interval between the ordered sticks by increments of .75 in. from 2.25 in. to .75 in. in successive stations that each child visited. Apparently, Schafer assumed that inserting a stick between two sticks that vary greatly in length is an easier task than inserting a stick between two that vary only slightly in length. This inference still remains at the conjecture stage, especially since Schafer found that his teaching module did not raise a significant number of children from Stage II to Stage III.

Number of Relevant and Irrelevant Variables

Shantz (1967) studied the effects of varying the number of relevant variables (those variables that increase or decrease in unison with the seriation variable) and irrelevant variables (those that change randomly, i.e., not in unison with the seriation variable). She hypothesized that adding a small number of redundant (relevant) variables would aid a child in completing a seriation task. Conversely, adding a small number of irrelevant randomly changing variables to a set of objects would make the task more difficult to the child. Shantz's hypotheses were based on Wholwill's (1962) proposal that as a child proceeds from perception to conception, "the amount of redundant information increases," and "the amount of irrelevant information that can be tolerated without affecting the response increases" (p. 98).

Shantz examined a sample of seventy two 7 1/2, 9 1/2 and 11 1/2 year olds by giving each S a double seriation task with three types of materials--one set with one redundant dimension, a second set with one irrelevant dimension, a third set with no added dimensions. She concluded that, as expected, the added irrelevant dimension made that set of materials significantly more difficult to seriate. Her second hypothesis concerning the redundant variable showed no significant differences, however. Shantz states her surprise at this finding; she says, "It is . . . possible that one redundant dimension is insufficient to elicit measurable effects" (p. 219).

Elkind (1964) used three distinct sets of materials that varied in unison on three dimensions, two dimensions and one dimension. He found that each of the three sets was significantly different from the other two in ease of seriating. The three dimensional was the easiest, the two dimensional next and the one dimensional the most difficult. He states that this evidence " . . . agrees with Piaget's suggestion on the influence of the perceptibility of size differences" (p. 283). However, a strong argument can be made that Elkind was not measuring "the perceptibility of size differences," but rather the result of redundant information on the task as defined by Shantz.

Whatever the argument, it is clear that these two different variables seem at least slightly related, if not totally confounded in this case.

Seriation Content

Many different specific types of materials have been used in the seriation studies that have been cited. These specific materials will be referred to as the seriation content. It is the intent of this section of the review of the literature to systematically discuss the two major types of seriation content--that differing on visually apparent parameters and that differing on non-visually apparent parameters.

Visually Apparent Seriation Content

Many different types of visual seriation content have been used in seriation tasks. Piaget (1964, 1965) and others have used sticks or dowels that differ from each other in length. This specific variable is a visually apparent one, since the subject gathers his data about which stick is to be placed next in line by visually discriminating one stick from another. Since these sticks were the first content used for seriation tasks by Piaget and by some who replicated his findings, they remain the standard today. There has been more data collected using these sticks and in fact there is enough data to form a baseline with which to compare new findings.

Elkind (1964) in his replication study used sticks similar to Piaget's, but also used 1 1/2" wide slats that varied on length and cubes that varied in three dimensions in unison. These materials have already been described in a previous section. Schafer (1972) used Piaget's sticks to assess a child's seriation ability. In addition he also used the sticks in his training program along with lined cards on which the width of a series of lines was the seriation variable. In his post tests Schafer used sticks, lined cards, drawing of cars of different length, a set of blocks differing in their shade of blue, a set of "happy face" cardboard cards that differed in width and a set of story cards showing a man diving off a diving board. Each of Schafer's and Elkind's tests was based on a visual cue. The child did not have to search for different values of the variable with any of his senses except vision.

The list of visually oriented seriation content is almost inexhaustible. Coxford (1964) used sticks and balloons, both ordered on size. Shantz (1967) used various combinations of the following dimensions: orientation, amount of border, brightness of color, size and degree of emptiness. Each dimension was divided into five different values. Prentice (1963) used pictures of objects that move at different speeds. Mackay _et al_. (1970) used different geometric solids that differed on shape and shade of color in their double seriation study. Again all of the seriation content mentioned is visually oriented.

In addition to the visual seriation content used in many seriation experimental studies, there are also some examples of such materials in early elementary school programs. Maria Montessori (1966) spoke of the materials she developed in the early 1900s to teach seriation. She described sets of cylinders which differ on one, two, or three visual dimensions. She also gave an account of a set of wooden cubes each differing in every dimension from the next by 1 cm and a set of ten rods varying from 10 cm to 1 m in length by increments of 10 cm. Her description of the use of the rods was as follows. "The child scatters the ten rods on a large carpet and mixes them at random, and, by comparing rod with rod, he arranges them according to their order of length, so that they take the form of a set of organ pipes" (1966, p. 35). Other visual materials she uses include objects of different shades of color and sets of wooden prisms that the child can arrange to form a stair steps configuration.

The Science Curriculum Improvement Study's first grade physical science unit, <u>Material Objects</u>, includes some lessons on seriation which incorporate visual materials. Children are directed to collect and order materials such as crayons and buttons of different lengths and sizes. They also practice inserting a stick into an ordered set of sticks. The Modular Activities Program in Science kindergarten unit, Learning to Learn, contains several seriation activities that use visual seriation materials. Children order sticks on length as well as width. They order sets of objects brought from home and construct towers by stacking a set of cups that decrease in volume and stack neatly one upon the other. In addition the children practice placing pictures of simple events into chronological order as well as practice ordering simple phrases to tell a story.

Nonvisually Apparent Seriation Content

Little experimental evidence is available showing the effects of different nonvisual seriation content upon the seriation task. What evidence is available, deals mostly with weight. Piaget (1941) performed a series of experiments with the ordering of a set of weights using a balance. His tasks included ordering a set of three pebbles, ordering a set of three clay balls whose weight differed inversely to the size of the balls, ordering a similar set of four to six clay balls, and ordering a series of ten clay balls of similar size but of different weight. From this work Piaget set out three stages of weight seriation. Stage I seriators were unable to order even the three pebbles either by using the balance or by hefting the materials. Piaget states that children in this stage often did not consider it useful to weigh the objects. Stage II children did order different pairs of objects and did use the balance to accomplish this task. Some even accomplished the seriation of ten weights, but did so with much trial and error. He described this stage as "empirical seriation proceeding by uncoordinated pairs" (p. 229). Stage III children, which Piaget terms operational seriation, "marks the achievement of the seriation of weight" (p. 233). Children in this stage easily accomplish all the tasks described above.

The average ages of the children whose protocols were reported were Stage I, 5 years 10 months, Stage II, 7 years 4 months, and Stage III, 8 years 7 months. When these ages are compared to the ages reported for length seriation (Stage 1, 4 years; Stage II, 5 years; Stage III, 6 years), a marked difference is apparent. Piaget hypothesizes that the age difference is due to the increased abstractness inherent in the property of weight. That is, one does not automatically perceive information about the weight of an object by looking at that object. One must act upon the object in order to get that information. Another hypothesis could be based on the number of opportunities a child would normally have to practice weight discrimination vs. the constant practice normally sighted children would have with visual discrimination.

A similar weight seriation study was performed by G. Baylor and J. Gascon in 1974. A group of twenty children ranging in age from 6 to 12 years were presented with a series of seven similar sized blocks and a pan balance. Each block differed from the next by .8 g to 1.2 g. The children were asked to use the balance to put the objects in order. Baylor and Gascon classified the seriation behavior of the children according to the stages set out by Piaget and reported above. They then attempted to use an information processing system developed by Newell and Simon (1972) to describe the behavior of the subjects. While no statistical analysis or Piaget-like task protocols were reported, the descriptions of the general behavior of subjects in each stage seemed consistent with the descriptions used by Piaget.

Smith and Padilla (1975), too, used weights and also attempted to classify the seriation behavior of task performers. This study used a slightly different approach to information processing routines and also reported descriptive statistics regarding task performance. Of the total of 48 first grade children asked to seriate a set of 4, 6, 8 or 10 weights, only 12 were able to do so with a high degree of accuracy. This compares to 30 children found to be highly accurate seriators with length. Smith and Padilla reported a significant F test ($P < .0001$) for the results obtained for length and weight.

It should be noted again that the major intent of both the Baylor-Gascon and Smith-Padilla studies was to describe the behavior of the subjects while they were completing the task. Both studies used an information processing approach to the problem, although the type of information processing systems used was considerably different. Interestingly, both studies report the same two prominent behaviors for correct seriation. One was characterized as the extreme value selection (EVS) strategy by Smith and Padilla and as the "find heaviest" strategy by Baylor and Gascon. Both studies reported the second behavior as the insertion strategy. Both also found a third, little used strategy called the heavy-light-sieve or the rearrangement strategy.

Padilla (1974) in an unpublished pilot project attempted to teach a group of first grade children to order different sets of non-visual materials. A set of eight cups, each possessing a different mass (Weight), a set of eight mailing tubes with different textured materials glued to the inside (Texture), and a set of eight pipes with handles which took different force to pull were the three sets of materials used. All the materials differed on only one variable. Using a partial credit scoring system and methods which allowed the subjects to practice until they reached criterion, it was found that even Stage I non-seriators reached a certain high degree of seriation accuracy. The groups taught a strategy for seriating performed significantly better than did the control group. All three seriation variables, weight, texture and force, seemed equally difficult for the children as the mean scores across trials and treatment groups showed a high degree of similarity.

As with the visual seriation materials, many nonvisual examples of seriation content are present in early elementary school programs. Again Maria Montessori (1966) led the way. She offered a "graduated series of sandpaper cards," as well as pieces of velvet, satin, silk, wool, cotton and linen for seriation (p. 38). In addition she supplied a series of wooden squares of identical size, but of different types of wood. This weight seriation task done with these squares and performed by resting the wooden squares on the tips of the fingers, is called "a much more difficult exercise" than the texture seriation by Montessori (p. 40). Another set of materials can be used for seriation on intensity of sound. A series of six closed cardboard and wood cylinders, filled with different materials produces "sounds varying in intensity from loud to almost imperceptible sounds, according to the nature of the objects inside the cylinder" (p. 58). A last set of materials, a set of bells differing by a full step on the chromatic scale, is included in Montessori's book. Children first learn to match bells of similar pitch. Later, after the child has mastered this task, a series of eight bells is used for seriation.

A similar set of chromatic bells, differing by one full step, was used by the author in a pilot project (Padilla, 1974) in an attempt to teach seriation. It was found that, while the children could easily learn to order on weight and texture, they had great difficulty with pitch. After asking the children several probing questions, the author concluded that the children's inability stemmed from their lack of knowledge of the scale. They simply did not understand the terms "higher" and "lower." Even though they could state when two bells were of differing pitch, many could not say which was the higher and which the lower, nor could they order the set of bells.

Several newer elementary science programs include nonvisual seriation materials. The Science Curriculum Improvement Study kindergarten program, <u>Beginnings</u>, includes texture materials similar to those described by Montessori, as does the Modular Activities Program in Science kindergarten unit, <u>Learning to Learn</u>. In addition both units stress the use of materials for sense education and one of the activities commonly done is seriation. The materials used for these activities include sound boxes, scent boxes, touch bags, and beads.

Training Studies

The present study is not attempting to teach seriation capabilities to children so that they move from one piagetian stage to another. Instead the seriation task in this study is viewed as one of a series of possible tasks in an elementary school program and study of transfer phenomenon. It has been shown that there is considerable precedent for this tradition in present day science curricula. However, it might be quite foolish to overlook the literature relevant to training children to perform certain Piagetian capabilities. Therefore, in this section of the review of the literature, those studies which attempted to alter stage placement by teaching certain aspects of seriation will be analyzed. In addition certain other Piaget training studies dealing with conservation tasks will also be reviewed. These conservation studies while not specifically applicable to the present work, nevertheless provide a broader view of the training studies in general. Very much more work has been done with conservation than with seriation and some of this work bears on the present study.

Conservation Training Studies

Many studies have concentrated on the series of Piagetian tasks termed conservation tasks. These tasks involve questions about what stays constant in a system when certain physical characteristics of that system change. One sample task is termed the conservation of liquid volume. In it a child is presented with two normal-size, plastic glasses filled to the same line with water. He is asked if the amount of water is the same in each glass. After he agrees that this is so, the water from one of the glasses is poured into a tall, thin container. The child is asked which of the two containers now holds more water or if they are equal. A conserver will state that the volumes are equal and will be able to explain the apparent heighth dimension difference. The non conserver will say that the tall, thin container holds more water and will usually not accept any logical explanations stating they are the same.

A number of different tasks have been used to identify conservation abilities and children gradually become operational in them from about five years up to approximately fourteen years of age. The names of some of these conservation tasks are number, area, length, liquid volume and solid volume.

Several studies have attempted to teach children conservation capabilities using short term training. Schafer (1972), in a very thorough review, points out that many of these attempts have followed a Piagetian logical operation method in which certain logical operations thought basic to subsequent operations were taught. An example of this is the attempt to teach reversibility, that a set of objects or events can be reversed to their former position or order, to children as a prerequisite structure to conservation tasks. Goldschmid (1968) taught one group of kindergarten children using reversibility training and a second using compensation training that showed that when one dimension of a material was increased a second was decreased, as with pouring water from a flat, wide container to a tall, thin container. Reversibility training proved to be the superior of the two methods used to teach prerequisite cognitive structures, although both were successful. Johnson (1972) points out that another example of teaching prerequisite cognitive structures centers around what Piaget calls centration or "the tendency of the young child to center attention on one salient attribute of an object" (p. 111). Gelman (1969) taught five year olds to decenter by practicing oddity problems which have various distracting stimuli. "Children of five who had failed the conservation tests learned not to attend to the irrelevant features of oddity problems and then became successful on conservation tests" (Johnson, p. 112).

A second line of thought in teaching conservation capabilities pointed out by Schafer (1972) is the "American learning theory viewpoint" (p. 28). "The learning theory approach . . . is characterized by emphasis upon such factors as learning set, reinforcement, corrective feedback, the influence of irrelevant cues, verbal rule learning, cue fading, and practice" (p. 28). Schafer's study is one which takes this approach with seriation and it will be reviewed in the next section. Beilin (1965) used several training methods to induce number and length conservation. The only effective method was a verbal explanation and modeling method which "provides S with a model or rule for processing relevant input data" (p. 337). Wohlwill and Lowe (1962) tried to teach kindergarten children to conserve number by reinforced practice as well as other methods. Although unsuccessful, the experimenters interpreted the lack of conservation as an inability to differentiate irrelevant from relevant perceptual cues.

While this inability to zero in on relevant cues has been described above as a cognitive structure called centration, Schafer insists that the use of practice and verbal feedback places this study in the learning theory group. While this distinction between two types of teaching is interesting, perhaps it is but the differentiation between the methods employed in training and the hypothetical structures assumed to be acting. Whatever the case, Schafer's distinctions prove useful in distinguishing among the training studies.

In a section discussing the relative merits of successful and unsuccessful studies, Schafer draws the following conclusion.

> The unsuccessful studies were characterized by very few training trials (Maximum number of trials was 18), no training performance criteria, and almost no means of providing subjects with feedback. In comparison, the successful studies used more training (Goldschmid, 1.5 hours; Gelman, 192 trials), trained to criteria (Wallach and Sprott; Wallach, Wall and Anderson; and Kingsley and Hall), and often provided the subjects with feedback. This comparison suggests that future training studies use adequate amounts of training and provide the subjects with feedback, and that possibly those methodological comparisons made in the unsuccessful studies should be repeated with more emphasis given to the extensiveness of the training and to the use of feedback (p. 50-51).

Further information about the conservation training studies is available in the thorough review provided by Schafer (1972).

Seriation Training Studies

Coxford (1964) attempted to raise Stage I and II seriators to Stage II and III competency. He pretested 60 children and isolated 48 Stage I and II seriators. He divided these children into two groups, one given the seriation treatment the other a control group. Twelve children in each treatment group were Stage I and twelve were Stage II. The control group received no instruction or alternative activities. Pairs of children in the treatment group were given four 10-15 minute training sessions over a period of four weeks. Stage I children practiced building shapes and ordering with sets of cardboard geometric materials of increasing size. They also practiced constructing a serial correspondence between two sets of figures. Stage II children practiced matching cardboard geometric figures as well as played games focusing on inserting objects into an ordered row that was matched to another ordered row of different shapes. Coxford showed no differences between Stage I control and treatment groups. He did find that the Stage II treatment group did significantly better than the control group on the post test tasks. He concluded that his method of teaching Stage II children produced this difference. However, since the control group did not receive any placebo training, Coxford's conclusion may not be solely attributable to the training difference. Perhaps the attention alone helped the Stage II seriators attend to the task well enough to do better than they might normally do.

Schafer (1972) attempted "to investigate the effectiveness (acquisition, retention, and transfer) of using cue fading and reinforcement to instruct children who were in Piaget's Seriation Stage II for performance at Piaget's Seriation Stage III" (p. 10). Thirty-four kindergarten age children were assigned to either a control or an experimental group. The control group received no training or alternative activities. The experimental group received three thirty minute training sessions, all similarly structured and given on consecutive days. In each session a child was individually guided through a number of separate training stations, where he practiced the insertion task with different materials. "At the beginning and whenever the number of task objects increased during a session, either the ease of object discrimination was high and then gradually decreased in levels, or cues were introduced and then gradually faded in levels" (p. 12). Two kinds of reinforcement, verbal and token (marbles), were used throughout the training. Post tests were given one, eight and 132 days after training with materials similar to those used in training (called near transfer measure) and materials dissimilar to those used in training (called far transfer measure).

Results showed the experimental group superior in near transfer, but no differences were found for the far transfer. As with Coxford's experiment, the control group in Schafer's study received no attention whatever, leaving the results open to question. Were the differences on near transfer items possibly a result of the attention received by the experimental group? Quite possibly a Hawthorne-like effect may be a part of the differences found in both Schafer's and Coxford's work.

A third training study, the pilot study for the present work (Padilla, 1974), can also be construed as a seriation training study. While the express purpose of this work was not the movement of children from one stage to another, it does in fact involve the teaching of specific strategies for purposes of seriating sets of non-visual materials.

Sixty first grade children were administered Piaget's stick seriation task and classified as Stage I and Stage III. From this number twenty-four children were chosen as subjects and assigned to strategy treatment groups. Treatment group one (EVS) was taught to seriate the materials using a strategy which focused on choosing the greatest element from the unordered elements and placing it next in the row until all the objects were ordered. Treatment group two (INS) was taught to seriate the materials by choosing randomly from the unordered elements and inserting this selection in its proper place in the row. Treatment group three (CON) was a control group which simply practiced the seriation task with feedback on correctness. Three different sets of materials, already described, were used. The children were told to, "Put these objects in a row according to their weight" or "roughness" or "how hard they pull."

Children in the treatment groups were taught individually in three separate sessions during which one of the three material sets was used and data was collected on the number of trials to criterion. Criterion was defined as the successful completion of the task using the exact strategy taught. During a fourth session, a post test was administered consisting of one try at seriating each of the three material sets. A Kendall's Tau correlation was computed to judge the degree of correctness for each task.

The training sessions featured several of the aspects discussed in the above studies, including a verbal explanation along with a modeling of seriation behavior, reinforcement from the trainer, practice to criterion and absence of irrelevant variables. The only difference between Strategy treatment and Control treatment was the verbal explanation and modeling of the specific strategy received only by the strategy groups. In this way a true placebo group was used, the members of which were given as much attention and practice with materials as the Strategy groups.

Analysis of the post test results showed that both strategy groups were significantly different from the control group ($P < .05$) with the EVS strategy group's mean scores superior to the INS and CON groups, and the INS group superior to the CON group. In addition the Stage I children achieved slightly higher seriation task scores than did the Stage III children, indicating that even Stage I children can learn to seriate, if taught correctly.

Two individual difference variables, Kagan's conceptual tempo (Kagan and Moss, 1963; Kagan, 1965) and short term memory as measured by the digit span test (Wechsler, 1974) were used in this pilot project. The four possible combinations of median splits of these two variables (Reflective, high memory; Reflective, low memory; Impulsive, high memory and Impulsive, low memory) were crossed with each treatment group. While the final results showed significant differences favoring the reflective and high memory children, these variables were not considered profitable since the hypothesized interaction between the traits and the strategy treatments was not found. One would normally expect reflective and high memory children to do better on a task involving some relatively difficult, logical thought as well as a high degree of memory.

Analysis of the trials to criterion data also showed good results. A strong tendency for the strategy treatment groups to transfer the taught strategy to a new training session was evident. The Control group children showed no such tendency and in fact fluctuated in performance from one training trial to the next.

While the magnitude of results of this study are open to question because of the small sample size (N=24), the general trends of the results can be very useful. Certainly a method of training using Beilin's (1965) verbal explanations and models, corrective feedback and practice to criterion can be very successful. Too, strategy training of some sort may prove more useful than allowing children to form their own strategies for seriating.

A Task Content Matrix Incorporating the Seriation Task

As a final component to this review of the literature chapter, a short integration of Smith's educational model with some special aspects of the seriation task is presented. The intent of this section is to place the task in its proper perspective within the model and to present the potential vertical and lateral transfer effects within a curriculum. Some of these potential effects are examined in the present work; others are not. All of these effects bear on the general questions raised in the first chapter.

Figure 4 is a representation of a task-content matrix of which seriation might be a part. This matrix leads to a terminal task which is discovering a correlational rule. All of the tasks along the left hand column can be performed with each of the systemic content areas across the top. The importance of the seriation task in this matrix is great. It is the basic task which makes up one method by which a correlational rule can be derived. Tasks one through four all contribute to the development of skills applicable to the seriation task. In turn this seriation task can be a basic component of a strategy for establishing a correlational rule.

Perhaps an example of how seriation can be a part of a correlational rule strategy would be appropriate. Let us say that a child is given several ramps with

	Length	Weight	Texture	Force	etc.
1. Compare					
2. Find Greatest					
3. Seriate, 3-4 Objects					
4. (Insertion)					
5. Seriate, 8-10 Objects					
6. Double Seriation					
7. Correlational Rule	w/weight w/texture w/force	w/length w/texture w/force	w/length w/weight w/force	w/length w/weight w/texture	etc.

Fig. 4.--One Possible Task Content Matrix Which Involves the Seriation Task.

differing angles of inclination and also a small cart. His task is to produce a correlational rule relating the angle of inclination with the distance traveled by the cart when it rolls down the ramp. One strategy for solving this problem involves seriating the ramps according to angle of inclination and then reseriating on the distances traveled by the cart. This puts the two variables in direct visual correspondence with each other, thus making the inference of a relation between the variables much easier. While this is not the only possible strategy for producing a correlational rule, it is one which involves seriation and fits into the vertical task hierarchy presented in Fig. 4. It also provides a basis for introducing more sophisticated strategies such as the representation of objects as data points on a two dimensional graph.

In order to better understand the tasks presented in this figure, the specific task descriptions in Fig. 5 are presented. Note that other similar tasks might be used in place of those listed. These tasks might be generated by the methods discussed earlier in this chapter.

As was alluded to in the previous discussion of the seriation task as a component of stating a correlational rule, transfer would be a very important aspect of this task-content matrix. The type of transfer dealt with in this study is lateral transfer across content,

Task Name		Task Description
1. Compare (Same/ Different)	Given:	-two objects with either the same or different values of a named variable -an observation/measurement procedure -instructions on Comparison
	Output:	-a statement indicating whether the objects have "same" or "different" values
2. Find Greatest	Given:	-a set of objects differing on a named variable -an observation/measurement procedure -instructions to find the greatest
	Output:	-one object with the greatest value
3. Seriation of 3-4 Objects	Given:	-a set of 3-4 objects differing on a named variable -an observation/measurement procedure -instructions to seriate the objects
	Output:	-a row of objects in order on the named variable
4. Insertion	Given:	-a set of 4-5 objects ordered on a named variable -an object for insertion -an observation/measurement procedure -instructions on insertion
	Output:	-the ordered set of 4-5 objects with the insertion object placed in the correct position
5. Seriation of 8-10 Objects	Given:	-a set of 8-10 objects differing on a named variable -an observation/measurement procedure -instructions to seriate the objects
	Output:	-a row of objects in order on the named variable
6. Double Seriation	Given:	-a set of objects differing on two variables -an observation/measurement procedure -instructions to seriate the objects on one variable and then the next
	Output:	-a set of elements seriated on one variable first and then reordered on a second variable
7. Correlational Rule	Given:	-a set of objects double seriated on two variables -instructions on the task
	Output:	-a correlational rule relating one of the seriation variables to the next

Fig. 5.--Seriation Hierarchy Task Descriptions.

i.e., from length to weight, etc. This transfer could be predicted in the example matrix because of the similar nature of the content areas (i.e., all belong to the variable value analytic network). If one taught a specific strategy for task completion, then the model predicts that lateral transfer would be greater for those taught the strategy than for those who must develop their own method for task completion. Those taught a strategy would, once the strategy is learned, be able to concentrate on the new content. Those constructing their own methods would most likely take more time in doing so and might never construct one which is transferable to other content areas.

Vertical transfer from task to task within this matrix is dependent on the task strategy previously learned. If the task strategies learned for comparing and finding the greatest could be incorporated into a strategy for seriating 3-4 objects, then vertical transfer would be expected. The fourth task on the chart, insertion, is enclosed in parentheses to indicate that it may or may not be a prerequisite task in the hierarchy, depending on the strategy used for seriation of 8-10 objects. Obviously it would be important for a strategy stressing that capability (e.g., the insertion strategy), but not for a strategy circumventing the capability (e.g., the extreme value selection strategy).

If both lateral and vertical transfer appeared to be in operation during the teaching of the seriation task content matrix, then every task would not have to be taught or practiced with every content area. Perhaps some sort of content sampling could be done for each task. Even better might be a method of using the more difficult or more abstract content with several, although not necessarily all, tasks, while the easier content might only be encountered one time. Likewise the easier tasks in the matrix might be practiced few times, while the more complicated and difficult ones may be practiced over and over. Thus a degree of variability must be a major component of teaching within a task-content matrix and this variability would rely heavily on the children's degree of intellectual development and their past experience.

It is quite obvious from the previous paragraphs that the present work addresses instructional rather than developmental questions. Why then, are all of the logical thought literature and the Piaget training studies cited? Simply because they bear heavily on the project, offering a clear insight into materials, tasks and training procedures. It is certainly an important part of curriculum development to pay close attention to the developmental characteristics of the children of interest. Hopefully future research will examine other transfer effects for the seriation task-content matrix as this work has examined lateral transfer.

CHAPTER III

THE RESEARCH METHOD AND PROCEDURES

The purpose of this chapter is to set out the research method and specific procedures used in carrying out this work. After a brief overview of the procedure, the chosen sample of children will be described. This will be followed by discussions of the treatment groups, the materials and the training and post testing sessions. Descriptions of all of the data collected during these sessions as well as the design used for analysis and the hypotheses and methods of analysis will then be systematically reviewed.

One hundred and twenty first grade children were divided into two groups based on their ability to order a set of sticks. Thirty six from each group were randomly chosen and were randomly assigned to one of three treatments. Two of the treatments used verbal modeling and task feedback to teach a seriation strategy. The third treatment was a control group given practice with the materials and outcome feedback. The children were taught in three separate sessions followed by a post test session in which they were asked to seriate the same materials that were used for the teaching. Measures of task accuracy, strategy use and efficiency of learning were taken to test hypotheses concerning the effects of strategy training on learning and transfer.

The Sample

The sample of first grade children used in this work was selected from two Lansing, Michigan public schools which were chosen because of the similarities between their student populations. Each of the two schools draws from a similar middle class neighborhood and they are located approximately ten miles from each other on the opposite sides of Lansing. Each has about the same percent of black and Latino students (approximately 10 percent). The students ranged in age from 73 to 86 months with a mean age of 82 months and all were considered within the normal age range of a first grade class in the Lansing Public Schools.

Each of the total of 120 first grade children was administered a pretest individually by one of a group of testers. The children were then randomly assigned to a series of treatments and testers blocking on pretest level. The following two sections describe the pretest and the system of random assignment.

The Pretest

The pretest, or Piaget Stick Task, assessed the state of each child's seriation ability. This test follows very closely the method used by Piaget which was described in the previous chapter.

Each child was asked to order a series of ten wooden 1/4" dowels of different length, varying from 9 cm to 16.2 cm, each differing from the text by 0.8 cm in length. The dowels were presented to the child on a piece of carpeting to prevent needless rolling and were arranged in the same mixed order for each child (see Appendix G).

Before being presented with the task, the children were shown a model set of five dowels ranging from 9 cm to 15.4 cm, each differing from the next by 1.6 cm, that were in perfect order. They were told that the sticks were put in a row from longest to shortest so that when the bottoms were even the tops formed stair steps. If the child, when asked, said he understood the order, then he was informed that he would be given a set of sticks to put into a row. Again he was asked if he understood, and, if he answered yes, the pretest began. All of the children said they understood both the order and the task they were to do.

When each child had finished the ordering and if he had done so correctly, then he was told that the experimenter had made a mistake and had forgotten to give him all of the sticks. The child was then presented with five sticks, one at a time, and was asked to insert the sticks into the ordered row. The five insertion sticks fit into the row in such a way that each could belong in only one position. For the exact length and placement positions of the sticks, see Appendix A.

From this task, the children were divided into one of three categories based on Piaget's findings. Stage I children cannot seriate or insert the dowels; Stage II children can seriate the dowels with difficulty but cannot insert; and Stage III children can both seriate and insert.

Method of Random Selection and Assignment

Several different selection and assignment processes were necessary so that the children in one particular group would not in some unknown, systematic way differ from the children in another group. In addition several variables, which were not a part of the chosen design, were controlled by random assignment of the children. All randomization was accomplished by choosing numbers from a hat.

Thirty six Stage I and thirty six Stage III seriators were randomly selected from among the pools of sixty three Stage I and forty Stage III children. In addition three extra Stage I and two extra Stage III children from each school were chosen as replacements should any of the original children become ill or move. These alternates were used only if a child was absent for two days or more and they were assigned by a person not involved in the training in order to maintain the secrecy of the stage of the child. Substitutes during the second and third training sessions were started with training session one in order to maintain the balance of the design and were post-tested after the others had finished. The remaining Stage I and III seriators and all of the Stage II children were dropped from consideration and were not given any further testing or training.

The total of 72 Stage I and III children were randomly assigned to one of four trainers with each trainer being responsible for nine Stage I and nine Stage III children. The trainers were ignorant of the stage of any child. In addition each trainer presented the training sessions in three different sequences. Each of the children assigned to each trainer were therefore randomly assigned to one of the three sequences so that three Stage I and three Stage III seriators were assigned to each sequence for each trainer. The three training sequences were weight, texture, force (WTF), texture, force, weight (TFW), and force, weight, texture (FWT) and each sequence indicates the order of materials during the three training sessions.

One last random assignment occurred when the three Stage I and three Stage III seriators assigned to one trainer and to one sequence were further assigned to one of three treatment groups, the EVS, the INS or the CON.

The order used in randomly assigning the children is reviewed in Figure 6.

The Treatment Groups

Three treatments were used in this study, two of which involved instruction on specific strategies found useful in seriating sets of objects and one of which was a control treatment. All three treatments used practice and outcome feedback methods.

The Extreme Value Selection Strategy Treatment

The first treatment, called the extreme value selection strategy (EVS) is one which primarily focuses on finding the greatest or most extreme value of all the unordered elements and placing it in the row. Repeated uses of this method will produce a completed and properly ordered row provided that the proper object was chosen each time as the extreme value and that the object chosen was correctly placed next to the previously chosen extreme value.

The EVS strategy is one which is highly repetitive in nature, and which takes few decisions on the part of the user. The child must only decide which element of the unordered ones is the greatest, place it at the end of the row and then repeat this process. He does not consider the

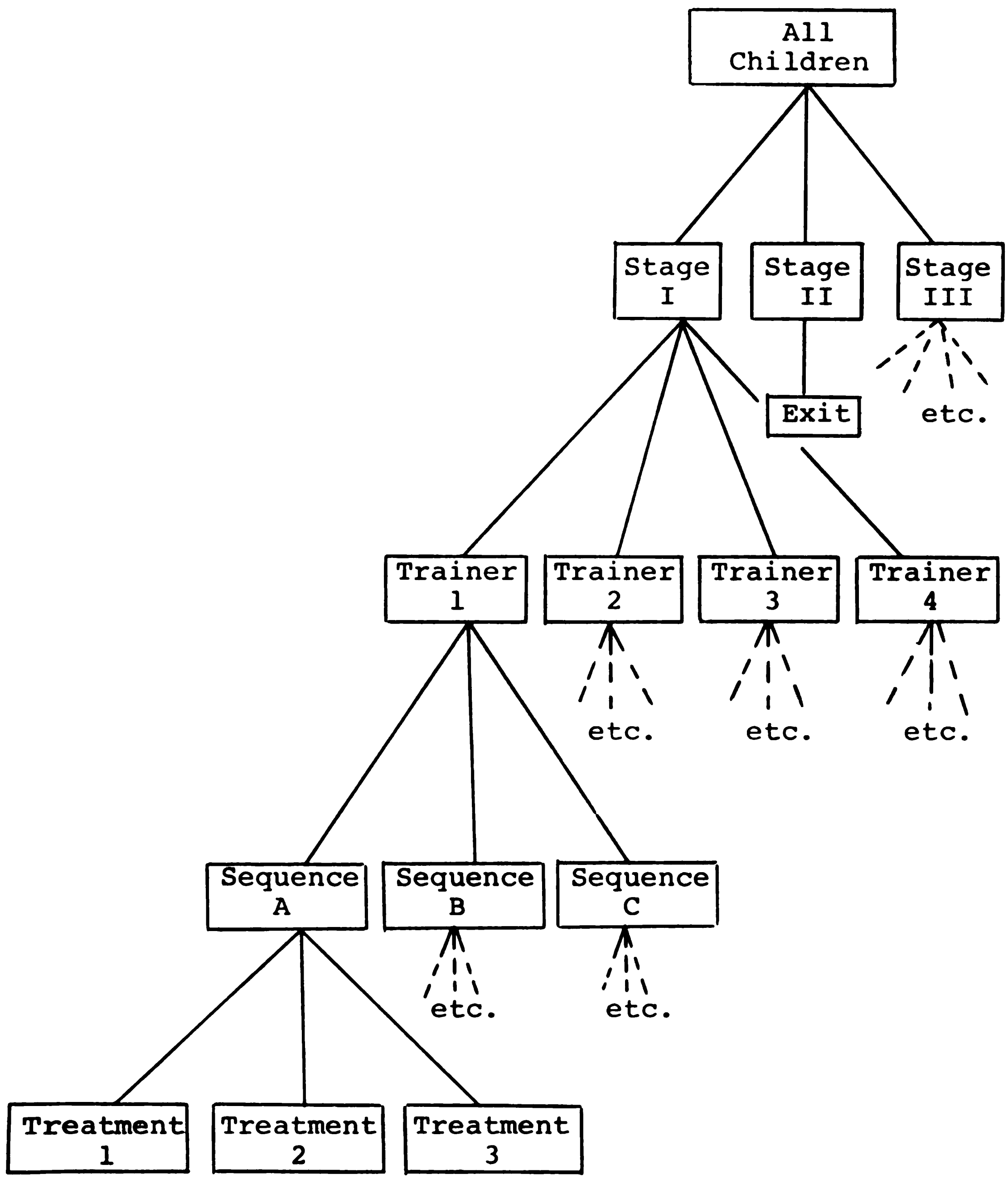

Fig. 6.--Diagram of the Sequence of Random Assignment and Selection of Subjects.

ordered row at all, nor does he decide where in that ordered row the next greatest element should be placed. That decision is always the same, it is to be placed at the end of the ordered row, next to the object most recently placed.

In order to better understand the EVS strategy an example of how a child might find the next extreme valued object and place that object can be explained using Figure 7 and weight as the variable. The child has already used the EVS strategy and has chosen the four heaviest weights, each in succession, and put them in a row, 1 through 4. The four remaining elements (A-D) should constitute the four lightest elements. The child's task is to find the heaviest object of those remaining.

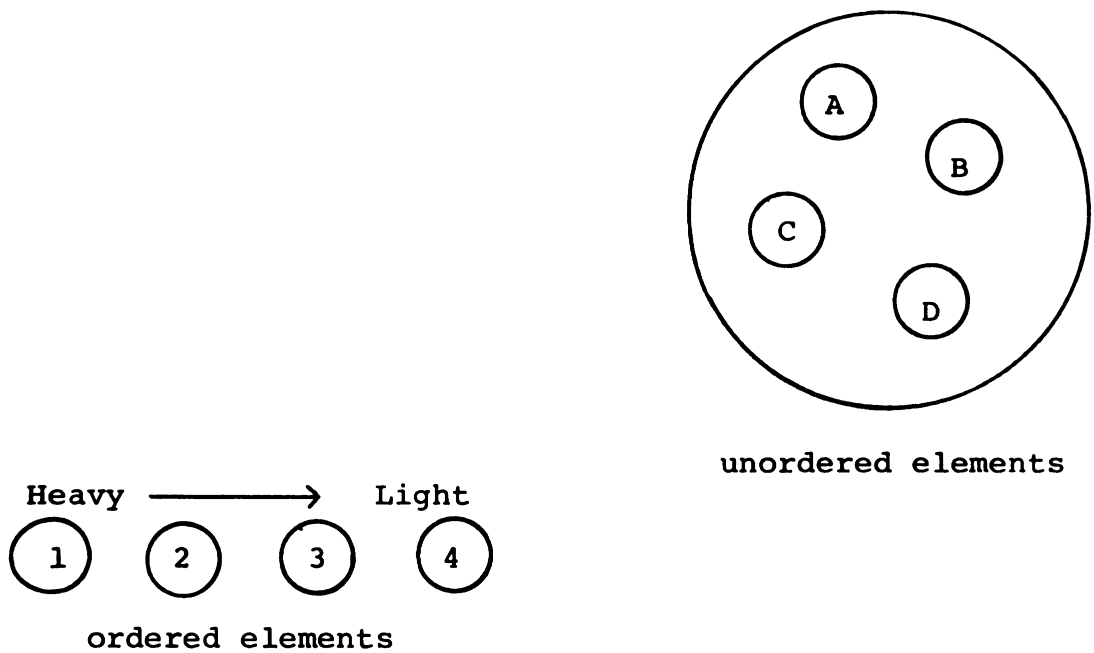

Fig. 7.--Using the EVS Strategy to Order the Weights.

He first picks D and C and compares their weight. He finds C heavier than D, so he discards D by moving it to start a discard pile. He then chooses A and compares it to C, finding C still heavier, he places A in the discard pile and takes B to compare to C. He finds B to be heavier than C, so he discards C and seeing that there are no more elements to compare, he places B at the end of the ordered row, next to 4. Object B then becomes the fifth object in the ordered row. In order to place the rest of the objects (A, C and D) in their proper places in the row, the child then repeats the process on these elements until all the elements are ordered.

The Insertion Strategy Treatment

The second treatment is called the insertion (INS) strategy and, contrary to the EVS, focuses primarily on the ordered row and chooses elements randomly from the unordered pile. The strategy begins with a random choice of an object as the first one in the row. The second object chosen is placed next to the first in the row and indicates the direction of the ordering. Each successive object chosen is acted upon and taken to the place in the ordered row where the child thinks it belongs. This judgment constitutes an educated guess based on the value of the object to be inserted and the values of the ordered objects which are stored in short term memory. The object to be inserted (e) is then compared to the object in the row (x). If e is greater than x, the subject moves e toward the greater end of the row comparing e to every object. When the subject comes to the end of the row or finds an object greater in value than e, he places e at the end of the row or between the object of greater value and the last object which was of lesser value. If e is lesser in value than x upon first comparison, then the same process occurs in the opposite direction until e is placed.

An example of this process shows that it is very simple in nature. If a child has ordered five of eight weights and has three more to put in the line, then Figure 8 would show the position of all the weights.

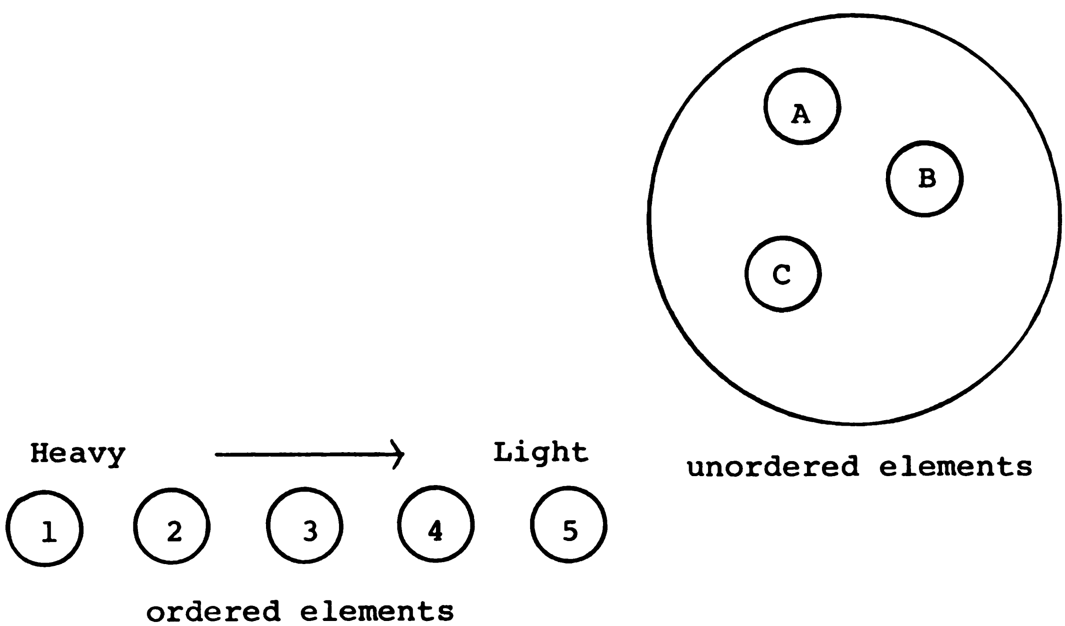

Fig. 8.--Using the Insertion Strategy to Order the Weights.

The next step is the choice of an unordered element, let's say C. The child picks up C and determines its weight relative to the five ordered weights. For this example let us say that C belongs between weights 4 and 5. When the child picks up C he perceives that C is a very light object and immediately takes it to number 5 in the row, where he compares C to number 5. He finds that C is heavier than number 5 so he moves to number 4, toward the heavier end. He then compares C to number 4 and finds that it is lighter than number 4. Because C is lighter than number 4 and heavier than number 5, the child makes enough room and places C between 4 and 5 in the ordered row. Thus are all of the placements made. If the child makes a slight miscalculation on his educated guess, he may have to compare the object to be inserted to more than two objects. But if he follows the strategy correctly he will always be able to place an object in its correct position.

The Control Treatment

The third treatment called the Control Group (CON) involves no specific strategy training, only task practice with the materials and feedback on correctness. The subjects in this treatment group were given the same instructions on how to observe the materials in order to find out about the variable of interest. Any systematic method of seriation used by these subjects would be idiosyncratic in nature, if it occurred at all.

The Materials

Three different sets of materials were used for the training sessions. The first was a set of cups of different mass. Each cup or weight, as each was called, was constructed from a 12 oz. white styrofoam cup and was filled with varying amounts of No. 8 lead shot and paraffin wax which held the shot so it did not move. Each cup was filled to a specific pre-determined mass and was covered with a plastic top which was glued on. The masses of the cups (± 5 gm) were as follows:

#1 - 10 gm	#5 - 529 gm
#2 - 64 gm	#6 - 784 gm
#3 - 169 gm	#7 - 1089 gm
#4 - 324 gm	#8 - 1444 gm

For a more detailed description of this and the following materials as well as a rationale for the values chosen, see Appendix A.

The second set of materials was a set of cups with different textured materials glued to the inside of each cup. The children ascertained the relative roughness of each cup by feeling the inside with their fingers. The cups, or feelies as they are called, were constructed from 4" high mailing tubes made from cardboard and metal over which was placed a man's sock (Figure 9). A rubber

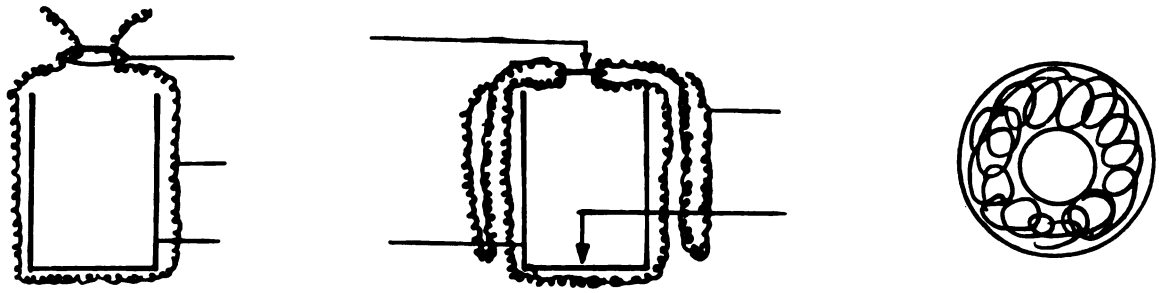

Fig. 9.--Diagrammatic Representation of the Feelies.

band was placed around the neck of the sock which was then doubled back around the tube. The rubber band held the sock closed around the top opening of the tube so that it was difficult to see inside of it. In addition, a circular piece of black construction paper, about the size of the tube diameter was glued to the metal bottom of each tube to prevent reflected light from lighting the inside of the feelies.

The following is a list of the different materials glued to the inside of the mailing tubes:

#1 acetate

#2 savin copy paper

#3 construction paper

#4 #400 grit wet-or-dry, Tri-m-ite sandpaper

#5 #280 grit wet-or-dry, Tri-m-ite sandpaper

#6 #120 grit wet-or-dry, Tri-m-ite sandpaper

#7 #80 grit Tri-m-ite, Resin bond cloth, open coat aluminum oxide sandpaper

#8 #50 Tri-m-ite, elek-tro-cut cloth sandpaper

The third set of materials was a set of pipes with handles, called pull toys, which differed on the amount of force necessary to pull the handle a certain distance. These pull toys were constructed from 9" lengths of 1/2" plastic pipe with 1/2" plastic caps on either end (Figure 10). Different kinds and combinations of rubber bands were stretched from a wire loop hanging through a hole in the top cap. The rubber bands were secured at the other end by another wire loop attached to a two hole #4 rubber stopper which was used as a handle. This loop

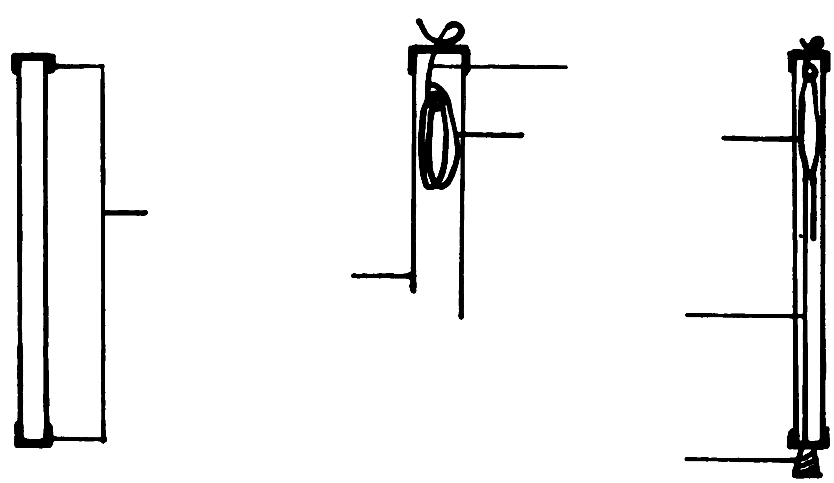

Fig. 10.--Diagrammatic Representation of the Pull Toys.

passed through a hole in the center of the plastic cap on the bottom.

Each handle could be pulled out a maximum of 10 to 11 cm. The children ascertained the amount of force necessary to pull the handle of each pull toy by holding the pipe in one hand and pulling the handle with the other hand.

The following is a list of forces necessary to pull the handle of the pull toys a distance of 10 cm. An error of ± 10 percent was allowed due to the difficulties in standardizing a series of rubber bands, in standardizing lengths of wire and thicknesses of caps and in obtaining very accurate measures of force.

Force

#1	1.00 lb.	#5	4.00 lb.
#2	1.40 lb.	#6	5.66 lb.
#3	2.00 lb.	#7	8.00 lb.
#4	2.83 lb.	#8	11.30 lb.

The Training and Post Testing Sessions

The children in each treatment group were trained in three separate sessions with either two or three days of no training between each. A post test was administered in a single session one to two days following the last training day. During each training session each child was either individually taught a specific method of putting a series of objects into a row (EVS and INS groups), or was given practice in putting the objects in order with feedback on errors (CON group).

All sessions began in a similar fashion, with the experimenter explaining the task and the materials to the child by showing him a model set of five objects which had been put into the proper order before the session had begun. After the child had observed the model set and when the child said that he understood the task, he was presented with a new set of eight objects and told to put them in a row from heaviest to lightest or roughest to smoothest or hardest to pull to easiest to pull. This first task was called his pretest with the materials and was considered his basal performance with the new objects at that point in the experiment.

When the pretest was finished and if the subject (S) was assigned to the INS or EVS treatment groups, then the experimenter (E) told S to pay close attention because he was going to show him a way to put these objects in a row. E then modeled and verbally described the desired behavior by ordering a set of objects using the correct strategy. When he finished with the modeling, E asked S to put the objects in order exactly as he had been shown. If the child did so to criterion (perfect seriation using the taught strategy), he was finished with that training session. If he was incorrect, then he was given specific feedback as to what he had done wrong on the trial (see

Appendix C). He was then asked to try the task again to see if he could do it without making a mistake. If S made two successive, non perfect attempts, E modeled and verbally described the strategy again, emphasizing the areas in which S had made errors. S was then allowed to attempt to reach criterion again. A child was terminated after five unsuccessful attempts or after his first successful attempt. In addition, each child was given much encouragement after each successful or unsuccessful attempt.

After the pretest, S's in the CON group were told to put a set of objects in a row and that this time they would receive feedback on how well they did. They did not receive any training on how to put the objects in order, just feedback and encouragement, similar to that given to the EVS and INS groups. They were given the same maximum number of trials to reach criterion (in this case, just perfect seriation). The session ended when S reached criterion or failed to do so in five trials.

Feedback was given each S after each attempt at seriating the materials following the pretest. Every child was allowed to finish an attempt or trial no matter how poorly he was proceeding. This was done so that data could be collected on all attempts.

Feedback for the EVS and INS treatment groups followed a similar pattern. When the child finished a trial, E asked S to observe the ordered row to see if he had performed the task correctly. When the child came to a mistake in placement as he moved along the row, he was asked to correct the mistake. After the mistakes had been corrected (for time's sake a maximum of three were acted upon), E then took from three to five of the objects to be ordered and showed S the reason for his errors and a method of correcting them. Some typical errors in strategy made by the EVS or INS groups are listed in Appendix C, which also contains a more specific delineation of the mini-model feedback routine as well as examples of some often occurring applications of it.

Feedback for the CON treatment group followed a format similar to that of EVS and INS groups, however no strategy oriented discussion was allowed. The same feedback on correctness was given, but no way of correcting strategy errors or method errors was specifically outlined. Instead the CON group feedback concentrated on slowing the fast child down, urging the careless child to be careful, or showing some of the children how to use the same hand to discriminate close objects. The how or method for seriation was left entirely up to the subject.

A series of post-tests was administered to each subject one or two days after the end of the last training session. They consisted of one single attempt to seriate each set of materials which were presented in the same order as they were presented in the training sessions.

That is, if a child A received the weights in training session 1, the feelies in session 2, and the pull toys in session three, then he received the weights as post-test 1, the feelies as post-test 2, and the pull toys as post-test 3. In addition, each subject was given the Piaget Stick Task as a fourth post-test. None of the subjects was administered the post tests by the same person who had trained him.

As a review of the sequence, content, and relative amounts of time between pre-tests, training sessions and post-tests, Figure 11 is presented.

The Data

During the previously discussed training sessions and post tests, several different kinds of data were collected. Whenever the subjects performed the task, whether in tests or training trials, the order in which the objects were placed and the serial order of the row were recorded. These data allowed the correctness of each ordering to be determined and the action of each child to be reconstructed. In addition, the number of trials necessary to reach criterion was recorded for each training session. These data are described in more detail in this section and are complemented by descriptions of measures derived from it.

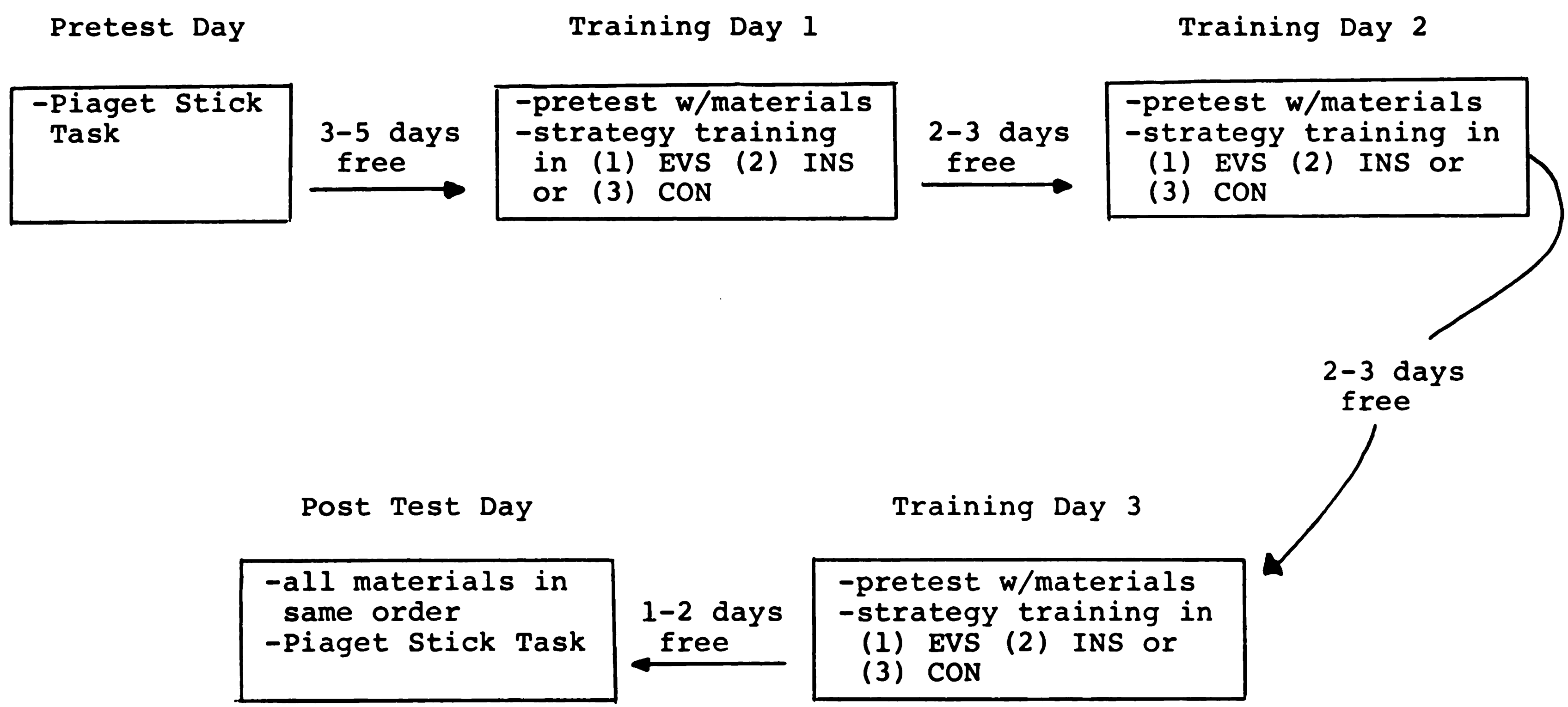

Fig. 11.--The Pretest, Training and Post Test Sequence.

Raw Task Data

During the pretests and trials of the training sessions and for all of the post test tasks, data was collected on the order of final placement and the sequence of placement of the objects. The order of final placement was simply the final order that the child deemed correct and it was recorded after the seriation attempt. A correct row of objects was recorded as 1 2 3 4 5 6 7 8. Any deviation from perfection would be indicated by a jumbled progression of numbers. A row reading 1 2 3 5 4 6 8 7 would indicate that a child reversed objects 4 and 5 and objects 7 and 8. The order of final placement, then, indicates the relative correctness of a row of seriated objects.

The sequence of placement of objects was collected while the child was performing the task. This was also recorded as a row of numbers and was completely independent of the final position numbers. This row indicates the order of placement of the objects, i.e. whether first, second, third, etc., as well as the position in which the objects were placed. For example a partial sequence of 3 1 2 4 would indicate that of four objects placed, the third one acted upon was placed on the far left end, the fourth on the far right end and the first and second in the middle two slots. If the child moved an already placed object to a new position, it was noted by an arrow from the old number to the new placement number. For example, the series of numbers 3 1 8 4 7 5 9 2 6 indicates that the fourth object positioned in the row was moved three places to the right and this was done as the ninth placement.

A hypothetical set of actions performed by one child and the resulting final position and sequence of placement data will illustrate the procedures and systems described above. For simplicity let us use only five objects and let the child place each one next to the other in a row. In this case the sequence of placement data would read 1 2 3 4 5, since that was the order of placement. If the child had then decided that the object indicated by number 2 was positioned improperly and if he moved it to a new position on the far left end of the row, then this would be indicated by the following number sequence 6 1 2 3 4 5.

The final position data could be determined, after the seriation was completed, by checking the true order of the objects. Each object was coded so that the trainer or tester could visually ascertain the true number of each (see Appendix B), and these true numbers were written immediately below the sequence of placement numbers. If our hypothetical child made one mistake and reversed the order of objects 4 and 5, then the final placement data would read 1 2 3 5 4.

Derived Scores

From the raw data mentioned above, a series of scores was derived which characterized the nature of each child's performance. One measure, the task score, describes the degree of correctness of a seriation attempt. Two other measures, the strategy scores, describe certain aspects of the way a child completed a task. These aspects reflect the degree to which a child's actions matched the strategy models in this work and are summarized by the composite work called the strategy chart. This section of the method chapter will review all of these scores as well as the strategy chart.

The Task Score

The task score (TS) is a Kendall's Tau (Kendall, 1962) correlation between the order of final placement and the hypothetically true or correct order of the objects. This score varies from 0 to 1.00 and it measures the accuracy of a seriation attempt. If the final order and the true order correspond exactly, a task score of 1.00 is given. If the two orders do not agree then a TS of somewhat less than 1.00 would be recorded depending on the degree of disagreement. For example, a pair reversal, when one object is one position out of place, would rate a Task Score of .93. More severe errors would rate lower scores. A comparison of the scores derived from some typical errors with eight objects appears in Figure 12.

Type of Error	Kendall's Tau Correlation Task Score
1 pair reversal i.e. a one place error	.93
2 pair reversals	.86
3 pair reversals	.79
1 two place error	.86
2 two place errors	.71
1 three place and 1 two place error	.79
1 pair reversal and 1 three place error	.71
1 two place and 1 three place error	.64
1 four place error	.71

Fig. 12.--A List of Typical Errors and the Resultant Kendall's Tau Correlation for Eight Objects.

The Strategy Scores

One single score could not be computed that would adequately reflect the major facets of both the EVS and INS strategies. Therefore two separate scores were used in conjunction with the task score in order to make decisions about strategy use. The two new scores are called the Tau Sequence Score (TSS) and the Sequence Score (SS).

Figure 13 summarizes the chief characteristics of both scores. The high and low TSS and SS values listed in the figure result from an analysis by Smith and Padilla (1975). While the two measures are very similar in nature and tend to describe similar behaviors, it was found that the SS was necessary to distinguish among subjects showing real tendencies toward a strategy and those who were only coming close by chance. Thus the SS allowed for the "fine tuning" of strategy assignment. This will become clearer after the explanation in the next section of the strategy chart.

The Strategy Chart

A chart which interrelated the TSS, the SS and the TS was drawn up and used for making decisions regarding strategy use. This strategy chart was very similar to one used by Smith and Padilla (1975). It was constructed by breaking the three scores down into sub-intervals and labeling the cells referring to each possible combination of these sub-intervals according to the inferred strategy.

	Tau Sequence Score TSS	Sequence Score SS
The score is derived from . . . and is defined as . . .	The sequence of placement and the final placement data and is a Kendall's Tau (1962) Correlation between the two scores.	The sequence of placement data only and is the proportion of consecutively placed objects in the row.
Numerical example	Sequence of Placement: 1 3 4 7 8 6 5 2 Final Placement: 1 2 3 4 5 6 7 8 (Q) Agreements: 0 1 1 3 3 2 1 0 = 11 $TSS = 1 - \frac{4(Q)}{n(n-1)} = 1 - \frac{4(11)}{56} = .21$	Sequence of Placement: 1 3 4 7 8 6 5 2 $\frac{\text{Number of adjacent pairs}}{\text{Total Possible Pairs}} = \frac{3}{7} = .43$
The score reflects . . .	The degree to which the sequence of placement data and final order data agree.	The degree to which the objects are sequentially placed in a row regardless of final placement data.
A high score indicates . . .	The accurate use of the EVS strategy, since the objects are placed one after another in direct correlation to the final placement.	A possible attempt to use the EVS strategy, since a good number of objects need be sequentially placed for a high score.
A low score indicates . . .	The use of the INS strategy, since objects are not placed sequentially relative to the final placement. Also the nonuse of the EVS for the same reason.	The use of the INS strategy, since few objects would be expected to be placed sequentially in this strategy. Also the nonuse of the EVS strategy would be indicated for the same reason.

Fig. 13.--Some Aspects of the TSS and SS Scores.

Not all cells could so easily be interpreted. The resulting chart with labeled cells appears as Figure 14.

The task score was used in this figure primarily to weed out low and non performers. It was thought that any strategy assignment to these two groups would be difficult to defend since the strategy is the way the task was performed and subjects in these two groups did not perform the task. In addition the term "w/mistakes," meaning with mistakes, makes a further distinction between high and medium high performers. It should be noted that the mistakes meant here are mistakes in task performance, not in strategy use.

Those cells labeled as EVS or INS indicate scores which in all probability occurred as a result of the appropriate strategy use. Those labeled as Quasi-EVS show a definite tendency toward that strategy, but not total use of it. The mixed categories report actions unrelatable to the two identified strategies; and the rearranger cells indicate a strategy characterized by initial incorrect ordering and subsequent rearrangement into a correct row.

One note of caution regarding the strategy chart is necessary. Because a child's scores do not fall into an EVS, Quasi EVS or INS cell, does not mean that the child performed the task using no strategy. Rather it

TSS	SS	TS: Low (< .40)	TS: Med. Lo .40-.69	TS: Med. Hi .70-.89	TS: High > .90
Low < .45	Low < .55	NON-PERFORMERS	LOW-PERFORMERS	INS w/mistakes	INS
	Med. .55-.69			INS w/mistakes	INS
	High > .70			rearranged w/mis	rearranged
Med Lo .45-.69	Low < .55			INS w/mistakes	INS
	Med. .55-.69			mixed	mixed
	High > .70			rearranged w/mis	rearranged
Med Hi .70-.89	Low < .55			mixed	mixed
	Med. .55-.69			Quasi EVS w/mis	Quasi EVS
	High > .70			EVS w/mistakes	EVS
High > .90	Low < .55			Quasi EVS w/mis	Quasi EVS
	Med. .55-.69			EVS w/mistakes	EVS
	High > .70			EVS w/mistakes	EVS

Fig. 14.--The Strategy Chart.

means that he did not use the EVS or INS strategies, although he could have used an indeterminate strategy.

Trials to Criterion and Its Derived Score

During the three training sessions, the number of trials to criterion (TTC) was counted for each subject. If criterion was reached on the pretest, a score of zero was noted. If criterion was never reached, i.e., five incorrect attempts were made, then a score of seven was recorded. After careful deliberation and much manipulation of hypothetical figures, this number, seven, was selected for its seeming sensitivity relative to larger or smaller numbers. Seven connotes the discontinuity between children who reach criterion on the fifth attempt and those not reaching criterion at all. Too, it does not disproportionately penalize those not reaching criterion, as would a score of eight or greater.

A further extension of the trials to criterion data was produced which not only took the numbers of trials into consideration, but also the correctness of each trial. This measure is called the task score to criterion (TSTC) and it differentiates between children who almost reach criterion on unsuccessful trials and those who order the objects randomly or poorly on these trials. This score is a simple mean task score achieved on all the trials. A perfect score of 1.00 is given for all "trials" up to five that remain after criterion is reached.

In order to illustrate the need and relevant calculations for the TSTC, one can compare the relative TSTC scores of three children, all with the same number of trials to criterion (see Table 1). The task scores for each trial are summed, with a score of 1.00 added for each trial after the third which was performed to criterion by A, B and C. This sum is then divided by five to form the TSTC. It is apparent from these TSTC scores that the seriation behavior of the three children was not the same even though all three attained a TTC equal to three.

Table 1.--Sample Computation of the Task Score to Criterion (TSTC).

	Child A Task Score	Child B Task Score	Child C Task Score
Trial 1	.93	.71	.42
Trial 2	.93	.86	.57
Trial 3	1.00	1.00	1.00
Trial 4	1.00	1.00	1.00
Trial 5	1.00	1.00	1.00
Sum TS	4.86	4.57	3.99
TSTC = TS/5	.972	.914	.798

The Design

Several variables have been named and discussed in the preceding pages which impinge upon the present work. Some of these variables were thought to be more important than others and were manipulated as independent variables. Others were considered less important and were controlled by design, but not considered as independent variables. One other was considered difficult to control by design and was instead controlled by method of selection. The purpose of this design section of the method chapter is to describe the specific variables of each general type mentioned above, and to give a rationale for the treatment given to each.

The Independent Variables and the Basic Design

Two major variables were manipulated as independent variables in a basic three by two design. The first major variable was instructional treatment with three levels (EVS, INS, CON). The second was stage and it had two levels (Stage I and Stage III). Figure 15 is a diagram of this design and it includes the number of subjects per cell.

A third independent variable was considered for the analysis of the Trials to Criterion and the pretest data. This third variable was the type of training session and it had three levels (Sessions 1, 2 and 3). For the

Stage I	EVS	n = 12
	INS	n = 12
	CON	n = 12
Stage III	EVS	n = 12
	INS	n = 12
	CON	n = 12

Fig. 15.--The Basic 3 x 2 Design Used for the Post Test Task Scores.

post test analyses this variable was not considered an independent variable. Figure 16 shows the design used for this trials to criterion and pretest data.

Variables Controlled by Design

In addition to the independent variables cited above, several other variables were controlled for, but were not considered in the design. Among these are seriation variables (weight, texture, force), sequence of variables (WTF, TFW, FWT), trainer (four trainers) and, except for the TTC and pretest data, training session (Sessions 1, 2, 3).

The three different sequences were arranged in a 3 x 3 latin square design (Figure 17) so that each sequence, seriation variable and training session would be equally balanced. One third of each strategy/stage group received training and post testing using sequence 1, one third using sequence 2 and one third using sequence 3.

		Session 1	Session 2	Session 3
Stage I	EVS	n = 12		
	INS	n = 12		
	CON	n = 12		
Stage III	EVS	n = 12		
	INS	n = 12		
	CON	n = 12		

Fig. 16.--The 3 x 3 x 2 Design Used for the TTC and TSTC and Pretest Scores.

	Session 1	Session 2	Session 3
Sequence 1	W	T	F
Sequence 2	T	F	W
Sequence 3	F	W	T

Fig. 17.--Latin Square Design for Controlling Sequence, Seriation Variable and Session.

Since each child was randomly assigned to sequence, a clear balancing of both sequence and seriation variables across sessions was achieved. Because there was no reason to expect one sequence or seriation variable to be superior to another, neither was included as an independent variable in the design. In fact no significant statistical differences and only slight mean task score differences were found among the seriation variables in the pilot project (Padilla, 1974). While a totally unconfounded test for sequence of variables in this pilot was unavailable, the data seemed to indicate a strong tendency toward no difference.

Trainer was not included as an independent variable, because each trainer was given a lengthy amount of training on the protocols and testing procedure. Each trainer participated in five sessions totaling more than twelve hours of practice involving the scoring procedures, protocols for treatment groups, and feedback, as well as actual practice with first grade children. During these sessions the trainers practiced with each other as well as with two master trainers who taught all of the procedures. A full description of the sessions is available in Appendix C. It was judged by the two master trainers that no appreciable difference among the trainers was evident when the training sessions ended. As a final check, however, the two master trainers sat in on some of the first sessions of each trainer, where again no training difference was apparent.

Because of these elaborate training procedures and because the trainers were limited in the actual format used in the sessions, the trainer variable, while balanced, was eliminated from consideration as an independent variable.

Variables Controlled by Selection

A final, sometimes important, variable was not included as an independent variable in the design, nor was it controlled by balanced distribution across strategy/ stage groups. This variable, school, was not included in the major design, since it was not of great interest to the present work and it would have made the design more complicated. Even attempting to control it by balancing schools across trainers, treatment groups, sequences, seriation variables, etc. would have necessarily increased the number of subjects from a manageable 72 to a very unmanageable 144.

For the reasons mentioned above, an attempt was made to isolate two schools with students who come from similar socioeconomic backgrounds. The students from the two schools chosen were then pooled and subjects were randomly selected and assigned to treatment groups.

No other variables that might significantly effect this work were identified and therefore no others were controlled by design or selection.

The Hypotheses and Method of Analysis

Many questions about the performance of the subjects both during and after the training sessions are of interest in this study. However, there are four major hypotheses which are of greatest import. It is the intent of this section to list and explain those four hypotheses and to show how each will be tested. Since some of these hypotheses will use statistical analysis that necessitate the use of an alpha or error term, a short discussion of the standard value chosen for all analyses will come first.

The Alpha Level

The present work involved predicting a number of related effects which in some cases might show themselves in quite subtle ways. If in fact the treatments in this work effect the outcome and process measures as predicted, it is very important not to overlook such differences. The chance of making a type II error, i.e., accepting the null hypothesis when it should have been rejected, is therefore of great concern. Too, the type of research being conducted here can be classified as conclusion oriented, not decision oriented research upon which much money and manpower is dependent. Therefore the alpha level in this work was set at a rather high level of .10 for significance testing.

Strategy Use

Since one major purpose of this study is to determine whether or not those children who learn strategies perform better than those who do not learn strategies, the question of whether the strategies can be learned is an extremely important one. If a child uses a strategy to perform the tasks on the post test, then one can say that the strategy was learned by that child. Therefore, the percentage of subjects in each strategy/stage group who performed the post test tasks using the taught strategy was tabulated.

The strategy chart presented in the data section of this chapter was used as the decision making device. Figure 18 is a copy of that chart and it outlines those cells which were considered to be evidence of EVS or INS strategy use. The decision rules used in constructing this chart were discussed in an earlier section.

One further consideration relative to this question is the actual percent of subjects necessary to consider this hypothesis as accepted. The author chose an arbitrary figure of 80 percent as the cut off between accepting and rejecting. This number was thought to reflect a balance between the possibility of setting a goal too high to be reached and a goal so low as to be meaningless.

TSS	SS	TS			
		Low (< .40)	Med Lo .40-.69	Med Hi .70-.89	High > .90
Low < .45	Low < .55			INS	INS
	Med .55-.69			INS	INS
	High ≥ .70				
Med Lo .45-.69	Low < .55			INS	INS
	Med .55-.69				
	High ≥ .70				
Med Hi .70-.89	Low < .55				
	Med .55-.69				
	High ≥ .70			EVS	EVS
High ≥ .90	Low < .55				
	Med .55-.69			EVS	EVS
	High ≥ .70			EVS	EVS

Fig. 18.--The Strategy Chart.

In review the first hypothesis can be stated as follows:

> At least 80 percent of each strategy/stage group subjects (i.e., EVS I, EVS III, INS I, INS III) will perform the post test tasks using the taught strategy as measured by the strategy chart with a task score of .70 or greater.

Post Test Task Performance

The second major hypothesis concerns the degree to which the subjects are able to perform the tasks after training. If the strategy is to provide a useful, systematic method of seriating a set of objects, then it is reasonable to assume that the subjects taught a specific strategy would perform better on the post tests because they only have to concentrate on the intrinsic differences of the materials to be seriated. The group given only practice on the materials and general feedback would not be as successful as the strategy groups unless they perfected their own strategies to perform the task. It is hypothesized that any self development of strategies will be minimal over so short a period of time and that, therefore, the control group will not perform as well as the strategy groups on the post tests.

The method of analysis used to test this hypothesis was an analysis of covariance (ANCOVA) on the mean post test task scores, covaried on pretest 1 task score. Since the pretest 1 scores were collected before any training, these scores provide a raw, pretraining measure of each child's seriation ability. The ANCOVA tested the equality of the three treatments, given the children's pretraining seriation ability differences. It was predicted that the two strategy treatment groups would outperform the control group on the post test tasks. That is, when scores are adjusted for pretraining seriation ability the strategy treatment groups would perform significantly higher on the post test tasks.

The second major hypothesis can be stated as follows:

> The three treatment groups will differ significantly on the mean post test task scores as measured by an analysis of covariance (ANCOVA) of these scores covaried on pretest 1. Furthermore, both strategy groups (EVS and INS) will attain higher post test task scores than the control group.

Transfer of Training

The last two major questions involve transfer of training of two different kinds. Both types involve the ability of the subjects to transfer what they learned with one set of objects to a new set of objects. However one is a measure of the degree of automatic transfer of learning in a pretest and the other is a measure of the ease of learning within a training session. Thus for the first kind, called autotransfer, the children who learned to order with different sets of materials on trials one and two, are given a third different set in a pretest before session three. The degree to which they improve their task scores from pretests one and two to pretest three can be considered as a measure of the amount of transfer from doing the task with the first sets to now doing it with the third set. The second kind of transfer, called facilitation of learning, involves the number of trials to criterion and the task score to criterion. The children who learn to order sets of materials in the first two trials, exhibit transfer if they take significantly less trials to criterion in the third session than in the first two.

Conceptually these two types of transfer can be thought of in two distinct ways. Let's assume that training sessions one and two are considered to be the original learning task and training session three is considered the test of transfer. One view would state that since the treatments were of variable difficulty with regard to learning, then this variable learning difficulty should be considered in a significance test for transfer. That is, given that some treatments were more difficult to learn, what is the relative transfer for each treatment from the original learning task to the transfer task. With this view it is possible that one treatment could produce greater relative transfer, even though another treatment produced better absolute scores on the third or transfer measure. This could occur if the treatment producing the greater relative transfer was more difficult to learn than the other treatments.

A second view of these two types of transfer might take an absolute approach. Again assuming training sessions one and two to be the original learning task and training session three to be the transfer task, then the absolute scores achieved on the third training session could be the measure of transfer. This view can be further strengthened if subjects are randomly assigned to treatment groups and if some raw score of seriation ability is available for use as a covariate.

From both points of view, it is predicted that the strategy treatment groups will perform significantly better than the control group on both analyses. The strategy groups will have a more systematic method of handling the new, unknown materials and therefore will not be so easily confused when confronted with them. That is, it is thought the strategy groups will be able to transfer the learned strategy to the new materials and therefore need only concentrate on the materials, making the task easier to perform. The control group, having been taught no systematic strategy must concentrate on the materials as well as a method of ordering them.

Both views stated above will be taken into account for the two transfer questions. A multivariate analysis of covariance (MANCOVA), covarying on pretest 1, will be run for the trials to criterion (TTC) and the task score to criterion (TSTC) and a multivariate analysis of variance (MANOVA) will be run for the pretest task scores. Since treatment effects within each stage are of greatest importance (as opposed to stage main effects) to this study, both the MANCOVA and MANOVA will be done by holding stage constant, thereby outputting treatment effects within each stage. In addition the univariate effects for each of the dependent variables (TTC1, TTC2, TTC3, or PRE1, PRE2, PRE3, etc.) will be available to answer the transfer question as framed by the second or absolute view of transfer. The multivariate stepdown F which covaries on previous scores will also be available for TTC3 and TSTC3 and this will answer the transfer question from the first or relative viewpoint.

The autotransfer hypothesis will be analyzed by a MANOVA on the pretest scores and the facilitation of learning hypothesis will be analyzed by a MANCOVA on the trials to criterion scores and the task score to criterion measure. The two hypotheses can be stated as follows:

> Autotransfer effects will be greater for both the strategy treatment groups (EVS and INS) than for the control group (CON). That is the mean task scores for pretest three, when covaried on pretests one and two will be significantly higher for the two strategy groups than for the control group. In addition the mean task scores for pretest three for the two strategy groups will be significantly higher in an absolute sense than those for the control group. This will be measured by a multivariate analysis of variance of pretest three scores.

Facilitation of learning effects will be greater for both the strategy treatment groups (EVS and INS) than for the control group (CON). That is the mean trials to criterion will be significantly lower and the mean task score to criterion will be significantly higher on the third trial, when covaried on the same scores from trials one and two, for the two strategy groups than for the control group. This will be measured by a multivariate analysis of covariance of the trials to criterion and task score to criterion, covarying on pretest one task scores. In addition the mean trials to criterion will be significantly lower and the mean task score to criterion will be significantly higher for trial three for the two strategy groups than for the control when these measures are taken in an absolute sense and not covaried on the previous trials. This will be measured by a multivariate analysis of covariance of the trials to criterion and task score to criterion, covarying on pretest one task scores.

CHAPTER IV

RESULTS

Several different analyses were completed with the data that was collected. Some of the analyses are those outlined in the previous chapter and others are additional ones thought to have some bearing on the questions of interest in this work. For simplicity this chapter will be organized by the four major hypotheses. That is, each of the major hypotheses will be dealt with separately and in the order of original presentation. The primary method of analysis specified for each hypothesis will be discussed first, followed by any secondary analyses thought applicable. Where analyses of covariance were used, charts showing the variance and standard deviations of the dependent measures before and after the covariate was removed as well as the regression statistics are included.

Strategy Use

Task Scores, Tau Sequence Scores, and Sequence Scores were computed for each individual in the EVS and INS groups and the strategy chart was used to classify strategy use. Table 2 shows the results of this analysis.

Table 2.--Percent of Children in Each Treatment/Stage Using the EVS and INS Strategies.

	% Using EVS	% Using INS
EVS III	88.92	8.33
INS III	2.75	88.92
CON III	55.58	22.25
EVS I	91.67	0.00
INS I	0.00	80.58
CON I	69.42	0.00

At least 80 percent of the children in each of the four treatment/stage groups performed the post test tasks using the taught strategies with a Task Score greater than .70. In fact the EVS III and I and the INS III groups approached or surpassed the 90 percent mark. Thus, the first hypothesis that those taught a strategy would use it in the post test tasks is supported.

In addition to reporting strategy use by the EVS and INS treatment group, Table 2 reports the percentage of CON children of each stage who self-developed the two strategies. More than 77 percent of the CON III children and 69 percent of the CON I group used either the EVS or INS strategy on the post tests. While the CON III group favored the EVS by a 2 to 1 margin, the CON I children used the EVS exclusively. These results indicate a clear preference for EVS by children who develop their own strategies and the exclusion of the INS by the Stage I children.

Post Test Task Accuracy

Kendall's Tau Task Scores reflecting task accuracy were computed for all children's post test tasks. The means are presented in Table 3 by treatment/stage group. The EVS III and I and the INS III and CON III groups all performed the post test tasks with a high degree of accuracy (mean TS greater than .90), while the INS I and CON I groups performed less accurately (mean TS slightly greater than .80).

After much thought it seemed that two alternative methods of analysis for testing post test task accuracy were appropriate and possible. The first was a 3 x 2 completely crossed factorial design analysis as explained in Chapter III. The second method was a design which highlighted treatment effects within stage. Given the data collection procedures employed, either of these analyses could have been selected. However the first analysis presupposes that the two independent variables (stage and treatment) could be freely manipulated so that the presence of an interaction effect in one or more of the cells could be interpreted. Upon reflection it was clear that only the treatment could truly be said to be manipulable. Cognitive developmental stages could not be randomly assigned to Ss. This fact dictated that the more appropriate

Table 3.--Means and Standard Deviations for the Post Test Task Scores.

Treatment/ Stage Group	Post Test 1	Post Test 2	Post Test 3	Mean Post Test
EVS III	$\bar{X}$ = .953 S.D. = .089	$\bar{X}$ = .971 S.D. = .047	$\bar{X}$ = .929 S.D. = .096	$\bar{X}$ = .951 S.D. = .039
INS III	$\bar{X}$ = .977 S.D. = .062	$\bar{X}$ = .947 S.D. = .092	$\bar{X}$ = .942 S.D. = .058	$\bar{X}$ = .955 S.D. = .061
CON III	$\bar{X}$ = .935 S.D. = .094	$\bar{X}$ = .953 S.D. = .054	$\bar{X}$ = .924 S.D. = .070	$\bar{X}$ = .938 S.D. = .036
EVS I	$\bar{X}$ = .929 S.D. = .114	$\bar{X}$ = .929 S.D. = .096	$\bar{X}$ = .929 S.D. = .087	$\bar{X}$ = .929 S.D. = .069
INS I	$\bar{X}$ = .816 S.D. = .169	$\bar{X}$ = .846 S.D. = .235	$\bar{X}$ = .829 S.D. = .163	$\bar{X}$ = .830 S.D. = .148
CON I	$\bar{X}$ = .798 S.D. = .297	$\bar{X}$ = .805 S.D. = .268	$\bar{X}$ = .805 S.D. = .205	$\bar{X}$ = .802 S.D. = .241

design was that which tested the simple main effects of treatment within each stage. While this design also provided for the main effect test of overall stage differences if desired, it resulted in the loss of overall treatment differences as well as interaction effects. These losses do not seem so important when one considers that children in a real school situation must be dealt with at their appropriate level of development. Thus, the second design clearly addressed the question of which treatment is most effective at which developmental stage and this was the design chosen.

An Analysis of Covariance (ANCOVA) was performed on the post test Task Score means covarying on the pretest 1 Task Scores. Stage was held constant in this analysis so that treatment effects within each stage were available. The pretest 1 task score correlated with the mean post test Task Score at .320. Table 4 reports the

Table 4.--Variance and Standard Deviations of the Mean Post Test Task Scores Before and After the Covariate was Removed. The Covariate was Pre test 1 Task Score.

Variable	Variance	Standard Deviation
Mean Task Score	.0152	.1233
	With Covariate Removed	
Mean Task Score	.0139	.1177

variance and standard deviations of this dependent variable before and after the covariate was removed. Table 5 contains the statistics for regression analysis, indicating that the effect of the covariate, the pretest 1 Task Score, was significant.

Table 5.--Statistics for Regression Analysis With One Covariate for the Mean Post Test Task Score. The Covariate Was Pretest 1 Task Score.

Variable	Square Mult. R	Mult. R	F Ratio	P less than
Mean Post Test Task Score	.1024	.3200	7.4132	.008

Table 6 reports the ANCOVA statistics for treatment within Stage III. No significant differences were apparent which indicates that none of the three treatments (EVS, INS, or CON) produced more or less accurate seriators on the post test tasks among Stage III children.

Table 6.--ANCOVA Statistics for Treatment Within Stage III With Mean Post Test Task Scores as the Dependent Measure. The Covariate Was Pretest 1 Task Score.

Sources of Variation	Degrees of Freedom	Mean Squares	F Ratio	P
Treatment	2	.0002	.0147	.985
Error	65	.0139		
Total	67			

Table 7 reports the ANCOVA statistics for treatment within the Stage I. A significant treatment difference is evident ($p < .012$). Least square estimates of the effects (see Appendix D) indicate that the EVS scores were significantly higher than the CON ($p < .01$) and no significant differences existed between the INS and CON. An orthogonal contrast was not available for comparison of EVS and INS, given the two contrasts just described.

Another representation of post test task accuracy can be shown with two figures. These bar graphs represent the distribution of post test Task Scores by treatment within the two stages. Figure 19 shows Stage III scores and Figure 20 shows Stage I scores. The post test consisted of three tasks and each was counted separately for these displays.

As expected the Stage III scores are grouped near the perfect end of the graph. A slight advantage for the

Table 7.--ANCOVA Statistics for Treatment Within Stage I With Mean Post Test Task Score as the Dependent Measure. The Covariate Was Pretest 1 Task Score.

Sources of Variation	Degrees of Freedom	Mean Squares	F Ratio	P
Treatment	2	.0652	4.705	.012*
Error	65	.0139		
Total	67			

* = significant

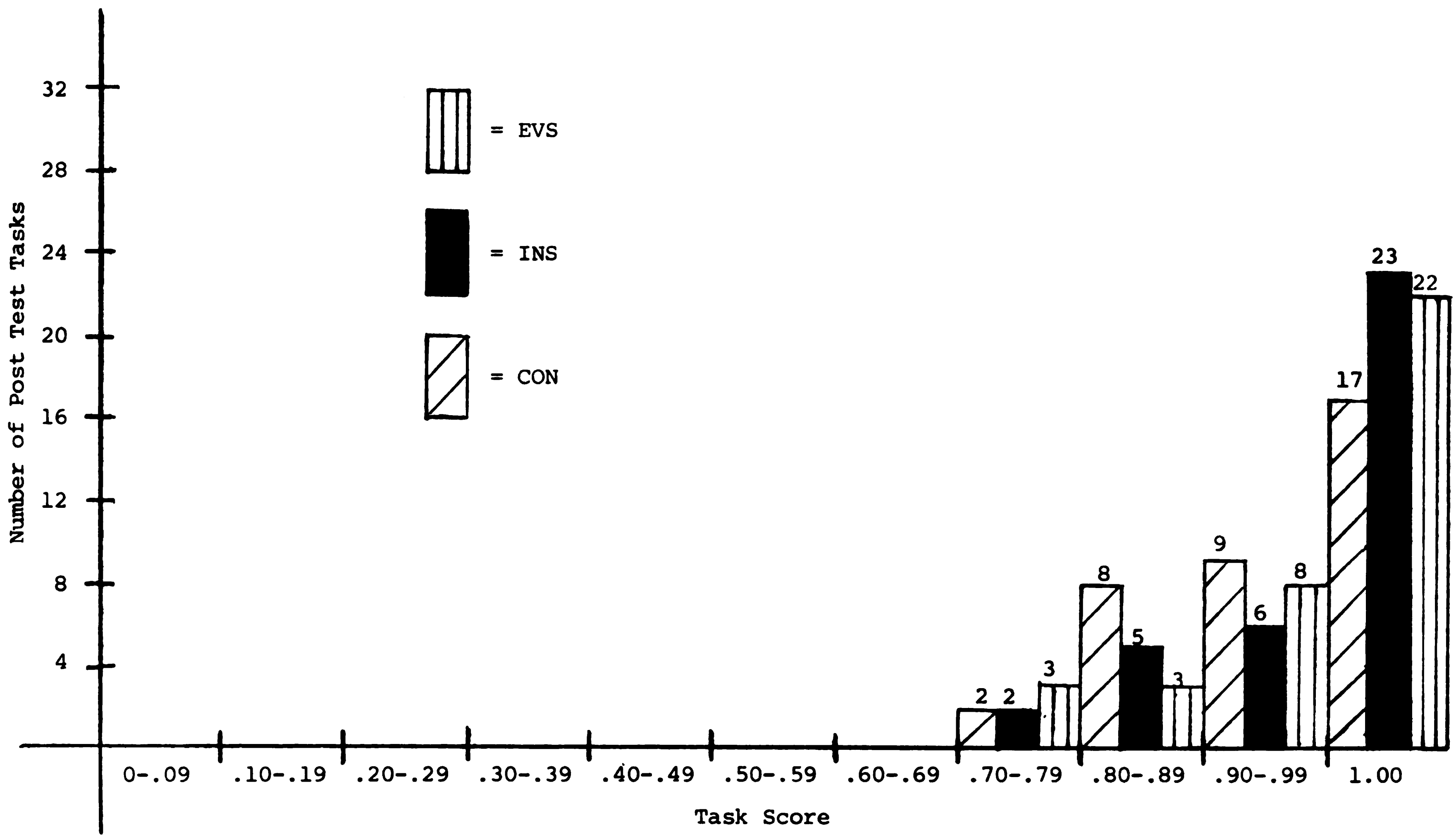

Fig. 19.--Number of Post Test Tasks Completed at a Given Task Score for Stage III Children.

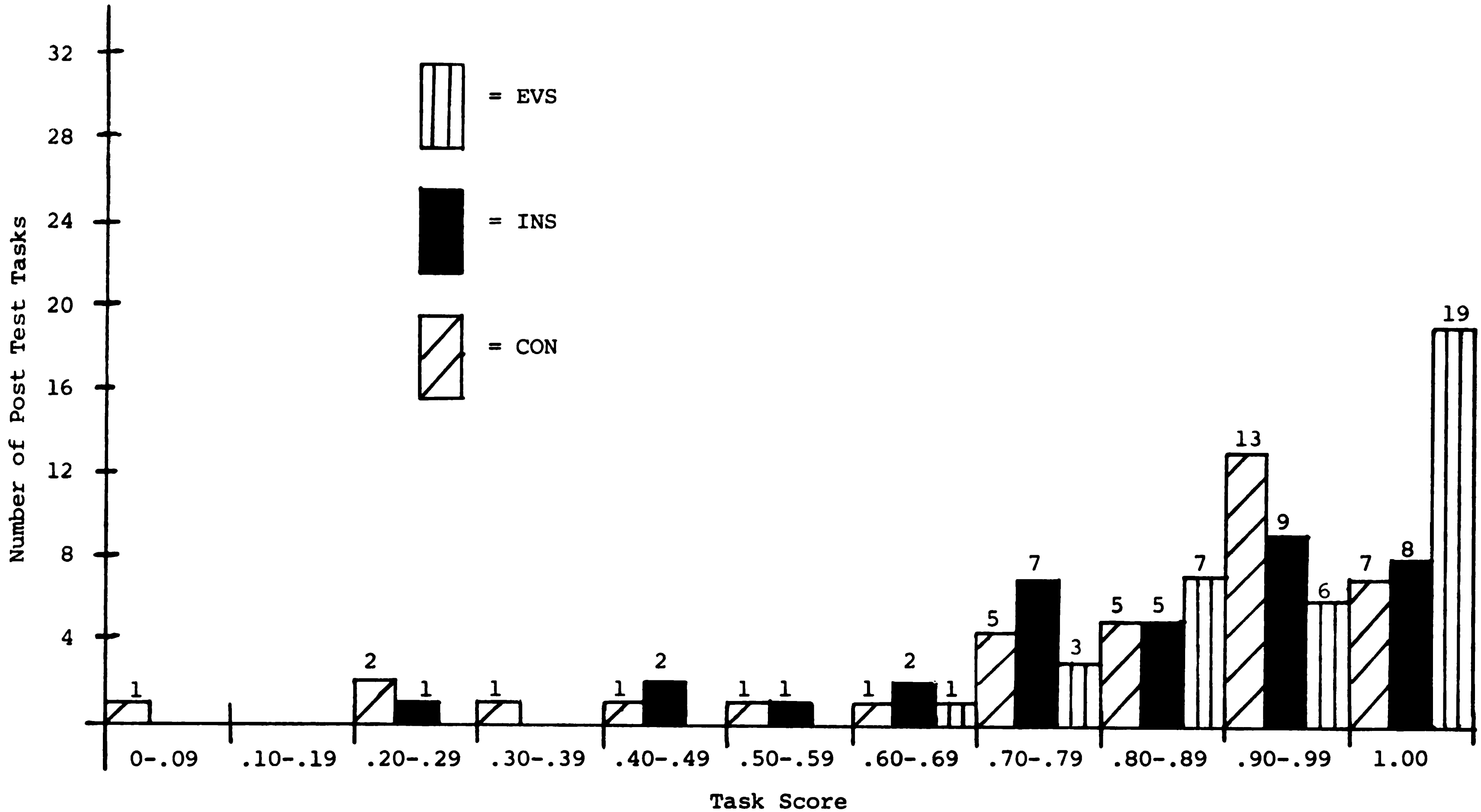

Fig. 20.--Number of Post Test Tasks Completed at a Given Task Score for Stage I Children.

EVS and INS groups is evident in the Task Score = 1.00 area. The distribution of the EVS I scores is very similar to those for the Stage III children, while the INS I and CON I distributions are skewed toward the lower scores. Thus these graphs point out the superiority of the EVS I children's post test task competency among the Stage I groups. This competency approaches that attained by the Stage III groups.

Thus, a main effect for treatment within both Stages I and III was not significant and the post test task accuracy hypothesis was not supported as originally stated. However, a significant main effect for treatment within Stage I was found favoring the EVS treatment. This finding of EVS superiority was confirmed by viewing the distributions of post test task accuracy scores. Therefore a modified version of this hypothesis involving only Stage I children seems plausible and is supported.

Transfer of Training

The two hypothesized transfer outcomes in this study are autotransfer and facilitation of learning. Autotransfer involves the children's ability to automatically transfer what they have learned to a new set of materials in the pretest before training session three. Facilitation of learning involves the children's ease of performing the task with a new set of materials in training session three. Each type of transfer will be discussed in the following pages from the absolute point of view, i.e., considering only the third trial results and not the original learning difficulty, and from the relative point of view, i.e., considering the third trial results in light of the original learning difficulty. It was hypothesized that the strategy groups would attain a significantly higher pretest three Task Score and perform the task to criterion using less trials when compared to the control group. The hypotheses were tested by using a multivariate analysis of variance for autotransfer and a multivariate analysis of covariance for facilitation of learning. The univariate ratios for training session three were read for the results of the absolute transfer question and the step down F ratios for training session three were read for the results of the relative transfer question.

The results of the post test Task Score accuracy analyses indicated that overall treatment differences may be difficult to find. However, differential treatment success for Stage I children seems quite probable. Therefore the following analyses were completed by holding stage constant, thus giving a test of treatment within each stage. This method of analysis allows for a clearer interpretation of results should a stage by treatment interaction occur.

Autotransfer

Table 8 contains the means and standard deviations of the pretest task scores for each treatment/stage group. Each of the groups increases its mean score, from pretest 1 to pretest 2, to pretest 3, except the CON III which drops .29 from pretests 2 to 3. On pretest 1, which is a pre-training indication of each group's raw nonvisual seriation ability, the Stage III children do much better than the Stage I children ($\bar{X}_{III} = .773$, $\bar{X}_{I} = .487$) as expected. Only the control group means within each stage differ from the other groups, with the CON III being slightly lower and the CON I being slightly higher.

Table 8.--Pretest Means and Standard Deviations for Each Treatment/Stage Group.

Treatment/ Stage Group	PRE 1	PRE 2	PRE 3
EVS III	$\bar{X}$ = .832 S.D. = .160	$\bar{X}$ = .930 S.D. = .073	$\bar{X}$ = .983 S.D. = .032
INS III	$\bar{X}$ = .810 S.D. = .171	$\bar{X}$ = .888 S.D. = .209	$\bar{X}$ = .947 S.D. = .102
CON III	$\bar{X}$ = .685 S.D. = .310	$\bar{X}$ = .947 S.D. = .082	$\bar{X}$ = .918 S.D. = .105
EVS I	$\bar{X}$ = .441 S.D. = .292	$\bar{X}$ = .672 S.D. = .315	$\bar{X}$ = .863 S.D. = .146
INS I	$\bar{X}$ = .462 S.D. = .278	$\bar{X}$ = .743 S.D. = .171	$\bar{X}$ = .768 S.D. = .284
CON I	$\bar{X}$ = .558 S.D. = .288	$\bar{X}$ = .810 S.D. = .179	$\bar{X}$ = .852 S.D. = .113

A multivariate analysis of variance (MANOVA) was performed on the pretest scores. Table 9 reports the sample correlation matrix among the three measures, showing a decreasing relationship from pretest 1 to pretest 3. Table 10 gives the variance and standard deviation of each dependent variable.

The MANOVA produced a multivariate F ratio for treatment within Stage III and treatment within Stage I. Univariate F and step down F ratios for each pretest within the above mentioned main effects were also calculated.

Tables 11 and 12 report the multivariate, univariate, and step down F ratios and related probability statements for treatment differences within Stages III and I. The results presented on these tables bear directly on both the relative and absolute autotransfer hypotheses. The step down F can be interpreted for the relative transfer since each pretest is covaried on the pretests that came prior to it. That is, pretest 3 is covaried on pretests 1 and 2 and pretest 2 is covaried on pretest 1. The univariate F ratio for pretest 3 can be interpreted for the absolute transfer since no covariates are used.

Tables 11 and 12 show no significant differences for treatment groups within Stage III or I. Neither the relative nor the absolute transfer hypotheses relating to the children in either stage is supported.

Table 9.--Sample Correlation Matrix Among Pretest Variables.

	Pretest 1	Pretest 2	Pretest 3
Pretest 1	1.00		
Pretest 2	.30	1.00	
Pretest 3	.16	.21	1.00

Table 10.--Variance and Standard Deviation of the Pretest Variables.

	Variance	Standard Deviation
Pretest 1	.066	.257
Pretest 2	.036	.190
Pretest 3	.023	.151

Table 11.--MANOVA Statistics for Treatment Within Stage III With Pretest Task Scores as the Dependent Variables.

F-Ratio for Multivariate Test of Equality of Mean Vectors = .7144

D.F. = 6. and 128.0000 P less than .6387

Variable		Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1	PRE1	.0699	1.0574	.3532	1.0574	.3532
2	PRE2	.0112	.3092	.7352	.6744	.5131
3	PRE3	.0127	.5566	.5759	.4445	.6431

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 66.

Table 12.--MANOVA Statistics for Treatment Within Stage I With Pretest Task Scores as the Dependent Variables.

F-Ratio for Multivariate Test of Equality of Mean Vectors = 1.1228

D.F. = 6. and 128.0000 P less than .3528

	Variable	Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1	PRE1	.0469	.7100	.4954	.7100	.4954
2	PRE2	.0574	1.5893	.2118	1.1206	.3324
3	PRE3	.0325	1.4200	.2490	1.5533	.2195

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 66.

The absence of significant differences among treatment groups for either stage does not necessarily indicate no autotransfer. In fact all three treatments show a substantial increase in mean Task Score from pretest 1 to pretest 3 and thus all three treatments showed autotransfer. The significance tests reported above state only that none of the treatment groups showed significantly better autotransfer than another. Figure 21 is a graph of the pretest Task Scores of each treatment/stage group and it shows the increase in pretest Task Score performance. It should be noted that only the EVS I improvement line appears to have a different slope, indicating a greater increase in pretest performance when compared to the other groups. This difference is not statistically significant, however. Thus while all groups showed autotransfer, the strategy treatment groups did not perform significantly higher on pretest 3 than the control group and the autotransfer hypothesis is not accepted as stated.

Facilitation of Learning

Two different dependent variables were used to measure facilitation of learning effects. It was originally thought that the trials to criterion variable and the task score to criterion variable would measure at least slightly different competencies during the training sessions. However, upon analysis the two variables produced the same general results. Therefore in order to

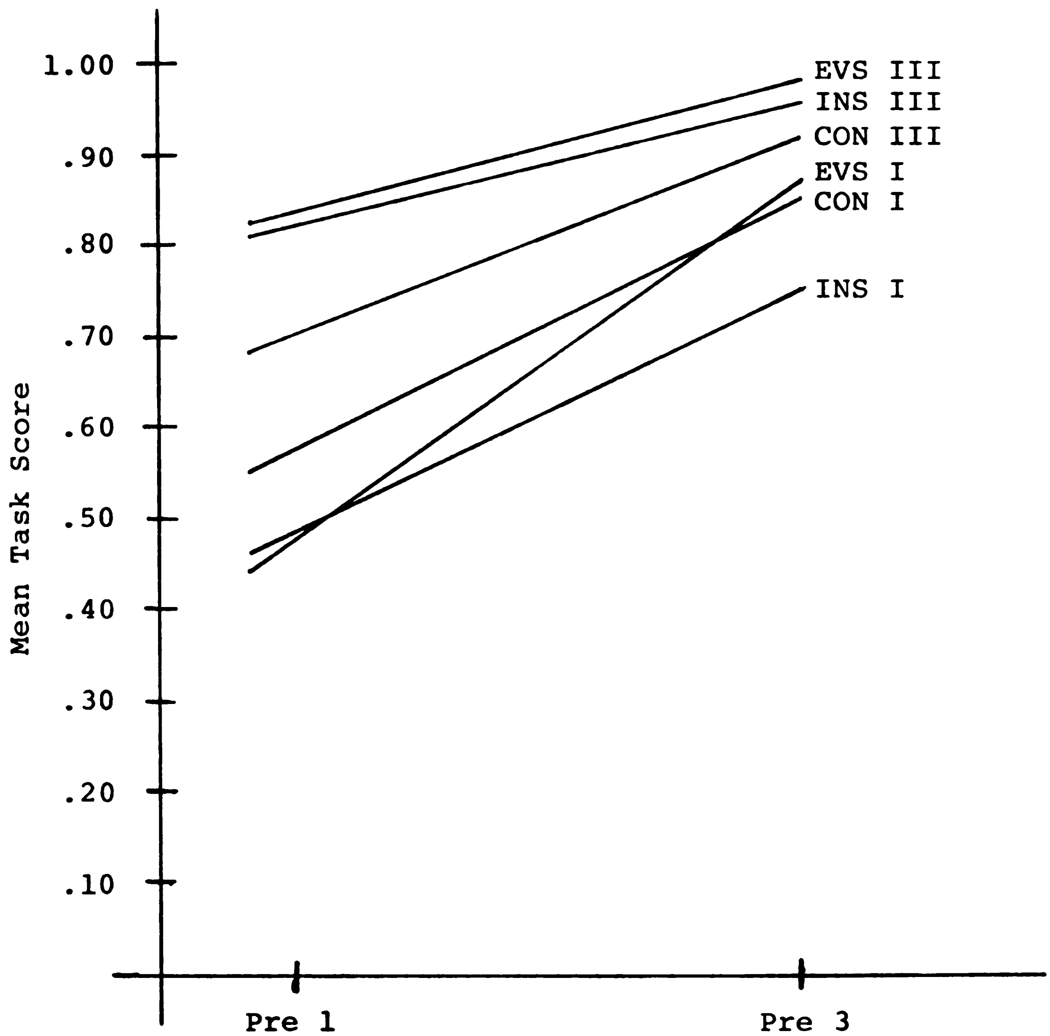

Fig. 21.--Increase in Task Scores from Pretest 1 to Pretest 3.

make the results more clear, the second variable, task score to criterion, will not be discussed here. Instead the results of this analysis are contained in Appendix I. The following is the results of the analysis of trials to criterion.

Table 13 contains the means and standard deviations for trials to criterion for each treatment/stage group on each trial. Each group decreases in number of trials to criterion from trial 1 to trial 3. The relative learning difficulty for each treatment/stage group is indicated by the mean TTC on trial 1. All of the groups are approximately equal except the INS I children who took substantially more TTC.

Table 13.--The Means and Standard Deviations on TTC for Each Treatment/Stage Group.

Treatment/ Stage Group	Trial 1	Trial 2	Trial 3
EVS III	$\bar{X}$ = 3.17 S.D. = 2.44	$\bar{X}$ = 2.67 S.D. = 2.71	$\bar{X}$ = 1.08 S.D. = 2.02
INS III	$\bar{X}$ = 2.75 S.D. = 1.06	$\bar{X}$ = 1.83 S.D. = 2.08	$\bar{X}$ = 1.25 S.D. = 2.14
CON III	$\bar{X}$ = 3.00 S.D. = 1.65	$\bar{X}$ = 1.58 S.D. = 2.07	$\bar{X}$ = 1.58 S.D. = 2.11
EVS I	$\bar{X}$ = 3.42 S.D. = 2.27	$\bar{X}$ = 3.00 S.D. = 2.59	$\bar{X}$ = 1.58 S.D. = 1.24
INS I	$\bar{X}$ = 6.08 S.D. = 1.73	$\bar{X}$ = 5.67 S.D. = 2.02	$\bar{X}$ = 5.08 S.D. = 2.61
CON I	$\bar{X}$ = 3.50 S.D. = 2.68	$\bar{X}$ = 3.42 S.D. = 2.35	$\bar{X}$ = 3.00 S.D. = 2.63

A multivariate analysis of covariance (MANCOVA) was performed on the trials to criterion covarying on the pretest 1 Task Scores. As in the autotransfer analysis, stage was held constant so that both univariate F and step down F ratios for treatment within each stage would be available. Again the step down F will be interpreted for the relative facilitation of learning question and the univariate F will be read for the absolute facilitation of learning question as described in Chapter III.

Table 14 reports the sample correlation matrix among the dependent variables and the covariate as well as the resulting correlation matrix after the covariate is removed. Table 15 reports the variance and standard deviation of the same measures before and after the covariate

Table 14.--The Sample Correlation Matrix of the TTC Variables With and Without the Covariate Removed. The Covariate is Pretest 1 Task Score.

	TTC 1	TTC 2	TTC 3	PRE 1
TTC 1	1.00			
TTC 2	.75	1.00		
TTC 3	.48	.34	1.00	
PRE 1	-.32	-.25	-.19	1.00
	With Covariate Removed			
TTC 1	1.00			
TTC 2	.73	1.00		
TTC 3	.45	.31	1.00	

Table 15.--Variance and Standard Deviations of the TTC Variables Before and After Covariate is Removed. The Covariate is Pretest 1 Task Score.

Variable	Variance	Standard Deviation
TTC 1	4.193	2.048
TTC 2	5.376	2.319
TTC 3	4.726	2.174
PRE 1	.066	.257
	With Covariate Removed	
TTC 1	3.809	1.952
TTC 2	5.114	2.262
TTC 3	4.632	2.152

has been eliminated. Finally Table 16 reports the statistics for regression analyses with the covariate. The overall effect of the covariate on the dependent measures is significant at $p < .067$.

Table 17 reports the multivariate, univariate and step down F ratios for the treatment effects with the Stage III children. The overall significance, the univariate and step down F ratios are not significant indicating no differences among treatments for Stage III children.

Table 18 reports the multivariate, univariate and step down F ratios for the treatment effects with the Stage I children. The overall multivariate significant ($p < .004$) indicates a strong difference among treatments

Table 16.--Statistics for Regression Analysis with One Covariate for TTC.

F Value for Test of Hypothesis of No Association Between Dependent and Independent Variables = 2.5105

D.F. = 3. and 63.0000 P less than .0667

Variable		Square Mult R	Mult R	F	P less than	Step Down F	P less than
1	TTC1	.0053	.3245	7.6492	.0074	7.6492	.0074
2	TTC2	.0631	.2512	4.3791	.0403	.0102	.9199
3	TTC3	.0347	.1862	2.3338	.1315	.0952	.7588

Degrees of Freedom for Hypothesis = 1
Degrees of Freedom for Error = 65.

Table 17.--MANCOVA Statistics for Treatment Within Stage III With TTC as the Dependent Variable.

F-Ratio for Multivariate Test of Equality of Mean Vectors = .5037

D.F. = 6. and 126.0000   P less than .8046

Variable		Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1	TTC1	.9537	.2504	.7793	.2504	.7793
2	TTC2	5.8314	1.1402	.3261	1.0884	.3430
3	TTC3	.2330	.0503	.9510	.1988	.8203

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 65.

Table 18.--MANCOVA Statistics for Treatment Within Stage I With TTC as the Dependent Variable.

F-Ratio for Multivariate Test of Equality of Mean Vectors = 3.4036

D.F. = 6. and 126.0000 P less than .0039

Variable		Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1	TTC1	26.0102	6.8279	.0021	6.8279	.0021
2	TTC2	23.9428	4.6814	.0127	.2242	.7998
3	TTC3	37.5679	8.1098	.0008	3.4085	.0394

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 65.

across trials to criterion. When the step down F ratio for TTC 3 is considered, this too is significant ($p < .039$). That is, for Stage I children, when TTC 3 is covaried with TTC 2 and TTC 1, treatment differences are apparent, thus partially verifying the relative transfer question for the facilitation of learning hypothesis with the TTC.

The univariate F ratio for TTC 3 is also significant ($p < .0008$). This indicates that when initial difficulty of learning is not considered, a treatment difference also exists on the transfer task.

When the least square estimates of effects adjusted for covariates are considered, the differences reported above can be further attributed to specific treatments. On trial 3 the EVS I treatment was significantly lower in trials to criterion than the CON I ($p < .10$), and the CON I was significantly lower in trials to criterion than the INS I ($p < .05$). Thus the EVS I group was also significantly lower than the INS I group, even though no orthogonal contrast was available for this test.

The lack of significant differences among treatments for Stage III children does not mean no transfer was occurring, but rather that one or another treatment appeared to cause no better or worse transfer across trials. Figure 22 is a graph of the improvement across trials of each of the treatment groups in both stages.

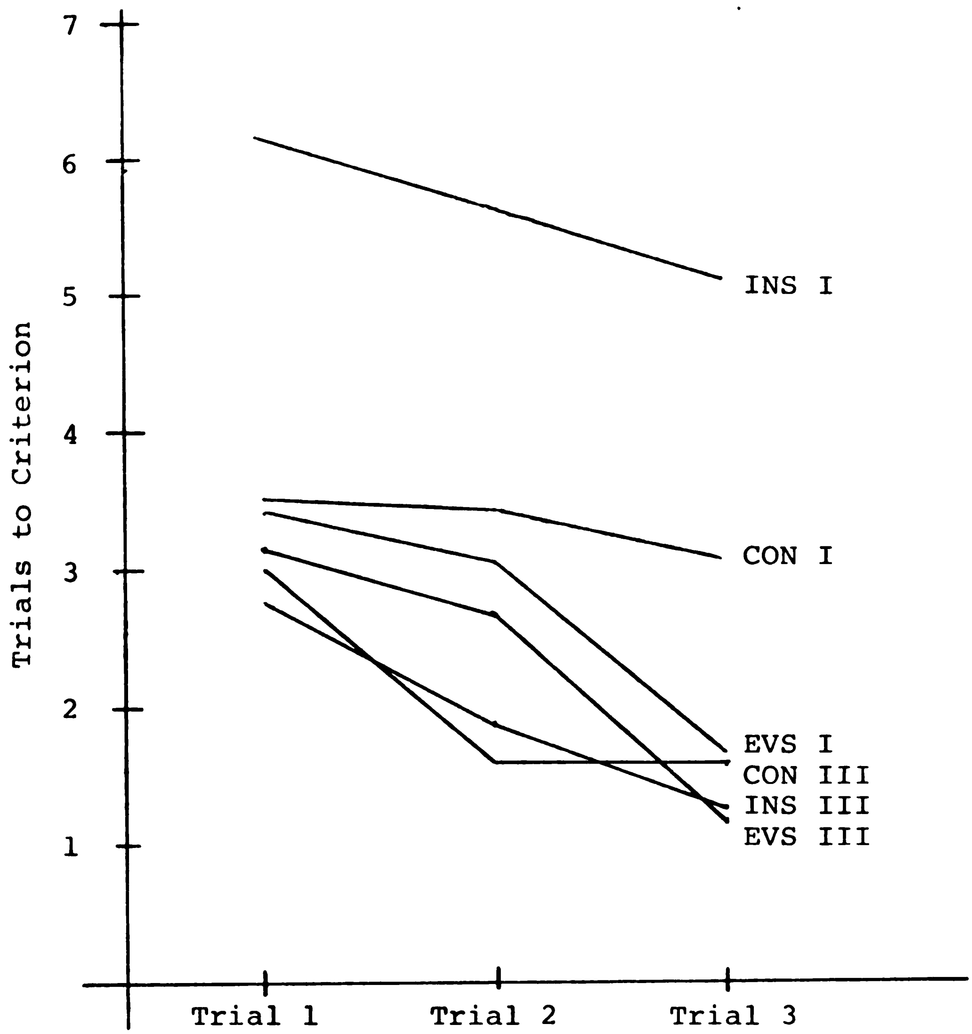

Fig. 22.--Trials to Criterion by Treatment/Stage Groups Across Trials.

It shows the improvement and thus the transfer across trials for each treatment/stage group.

In summary, the results can be stated as follows. The first hypothesis that at least 80 percent of each treatment/stage group taught a seriation strategy (EVS or INS) would use that strategy on the post test tasks, was supported when 80-90 percent of each group used the taught seriation strategy. The second hypothesis, that the children taught a seriation strategy would perform more accurately on the post test tasks, was partially supported. No treatment differences were found among the Stage III seriators, although a ceiling effect was strongly indicated. Significant treatment differences ($p < .02$) were apparent among Stage I children, with post hoc analysis identifying the EVS as significantly higher ($p < .01$) than the CON. No significant difference existed between the INS and CON. The third hypothesis, that the treatment groups would show a higher degree of transfer of training in the pretests prior to each training session (autotransfer), was not supported. No significant differences among treatments for either stage were apparent. The last hypothesis, that the treatment groups would show a greater amount of transfer as reflected by trials to criterion (facilitation of learning), was partially supported. Again no significant differences were apparent among the Stage III treatments. Stage I effects were significant ($p < .04$) with post hoc analysis showing the EVS Stage I children significantly ($p < .05$) better than the other two treatments while the CON was significantly better than the INS.

CHAPTER V

DISCUSSION AND IMPLICATIONS

The analyses presented in the previous chapter lead to and imply several possible conclusions which are discussed in this final chapter. After a brief overview of the study, the results of each major hypothesis will be reviewed and implications will be drawn. Then a short comparison of the EVS and INS strategies will be followed by a discussion of some general implications for the Piagetian logical thought literature and a discussion of some implications relative to the model under which this study was conducted. Ideas for further research generated by the results of this study will be illuminated as they arise in the discussion.

Overview of the Study

First grade children were pretested and divided into two groups, those who could order a set of sticks on length (Stage III) and those who could not (Stage I). Twelve children from each group were randomly chosen and assigned to one of the three treatments: the EVS strategy group, the INS strategy group, and the CON group. The two strategy groups were taught seriation strategies for ordering objects on three nonvisual variables; the CON group was given practice using the same materials with outcome feedback. Data was collected throughout the training sessions on ease of learning and task accuracy. During the post tests, task accuracy data and raw data from which strategy use could be inferred was recorded.

Discussion of the Results

The following sections contain a discussion of the results relative to each of the four major hypotheses. Besides discussion of the major question each section considers several questions related to or impinging upon the major hypothesis.

Strategy Use

The first hypothesis stating that children taught a seriation strategy would use that strategy during the post tests was upheld. More than 80 percent of EVS and INS groups used their taught strategy. Even the Stage I children taught the seemingly more complicated INS strategy used that strategy on the post test tasks. Thus it can be concluded that most first grade children can learn relatively simple seriation strategies in a short three session training period. Future studies might investigate different methods of teaching strategies to children. Certainly small group and class instruction, if successful, could bring about a more practical classroom instructional method than the individualized one used in this study.

An intriguing strategy use result is that attained by the CON group. Fully 77 percent of the CON III and 69 percent of the CON I post tests were performed using either the EVS or INS strategies. While this result is not too surprising, given that the two strategies were adapted from the observed seriation behavior of first graders, it leaves many questions to be answered. Were the children who self-developed the EVS or INS any more or less accurate on the post tests than those who were taught one of the strategies? That is, could those who were taught a strategy have learned that strategy much better than those who were self taught, such that they performed more accurately on the post tests? Or, on the contrary, is it possible that those children who developed their own strategies performed more accurately as some of the discovery literature might suggest? Also, how would the groups under discussion compare on transfer, both auto-transfer and facilitation of learning?

Another question of importance involves the consistency of strategy use by the CON children. Just how consistent were the children who developed their own strategies? Since each individual attempt with each set of materials on the post tests was judged separately, the high percentages do not necessarily reflect consistent use of a strategy. Were the CON children who developed strategies more or less consistent than those in the strategy groups? More importantly, were those who used a consistent and systematic strategy more accurate in their seriations than those who seem to develop or use a different method each time?

Yet another simple analysis might bring additional insight to the post test strategy analysis. This would be a strategy analysis of both the CON group and the two strategy groups pretest performance. Thus a comparison of ease or quickness of acquisition of the EVS strategy, for example, by direct modeling (EVS treatment children) vs. self discovery (CON children who self developed an EVS strategy) might be accomplished. While the possible results of such a strategy analysis would be conjecture at this point, certainly a thorough study of them should be performed.

Post Test Task Accuracy

The second hypothesis that the strategy group children would perform more accurately than the CON children was only partially supported. No significant differences were found among the treatments with Stage III children even though simple means favored the two strategy groups. These results imply that specific strategy training with youngsters who already have the Piagetian logical structures associated with Stage III capabilities might not be necessary. Practice with materials and outcome feedback seems to suffice. Many CON III children developed their own strategies under these conditions as described above. It is even possible that these children may be capable of constructing their own strategies without feedback. Another experiment, employing a true control group given only task instructions and materials, would be necessary if an answer to this question were desired.

The Stage I EVS group did perform the post test tasks more accurately than either the CON I or INS I children. In fact this group's accuracy approached that attained by the Stage III children (mean Stage III task score = .948, mean EVS Stage I task score = .929). Thus one could conclude that for Stage I children the EVS strategy provides a more accurate method of seriation than either INS or CON. The INS strategy children, while out-performing the CON children (mean INS I TS = .830, mean CON I TS = .802) did not perform significantly higher. This leaves the effectiveness of this strategy with Stage I children in question. Perhaps it might be better to teach this strategy to Stage III children only.

Another point concerning task accuracy which is of great impact involves retention. Will the supremacy shown by the EVS strategy be retained over time? Also will the children taught a certain strategy continue to use that strategy or modify it or even adopt a new one in time?

The answers to these questions lie beyond the scope of the present study. However, data will be collected on retention and analysis will be forthcoming in the near future.

Autotransfer

The third hypothesis that the strategy treatment groups would show more autotransfer on the pretest before the third training session was not supported. Even when original learning difficulty was taken into account, no differences surfaced. While all three treatments produced transfer from pretest one to pretest three, the results indicate that no treatment within either stage was superior to the others in producing autotransfer.

Perhaps the confusion surrounding a new set of materials overcame any advantage that a strategy may have had in autotransfer. Too, the pretest 3 results were gathered after only two training sessions. There is some evidence in the TTC data that suggests that two sessions may not have been enough training for the children to fully master a strategy. That is, all strategy groups continued to improve greatly during the third training session indicating that maximum learning had not yet been reached. A new set of materials administered in a pretest before the post tests or before a fourth training session would shed new light on this hypothesis which remains conjecture at this point.

Perhaps some further manipulation of the materials could illuminate the autotransfer problem from a slightly different perspective. As was pointed up in the review of the literature, irrelevant variables which fluctuate from element to element and which are not consonant with the seriation variable, make a seriation task more difficult. Possibly a second set of post tests using materials similar to those used for training, but with one or two added irrelevant variables would provide a different kind of autotransfer task. That is, to what degree would the children have automatically transferred what was learned in the three training sessions and the first post test session to these slightly different materials? If all the treatments produced the same degree of transfer, then surely no special autotransfer capabilities could be attributed to learning either of the strategies. If, however, the added practice in training session three and in post tests caused the strategy groups to surpass the control, then one could conclude that learning a strategy aided autotransfer. Theoretically, this result might be expected especially if the controls tended not to form their own consistent systematic methods.

Facilitation of Learning

The last hypothesis, that the two strategy groups would show significantly more facilitation of learning than the control, was partially supported. No significant differences were found among Stage III children even though the EVS group performed in fewer trials to criterion than the INS which required fewer than the CON. It is quite possible that some sort of ceiling effect prevented true differences, if any existed, from surfacing. All three treatments among Stage III children produced mean TTC scores on the third trial under 1.6. Since the lowest possible score was 0, this does not leave much room for improvement. Also, as with the autotransfer hypothesis, there was solid evidence that all groups showed facilitation of learning (the mean decrease in TTC for Stage III children across trials = 1.67). No one treatment group among Stage III seriators showed significantly more or less facilitation of learning than the others, however.

Stage I results showed significant differences favoring the EVS strategy over the CON and the CON over the INS. When original learning difficulty was taken into account, the same significant differences remained. The EVS I children by the third trial were completing the task in the same mean trials to criterion as the CON III and approaching the EVS III and INS III scores. In fact while the EVS I children decreased their mean TTC by 1.84, the INS I decreased by only 1.00 and the CON I by .50. This indicates a very strong superiority for the EVS strategy in transfer. When combined with the task accuracy results from the second hypothesis, these results show a decided advantage for the EVS strategy with Stage I children. That is, Stage I children performed the seriation task more accurately and transfer prior learning more easily to learning with new sets of materials when they are taught with the EVS strategy as opposed to the INS strategy or CON treatment.

All of the treatment groups in both stages decreased in trials to criterion across trials. With only three training sessions, it was difficult, if not impossible, to ascertain at what point maximum learning had occurred. That is, after how many training sessions would reteaching the strategy with new materials result in no decrease in trials to criterion. This limit might be important to ascertain if perfect seriation were demanded in a curriculum situation, where redundancy was to be avoided. Perhaps the point was reached after the third trial for the Stage III and EVS Stage I children; perhaps it was not. Only a new training experiment with several more sets of materials might answer this question.

A Comparison of INS and EVS Strategies

At several points throughout this study reference has been made to the greater difficulty of the INS strategy relative to the EVS, at least with Stage I children. Evidence for this statement comes from many sources, not the least of which is the first hand observation of the trainers who reported greater difficulty in teaching the

INS strategy to children of both stages. While the INS III children performed as well as the other Stage III children, the data shows that for the Stage I children this strategy proved quite difficult. The INS I children took significantly more TTC on trial three than the other treatments and they scored the lowest on the third pretest, although the difference was not statistically significant. They were also second lowest (CON I was lowest) on the post test task accuracy scores. The Stage III INS users seemed much less effected than their Stage I counterparts and they performed as well with the INS as with the EVS.

Piaget might explain that the lack of basic cognitive structures would account for the difficulty experienced by the Stage I children. He might also argue that since the Stage III children had these structures, that they encountered little difficulty with the task. This reasoning seems to fit well until the EVS results, stated above, are considered. How would Piaget's cognitive structures explain the EVS superiority with the Stage I children? Perhaps a further analysis of the two strategies might shed a brighter light on the difficulties encountered.

Intrinsic to the process of ordering using the INS is the ability to keep many bits of information in short term memory. INS strategy users had to remember which was the heavy or hard or rough end of the row and which was the light, easy or soft end. In addition the child had to remember the approximate values of the elements previously placed in the row in order to produce a competent educated guess as to the position of the next element. Finally the INS user had to remember that if an element was greater in value than another and lesser in value than the next that that element was to be placed in between the greater and the lesser. This last process of inserting an element into its proper place in the row is not only difficult to explain but even more difficult to perform, especially for Stage I children. The trainers often experienced a breakdown of this strategy at this point.

The EVS strategy was far simpler by comparison. The child had to remember the appropriate end of the ordered row on which to place the next element in the series, and this was usually accomplished by some sort of spatial coding. He also had to remember which element was the maximum value so far and which elements had already been compared to it. These processes were also achieved through a simple form of spatial coding which proved easy and effective for both Stage I and III children.

Thus simple analysis of the two strategies shows some important reasons for the INS strategy being more difficult. Perhaps Piaget's insistence concerning cognitive structures can now be more easily understood. Surely the more cognitively complex INS strategy seems to be more difficult for children who do not have the

Piagetian structures to deal with such complexity. The EVS strategy, on the other hand, is relatively simple and quite repetitive in nature and does not seem too difficult for those not having the Stage III cognitive structures. Maybe a future study can reduce the INS memory load by some sort of spatial organization scheme or other method, thus allowing the INS to be as easily learned by the Stage I children as the EVS.

Implications for Piagetian Studies

Several implications can be drawn from the results of this study which shed light on the work of Piaget. The notion of a cognitive structure and its implications for the INS and EVS strategies has been discussed in a prior section of this chapter. Two further major points of discussion can be made at this time.

The results of the post test stick task (Appendix J), showing fully sixteen Stage II or III seriators among the Stage I children, leads one to question Piaget's assertion that it is difficult to move children from one stage to the next with short term instruction. Certainly teaching a seriation strategy did not prove to be more efficacious than allowing children to form their own methods, but possibly just practice at seriating with nonvisual materials produced the gains that are in evidence. Whatever the reason, surely these gains seem beyond the realm of normal cognitive development, having been produced in just three weeks of training.

Another Piaget assertion, that operational nonvisual seriation develops about age 8 or 9 is brought to question by the results of this study. According to the post test accuracy scores, most of the tasks were completed with perfect or near perfect order by the Stage III and EVS I children and some of the INS I and CON I children. Piaget defines this as operational or Stage III weight seriation. And yet the mean age of the children in the present study was only 6 years 10 months. Could Piaget's assertion have encompassed only the natural acquisition of nonvisual seriation? Or did he really mean that most children could not learn to order nonvisual materials until age 8 or 9? If the latter, then the present results do not support his contention.

Implications for the Model

While only a small portion of the model that was used in structuring this study was actually tested, at least a few general comments relative to its efficacy seem appropriate. The method of ordering content by systemic networks, that is, ordering pieces of content because of its similar intrinsic structure, seems to be quite profitable. All treatment groups showed a substantial amount of transfer from training session one to training session three indicating that at least for the three areas of systemic content in this study the method of ordering content was beneficial.

The construct of a strategy was partially upheld by this study. For some individuals some strategies produced more accurate seriators who transferred more to new learning with different materials. In fact the strategy which proved most successful (EVS) paralleled the behavior of beginning seriators described by Piaget (1965). Perhaps further research in helping children develop their natural tendencies with specifically designed strategies may prove useful.

The following table is a summary of the conclusions, implications and possibilities of further research or analysis discussed in this chapter.

Table 19.--A Summary of Conclusions and Further Study and Analysis.

Conclusion	Further Study or Analysis
Strategy Use	
--First grade children of Stage I or III ability can learn to perform a seriation task using relatively simple seriation strategies.	--Were the EVS, INS and CON group children consistent in their strategy use on the post tests?
	--Did those CON children who self-developed their own strategies do so as quickly as those who were taught a strategy?
Task Accuracy	
--Teaching some strategies (EVS) allows for greater task accuracy than practice with feedback with Stage I children.	
--If taught an appropriately simple seriation strategy, Stage I seriators can order nonvisual materials as accurately as Stage III children.	--Were those children who self-developed their own strategies as accurate on the post tests as those who learned a taught strategy?
--Children with Stage III seriation capabilities perform as accurately in ordering nonvisual materials whether they are taught a seriation strategy or are given practice with feedback.	--Will those taught a strategy retain more or less over time than the CON children?

Table 19.--Continued.

Conclusion	Further Study or Analysis
Autotransfer	
--No treatment differences for either stage seemed apparent on the analysis of the pretest data, although all treatment/stage groups showed autotransfer.	--Would additional sets of materials or materials with differing irrelevant variables used in the post tests or in extra training sessions show the strategy groups superior in autotransfer?
Facilitation of Learning	
--Teaching some strategies allows for greater facilitation of learning (EVS) and others for lesser facilitation of learning (INS) than does practice with feedback (CON) with Stage I children.	
--Stage III children show no difference in amount of facilitation of learning whether they are taught a strategy or are given practice with feedback.	
Others	
--The EVS strategy is less complicated and simpler to learn than the INS and this may have caused the superiority of the Stage I children.	--Would a simplification of the INS strategy, perhaps by a spatial organizational scheme, make that strategy as learnable to Stage I children as the EVS?

Table 19.--Continued.

Conclusion	Further Study or Analysis
--Piaget's assertion that operational nonvisual seriation does not come until age 8 or 9 is not supported by the results of this study.	
--The post test Piaget Stick Task results leads one to question Piaget's assertion that it is difficult to move children from one stage to the next with short term instruction.	
--The method of ordering content by similar intrinsic structure seems profitable and future studies should continue to explore this phenomenon.	
--Smith's strategy construct proved useful in conceptualizing methods of seriation and was partially upheld by the results.	--Will strategies that follow children's natural tendencies be more successful than those which do not?

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APPENDICES

APPENDIX A

THE MATERIALS

APPENDIX A

THE MATERIALS

Unique sets of materials were created and standardized for this work. Much careful consideration was put into choosing specific values for the elements in each set of materials and in adopting materials which would withstand the rigors of the testing and training procedures. This appendix lays out the rationale for the chosen values in each set of materials and explains the standardization processes used. In addition, a list of the values for each set of objects, including model sets, and a list of all materials used and where they can be obtained is included.

The Weights

In a study on discrimination of lifted weight, David Bessemer (1973) found that young children discriminate a series of weights according to the difference of the square roots of the physical weights observed. This study was the basis for the series of weights used in the present project. In later communication with Bessemer he stated, "the kids discriminate weights according to the Fullerton-Cottell square root law, i.e., the weights have to be arranged in a square root series for equally discriminable intervals, rather than an arithmetic or logarithmic series" (1973b). Still later in a telephone communication, Bessemer stated that a difference of five in the square roots of adjacent weights provided a series which can be discriminated by young children.

The values of the training weights and their square roots are listed below.

Number	Weight ± 5g	$\sqrt{\text{Weight}}$
#1	10 g	3.2
#2	64 g	8
#3	169 g	13
#4	324 g	18
#5	529 g	23
#6	784 g	28
#7	1089 g	33
#8	1444 g	38

The values and square roots of the model set of weights used in explaining the task and the materials are as follows:

Number	Weight ± 5g	$\sqrt{\text{Weight}}$
#1	64 g	8
#2	324 g	18
#3	784 g	28
#4	1444 g	38
#5	2304 g	48

No discrimination difficulties were observed for weights based on the above values during this study or during two previous investigations (Padilla, 1974; Smith and Padilla, 1975).

Each weight was constructed from a 12 oz. white styrofoam coffee cup which was filled with varying amounts of lead shot and melted paraffin wax. When the wax solidified the lead shot was held in place. A white plastic coffee cup top was glued to the top of the cup. For this study, the coffee cups and tops were secured from the Dart Container Corporation, Mason, Michigan. The wax was obtained from a local discount store and the lead shot was obtained from a local gunshop, the Classic Arms Company, East Lansing, Michigan 48823.

The Feelies

No specific literature could be found that discussed children's abilities to discriminate different grades of sandpaper or other tactile materials. Therefore a standardization process of some type was necessary in order to approximate equal intervals on this variable. Different grades of sandpaper and other materials were obtained and made into feelies. Only those grades of sandpaper that could be discriminated as different by the experimenter were used. The following is a list of those trial feelies.

1. Acetate
2. Savin Copy Paper
3. Mimeograph paper
4. Construction paper
5. #400 Sandpaper
6. #320 Sandpaper
7. #280 Sandpaper
8. #220 Sandpaper
9. #180 Sandpaper
10. #150 Sandpaper
11. #120 Sandpaper
12. # 80 Sandpaper
13. # 60 Sandpaper
14. # 50 Sandpaper
15. # 40 Sandpaper

These objects were presented to a series of ten adults who were first asked to put them in order from roughest to smoothest. When this was completed the final order was checked for mistakes and recorded. The experimenter then asked each adult to spacially represent the series according to the "gap" felt between each object.

From this data a series of eight objects was chosen all of which were discriminable by adults and seemed to be equidistant on the scale of roughness. These eight objects were then tried out with a series of ten first grade children who were presented with two feelies at a time and asked if they were the same or different, and if different, which of the two was rougher. The children made no mistakes, which indicated that first graders like adults had little difficulty with discrimination. It should be noted, however, that the discrimination of one feelie from the next in the series was not such an easy task either. Many times the children and adults too, found it necessary to test a pair of objects two or three times before deciding on the roughest or smoothest. Few discrimination problems were observed for these materials during this study or a previous work using these materials (Padilla, 1974).

A description of how the feelies were constructed is contained in Chapter III of this work.

The materials used for the feelies can be obtained from the following places. The 4" Mailing Tubes were obtained through the Dudley Paper Division of Copco Papers, Inc., 740 East Shiawassee, Lansing, Michigan. The different grades of sandpaper were obtained from local automotive supply stores and from the 3M Company, Abrasives Division, St. Paul, Minnesota, 55101. The Savin Copy Paper is available from the Polack Corporation, Lansing, Michigan 48910. The rest of the materials used are common objects and are easily collected.

The following is a list of the texture materials used for the eight training objects in this study.

Number	Material
#1	Acetate
#2	Savin Copy Paper
#3	Black construction paper
#4	#400 grit wet-or-dry, Tri-m-ite Sandpaper
#5	#280 grit wet-or-dry, Tri-m-ite Sandpaper
#6	#120 grit wet-or-dry, Tri-m-ite Sandpaper

Number	Material
#7	#80 grit Three-m-ite, Resin bond cloth, open coat, aluminum oxide sandpaper
#8	#50 Three-m-ite, elek-tro-cut cloth, sandpaper

The following is a list of values for the model sets used.

Number	Material
#1	Acetate
#2	Black construction paper
#3	#280 grit, wet-or-dry, Tri-m-ite Sandpaper
#4	#80 grit, Three-m-ite, Resin Bond cloth, open coat, aluminum oxide sandpaper.
#5	#40, Three-m-ite, elek-tro-cut cloth sandpaper.

The Pull Toys

As with the feelies, no specific literature on children's ability to discriminate forces was found. Therefore as with the feelies, a number of pull toys of different forces were constructed and tested before the final set was chosen.

It was originally thought that there was a good probability that a strong relationship existed between the ability to discriminate a series of pulled forces and the ability to discriminate a series of lifted weights. Based on this assumption, different series of forces could be hypothesized. The most obvious series would have the pulled forces differ in their square root by five like the weights. But this relationship did not prove feasible.

The minimum force obtainable was about one pound, which meant that the second object in this series would have a square root of six and therefore a value of thirty-six pounds of force. Since the children and some adults found it difficult to pull more than fifteen pounds, this relationship was not pursued.

An alternate route of ascertaining discriminability was taken. A series of ten pull toys was constructed by the experimenter. These pull toys were presented to a series of adults who first put them in order and then spatially arranged them to indicate relative closeness on the force scale. From this data a series of eight pull toys was secured which seemed both discriminable and somewhat equidistant on the scale. These pull toys were then measured on a force measurer and the following values were obtained.

Number	Force	$\sqrt{\text{Force}}$	Difference in $\sqrt{\text{Force}}$
#1	.80	.90	---
#2	1.60	1.26	.36
#3	2.35	1.53	.27
#4	3.25	1.80	.27
#5	4.10	2.02	.22
#6	5.25	2.29	.27
#7	8.50	2.92	.69
#8	11.25	3.35	.43

From this data, it was thought that a series of objects differing in the square root of the force by .3, might prove effective therefore a series differing in this way was constructed and tested on adults. As was shown with the earlier data, the .3 relationship held up with the lower forces, however, it made the higher forces difficult to discriminate.

Other mathematical relationships were used to construct and test materials on a trial and error basis and others were rejected. Finally a set based on a difference of the $\sqrt{2}$, that is each successive pull toy was 1.4 or $\sqrt{2}$ times more difficult to pull, was tried and found both practical and discriminable. These pull toys were tested by adults in much the same manner as the feelies and were found not only to be discriminable, but also equidistant from each other in perceived force necessary to pull each handle. As with the other materials, the children had little difficulty with discriminating among the pull toys in this study or the pilot project (Padilla, 1974).

The pull toys were constructed from pieces of plastic pipe, wire, rubber bands and rubber stoppers. They are described in the text of this work in Chapter III.

The following two tables lay out the number of each pull toy, its force measured in pounds, the length of the wire hook, the length of the overlap of each hook, and the number and kind of rubber bands inside each for

Table A1.--The Training Set of Pull Toys.

Number	Force (lbs.)	Length of Wire Hook (cm)	Length of Wire Hook Overlap (cm)	Number and Kinds of Rubber Bands
1	1.00	16.5	5.5	One #14 B. F. Goodrich Rubber Band
2	1.40	14	3	One #18 Wallace Invader Rubber Band One #32 Wallace Invader Rubber Band
3	2.00	15	4	Four #16 Wallace Invader Rubber Bands
4	2.80	14	3	Two #32 Wallace Invader Rubber Bands One #18 Wallace Invader Rubber Band
5	4.00	16	5	Four #30 B. F. Goodrich Rubber Bands
6	5.60	14	3	Four #32 Wallace Invader Rubber Bands One #18 Wallace Invader Rubber Band
7	8.00	15	4	Four #62 B. F. Goodrich Rubber Bands One #16 Wallace Invader Rubber Band
8	11.30	13	2	One grey 6" long and 1/8" in diameter rubber band. Tripled over.

Table A2.--The Model Set of Pull Toys.

Number	Force (lbs.)	Length of Wire Hook (cm)	Length of Wire Hook Overlap (cm)	Number and Kinds of Rubber Bands
1	1.00	16.5	5.5	One #14 B. F. Goodrich Rubber Band
2	2.00	15	4	Four #16 B. F. Goodrich Rubber Bands
3	4.00	16	5	Four #30 B. F. Goodrich Rubber Bands
4	8.00	15	4	Four #62 B. F. Goodrich Rubber Bands One #16 B. F. Goodrich Rubber Band
5	16.00	19	8	Three red SCIS Whirly Bird Rubber Bands 6" in length and 1/8" in diameter.

both training and model sets. The length of the wire hook is measured from its curved, top end to the point where it enters the rubber stopper. The length of the overlap part of the hook is measured from the curved, top end down the other way to the point where the wire ends. This overlap functioned as a stopper and allowed the handle to be pulled out only ten to eleven cm.

The materials for the pull toys were bought at a number of different establishments. The rubber bands were obtained from an office supply store, The Shattuck Company, 912 Michigan Avenue, Lansing, Michigan 48905. The SCIS rubber bands were donated by Rand McNally and Company, P. O. Box 7600, Chicago, Illinois 60680. The plastic pipe and plastic caps were bought from a local discount store as was the 1/8" wire. The name of the discount house is Meijer Thrifty Acres. The rubber stoppers can be obtained from any chemical or science supply company.

The Sticks

The sticks were cut from 1/4" round, wooden dowels and were left unpainted for this experiment. The following is a list of the lengths of each seriation stick.

Number	Length (cm)
1	9.0
2	9.8
3	10.6

Number	Length (cm)
4	11.4
5	12.2
6	13.0
7	13.8
8	14.6
9	15.4
10	16.2

The following is the length of the five seriation sticks.

Number	Length (cm)
1	10.2
2	11.8
3	13.4
4	15.0
5	16.6

APPENDIX B

THE DOT LABELING SYSTEMS

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THE DOT LABELING SYSTEMS

In order to give feedback to the children immediately following a trial, it was necessary to devise a system whereby mistakes would become apparent to the tester as soon as they were made. A system using blue, green, orange and yellow colored dots, each 3/8" in diameter, was used to identify the different seriation objects.

Ten dots were attached to the tops of the weights in a circular pattern which resembled a clock face. At 12 o'clock, two green dots were placed to indicate a starting point. The indicator color was the bright orange, so that the number one weight code had an orange dot as the first one clockwise of the double green. The rest of the dots were randomly placed green, yellow and blue ones. No two dots of the same color were placed next to each other, except the two green ones which indicated the orientation of the circular tops. Only one bright orange dot was used per top.

In order to read the code, one must first find the double green dots and orient himself to them. Then he must count in a clockwise direction the number of dots up to and including the bright orange one. For example, Fig. B1 is a top for a number four weight. The letters refer to the colors.

The coding used for the feelies and the pull toys was similar to that used for the weights. Instead of a circular pattern, though, a vertical line of eight dots was used. Again one dot was used as the indicator, depending on its position in the vertical line. If first at the top then it is object number one, if sixth then it is object number six and so on. Because of the possibility of lining up the eight objects to form a diagonal one-colored line, the indicator color was switched from yellow to blue for every other object. That is, object number one would have blue as the indicator color, object number two would have yellow, three blue and so on. When

KEY: G - Green
Y - Yellow
B - Blue
O - Orange

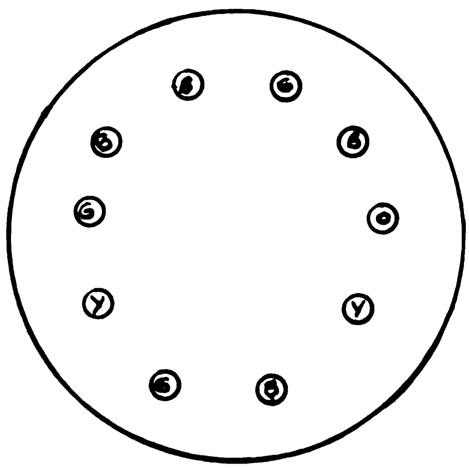

Fig. B1.--The Dot System for Weights.

blue was the indicator color, three yellow dots were distributed throughout the eight dots. When yellow was the indicator, three blue dots were distributed throughout the eight dots. Even if the code was forgotten, one would only have to look for whichever color was represented by only one dot.

Two rows of the self-adhesive dots were stuck on opposite sides of the pull toys. Both rows began just below the top plastic cap and were covered with transparent scotch tape so that they would not come loose (see Fig. B2).

Four rows of dots were stuck to each feelie. The dots were first stick onto a piece of self adhesive black tape, which was then stuck onto the sock covering the feelies. One row of dots was arranged vertically in each quadrant of the feelie, so that at least one row would be visually evident to the experimenter at any one time (Fig. B3).

The dots were obtained from the Science Curriculum Improvement Study (SCIS) materials. They can be bought from the Rand McNally Co., P.O. Box 7600, Chicago, Illinois 60680.

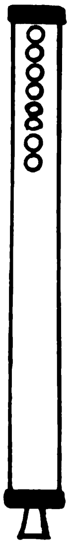

Fig. B2.--The Dot System
for Pull Toys.

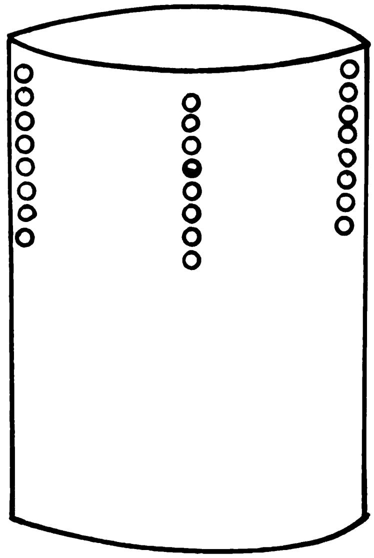

Fig. B3.--The Dot System
for Feelies.

APPENDIX C

TRAINING THE TRAINERS

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TRAINING THE TRAINERS

During the time preceding the experiment several meetings were held with the four individuals who were to train the children. During these sessions the trainers were introduced to the different materials, the scoring procedures, the training protocols and the feedback protocols. The purpose of this appendix is to describe the training received during these sessions.

Five different meetings were held during the month preceding the experiment. All of the trainers attended each session or were given a make up as soon as possible. Each meeting followed a similar model in which the new material to be learned was presented first with enough time for question and answer. Then the trainers broke down into pairs and while one role played the child, the second practiced the new material. In addition, each pair was assigned a master trainer, one who already was familiar with the procedures of the study. The master trainer gave feedback on the practice sessions, answered questions and sometimes modeled unusual child behavior. To ensure homogeneity of training, the master trainers switched from one pair to the other during most training sessions. A list of the amount of time spent and each specific aspect of training worked on is contained in Table C1.

The first training session involved only the scoring procedures. After this meeting each trainer was given a set of materials to take home over the Christmas holidays in order to practice on his own. In addition to this the trainers often practiced the scoring procedure during subsequent meetings.

The next three meetings were used to practice the training protocols and the feedback and errors specific to each strategy. Each trainer was given a set of typed training protocols to read over the Christmas holidays. Practice on these began soon after. Feedback from the master trainers emphasized communication with the youngster

Table C1.--The Training Sessions for Trainers.

Date	Duration	Aspects Worked On
December 13	2 hours	Scoring
January 3	2 hours	Training Protocol
January 6	2.5 hours	Training Protocol, Feedback
January 8	1.5 hours	Feedback
January 10	4.0 hours	Practice with Children

as well as standardization across trainers. This standardization was especially stressed during the sessions dealing with feedback since no specific protocols had been written for this aspect, because individualized feedback was desired. Figures C1 and C2 are two handouts used in training the trainer on errors and feedback.

The last session utilized first grade children in a school and forced the trainers to put all of the parts learned so far (i.e., scoring, training protocol and feedback) into a comprehensive whole. Each trainer taught each strategy protocol at least once or twice with individual children. In addition each trainer was observed by each master trainer at least once and was given feedback on an entire session with one child. The trainers worked with five to seven children during the four hour period. As with previous sessions standardization was stressed in the master trainer's feedback and especially in a post session discussion among all trainers and both master trainers.

Feedback on Errors

When the child finishes the trial and if he has made some errors, then have him start at one end of his final row of objects and have him feel, pull or lift each object in turn until he comes upon a mistake in placement. Ask him to note the error.* After he has done so, take three to five of the objects and do a mini-model of the type of error that caused the mistake in placement. If more than one mistake is made, wait until the child finds the rest of his mistakes and corrects them, before giving mini-models of all the errors. Errors that do not happen to result in placement mistakes can be mini-modeled after the child checks the row for corrections.

The Mini-Model

The mini-model feedback consists of taking from three to five seriation objects and modeling how each error occurred and can be avoided. For example if a child consistently chooses objects from the unobserved pile in a non-random way while doing the INS strategy, then after he has checked the row for correctness the error can be mini-modeled. The trainer will take 3-5 objects, and arrange

Fig. C1.--The Error Feedback and Mini-Model Handout

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*If the error is small, have the child correct it. If the child makes more than three errors or if the errors are large ones, then correcting them until the row is perfect will be _too_ tedious and should not be done.

them in a way to resemble the unobserved pile. Then he explains how the child made the error. Then, while explaining to the child that when he picks objects to insert it doesn't matter which ones are selected, the trainer randomly picks an object from the unobserved pile. A repeat of the words and actions might be necessary for emphasis. In like manner other errors can be modeled including discrimination errors which are mainly a matter of being careful and taking time. In this case the trainer can first tell the child how he quickly looked at the objects and therefore made an error. Then he can slowly pull, life, or feel one object and then another, while explaining that one must take his time and be careful.

The rest of the listed errors follow a similar series of steps for mini-modeling. First, selecting 3-5 objects and set up the appropriate situation. Second, verbally explaining the error as the child made it. Third, verbally explain the correct behavior while showing the child the correct behavior with the materials. Fourth, repeat the mini-model if it is necessary to make the point.

Fig. Cl.--Continued.

ERRORS

INS STRATEGY

1. Doesn't pick objects randomly from the pile, that is the child observes 2 or more objects before choosing one to insert in the row. (Two or more non-random picks will necessitate a new trial.)

2. Doesn't check both sides of a "hole" before inserting. This error will not necessitate a new trial unless it results in an error in object number.

3. Doesn't perform the educated guess, but checks each object in the row to see where the new object should be inserted. Two or more occurrences necessitates a new trial.

4. The subject puts the object on the wrong side of the checked object, i.e., he doesn't put it in the proper "hole." This error will result in an object number error and therefore a new trial.

EVS STRATEGY

1. Doesn't check every object every time. This may result in a mistake in object placement. If it does or doesn't <u>it will be necessary</u> to have a new trial.

2. The subject confounds the unobserved and discard piles. This usually results in a mistake in object placement. Either way <u>it will be necessary</u> to have a new trial.

3. Doesn't select the extreme object (discrimination error). New trial needed.

4. Doesn't place the selected extreme object next in the row, resulting in an object placement error. New trial needed.

Fig. C2.--Some Typical Strategy Errors Handouts.

APPENDIX D

LEAST SQUARE ESTIMATES OF THE EFFECTS

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LEAST SQUARE ESTIMATES OF THE EFFECTS

Least square estimates of the effects were used to verify which treatments were causing significant statistical differences in the different analyses. The following is the computer output for the least square estimates for the ANCOVA on the post test mean and for the MANCOVA on the trials to criterion and the task score to criterion.

Table D1.--Least Squares Estimates of the Post Test Mean.

	L.S.E Estimates	Standard Errors
Grand Mean	.8042	3.81×10^{-2}
Stage	.0499	3.21×10^{-2}
Treatment w/i Stage III	.0079 .0017	4.87×10^{-2} 4.86×10^{-2}
Treatment w/i Stage I	.1444 .0422	4.85×10^{-2} 4.84×10^{-2}

Table D2.--Least Square Estimates Adjusted for Covariates of the TTC.

Least Square Estimates Adjusted for Covariates--Effect x Variables

		1 TTC1	2 TTC2	3 TTC3
1	Gr Imn	5.281181	4.455399	3.255761
2	Stage	-.623016	-1.352912	-1.467088
3	Tr Sg1	.524226	1.396806	-.282208
4		.073096	.533258	-.136533
5	Tr Sg3	-.387043	-.682929	-1.601659
6		2.335626	2.032835	1.932453

Standard Errors of Adjusted Estimates--Effects x Variables

		1 TTC1	2 TTC2	3 TTC3
1	Gr Imn	.632116	.732431	.697062
2	Stage	.531840	.616242	.586484
3	Tr Sg1	.807226	.935330	.890163
4		.805324	.933127	.888066
5	Tr Sg3	.804338	.931983	.886978
6		.801824	.929071	.884206

Table D3.--Least Square Estimates Adjusted for Covariates of the TSTC.

Least Square Estimates Adjusted for Covariates--Effect x Variables

		1 TSTC1	2 TSTC2	3 TSTC3
1	Gr Imn	.747797	.815618	.898066
2	Stage	.058091	.049065	.046423
3	Tr Sg1	-.032056	-.040074	-.000723
4		-.015362	-.003892	-.013775
5	Tr Sg3	.035607	.105258	.078982
6		-.134333	-.046350	-.066994

Standard Errors of Adjusted Estimates--Effects x Variables

		1 TSTC1	2 TSTC2	3 TSTC3
1	Gr Imn	4.123489E-02	4.147851E-02	2.370558E-02
2	Stage	3.469359E-02	3.489856E-02	1.994505E-02
3	Tr Sg1	5.265785E-02	5.296896E-02	3.027255E-02
4		5.253380E-02	5.284417E-02	3.020123E-02
5	Tr Sg3	5.246942E-02	5.277942E-02	3.016422E-02
6		5.230545E-02	5.261448E-02	3.006995E-02

APPENDIX E

TRAINING PROTOCOLS

APPENDIX E

TRAINING PROTOCOLS

Each trainer trained each strategy group using the same set of strategy protocols. That is, all trainers used roughly the same words to train all extreme value selection children, all insertion children and all control children. The following is a set of the pretest and training protocols used for each strategy with each set of materials. Note that capital letters denote the <u>exact</u> words used by the trainer; lower case letters denote directions to the trainer.

I PUT THESE STICKS IN A ROW ACCORDING TO HOW HARD THEY ARE TO PULL. SOME ARE HARD TO PULL AND OTHERS ARE EASY. PULL EACH ONE LIKE THIS (Model it). START HERE (Point to hardest).

--SEE HOW EACH ONE IS EASIER TO PULL THAN THE ONE BEFORE IT? I PUT THEM IN A ROW FROM HARDEST TO EASIEST.

--IN A MOMENT I WANT YOU TO PUT SOME STICKS IN A ROW ACCORDING TO HOW HARD THEY PULL. DO YOU UNDERSTAND WHAT TO DO?

--Present the sticks.

PUT THESE STICKS IN A ROW ACCORDING TO HOW HARD THEY ARE TO PULL. DO YOU UNDERSTAND WHAT TO DO?

Fig. E1.--Pretest Protocol for Force.

I AM GOING TO SHOW YOU A WAY TO PUT THESE STICKS IN A ROW FROM HARDEST TO PULL TO EASIEST TO PULL. PAY VERY CLOSE ATTENTION--OKAY? I WANT TO FIND THE HARDEST ONE OF ALL OF THESE STICKS (Point).

--Pick two and pull them.

--IT'S NOT THAT ONE (While discarding). THIS ONE IS HARDER TO PULL (Heft harder one).

--Pick another one and compare to hardest so far.

--IT'S NOT THAT ONE (While discarding). (Say once or twice per round.)

--When finished with round one, say:

THIS IS THE HARDEST ONE TO PULL OF ALL OF THOSE (Point), SO I'LL PUT IT DOWN HERE TO START THE ROW.

NOW I WANT TO FIND THE HARDEST ONE OF ALL THE STICKS THAT ARE LEFT.

--Repeat the procedure for all the remaining rounds.

THIS IS THE HARDEST ONE OF ALL THOSE LEFT (Point), SO I'LL PUT IT NEXT IN THE ROW.

--During the modeling, make each of these three comments once.

****SEE, I ALWAYS PUT THE EASIER ONES ASIDE AFTER I'VE CHECKED THEM.

****SEE, I CHECK EVERY STICK EVERYTIME, THAT'S TO MAKE SURE I DON'T MAKE A MISTAKE.

Fig. E2.--EVS Strategy Protocol for Force.

****SEE HOW I PULL THE HANDLE ALL THE WAY OUT EACH TIME? THAT'S VERY IMPORTANT.

--When you place the last stick, say:

WHEN I HAVE ONLY ONE STICK LEFT, I PUT IT AT THE END OF THE ROW.

--When finished, say:

NOW I WANT YOU TO PUT SOME STICKS IN A ROW FROM HARDEST TO PULL TO EASIEST TO PULL, DOING IT EXACTLY LIKE I DID--OKAY?

--Present the sticks and say:

PUT THESE STICKS IN ORDER FROM HARDEST TO PULL TO EASIEST TO PULL. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND?

--If Yes, continue.

Fig. E2.--Continued.

I AM GOING TO SHOW YOU A WAY TO PUT THESE STICKS IN A ROW FROM HARDEST TO PULL TO EASIEST TO PULL. PAY CLOSE ATTENTION--OKAY?

PICK ANY STICK. IT GOES FIRST IN LINE (Place it first in line). PICK ANOTHER (Put in front of first and pull both). IT'S HARDER/EASIER THAN THIS ONE, SO IT GOES ON THIS SIDE (Place to one side or another).

--Pick new sticks one at a time. Go to the proper position in the ordered row and compare the new one to those in the row. Say:

THIS ONE IS HARDER/EASIER THAN THAT ONE (Point) BUT EASIER/HARDER THAN THIS (Point). SO WE HAVE TO MAKE A HOLE TO PUT IT IN BETWEEN. (Make a hole and put the stick in.)

--Say one of the following statements for each stick after the third one.

THIS IS A HARD ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

THIS IS A MIDDLE ONE, SO I'LL TRY IT IN THIS PART OF THE ROW.

THIS IS AN EASY ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

--During the modeling, make each of these three statements once.

****SEE, I PICK ANY STICK FROM UP HERE (Point). IT DOESN'T MATTER WHICH ONE I TAKE.

****SEE, I CHECKED ON EACH SIDE OF THIS ONE TO MAKE SURE IT GOES HERE.

Fig. E3.--INS Strategy Protocol for Force.

****SEE HOW I PULL THE HANDLE ALL THE WAY OUT EACH TIME?

THAT'S VERY IMPORTANT.

--When finished, say:

NOW I WANT YOU TO PUT SOME STICKS IN A ROW FROM HARDEST TO PULL TO EASIEST TO PULL, DOING IT EXACTLY LIKE I DID--OKAY?

--Present the sticks and say:

PUT THESE STICKS IN ORDER FROM HARDEST TO PULL TO EASIEST TO PULL. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND?

--If Yes, Continue.

--If No, Repeat Instruction.

--If still No, Count as one trial and repeat strategy model.

Fig. E3.--Continued.

NOW I WANT YOU TO PUT A DIFFERENT SET OF STICKS IN A ROW FROM HARDEST TO PULL TO EASIEST TO PULL. WHEN YOU ARE FINISHED, I'LL TELL YOU HOW WELL YOU DID. DO YOU UNDERSTAND WHAT TO DO?

--When the child is finished go down the line and explain his mistakes, asking him to feel each pair of sticks wrongly placed. Ask him if they are in the right place. If he says no, tell him to put them right. If he says yes, mix the two up and ask again. If he still insists he was correct, then count as if correct.)

--When finished with errors, say the following:

I WANT YOU TO TRY TO PUT THE STICKS IN A ROW AGAIN. THIS TIME BE VERY CAREFUL AND TRY NOT TO MAKE ANY MISTAKES.

Fig. E4.--CON Treatment Protocol for Force.

I PUT THESE CUPS IN A ROW ACCORDING TO HOW ROUGH THEY ARE. SOME ARE SMOOTH. FEEL THE INSIDE OF EACH ONE LIKE THIS (Model how to feel). START HERE (Point to roughest) AND FEEL EACH ONE.

--SEE HOW EACH ONE IS SMOOTHER THAN THE ONE BEFORE IT? I PUT THEM IN A ROW FROM ROUGHEST TO SMOOTHEST.

--IN A MOMENT I WANT YOU TO PUT SOME CUPS IN A ROW ACCORDING TO HOW THEY FEEL. DO YOU UNDERSTAND?

--If Yes, Continue.

--If No, Repeat.

--If still No, Repeat.

PUT THESE CUPS IN A ROW ACCORDING TO HOW THEY FEEL. DO YOU UNDERSTAND?

Fig. E5.--Pretest Protocol for Texture.

I AM GOING TO SHOW YOU A WAY TO PUT THESE CUPS IN A ROW FROM ROUGHEST TO SMOOTHEST. PAY VERY CLOSE ATTENTION--OKAY?

I WANT TO FIND THE ROUGHEST ONE OF ALL OF THESE CUPS (Point).

--Pick two and feel them.

--IT'S NOT THAT ONE (While discarding). THIS ONE IS ROUGHER (Heft rougher one).

--Pick another and compare to roughest one so far.

--IT'S NOT THAT ONE (While discarding). (SAY ONCE OR TWICE PER ROUND.)

--When finished with round one, say:

THIS IS THE ROUGHEST ONE OF ALL OF THOSE (Point), SO I'LL PUT IT DOWN HERE TO START THE ROW.

NOW I WANT TO FIND THE ROUGHEST ONE OF ALL THE CUPS THAT ARE LEFT.

--Repeat the procedure for all the remaining rounds.

THIS IS THE ROUGHEST ONE OF ALL THOSE LEFT (Point), SO I'LL PUT IT NEXT IN THE ROW.

--During the modeling make each of these two comments once.

****SEE, I USE THE SAME HAND EVERYTIME, SO I WON'T MAKE A MISTAKE.

****SEE, I ALWAYS PUT THE SMOOTHER ONES ASIDE AFTER I'VE CHECKED THEM.

Fig. E6.--EVS Strategy Protocol for Texture.

****SEE, I CHECK EVERY CUP EVERYTIME, THAT'S TO MAKE SURE I DON'T MAKE A MISTAKE.

--When you place the last cup, say:

WHEN I HAVE ONLY ONE CUP LEFT, I PUT IT AT THE END OF THE ROW.

--When finished, say:

NOW I WANT YOU TO PUT SOME CUPS IN A ROW FROM ROUGHEST TO SMOOTHEST, DOING IT EXACTLY LIKE I DID. OKAY?

--Present the cups and say:

PUT THESE CUPS IN ORDER FROM ROUGHEST TO SMOOTHEST. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND WHAT TO DO?

--If Yes, Continue.

--If No, Repeat Instruction.

--If still No, Count as one trial and repeat strategy model.

Fig. E6.--Continued.

I AM GOING TO SHOW YOU A WAY TO PUT THESE CUPS IN A ROW FROM ROUGHEST TO SMOOTHEST. PAY CLOSE ATTENTION--OKAY?

PICK ANY CUP. IT GOES FIRST IN LINE (Place it first in line). PICK ANOTHER (Put in front of first and feel both). IT'S ROUGHER/SMOOTHER THAN THIS ONE, SO IT GOES ON THIS SIDE (Place to one side or another).

--Pick new cups one at a time. Go to the proper position in the ordered row and compare the new one to those in the row. Say:

THIS ONE IS ROUGHER/SMOOTHER THAN THAT ONE (Point) BUT SMOOTHER/ROUGHER THAN THIS (Point). SO WE HAVE TO MAKE A HOLE TO PUT IT IN BETWEEN (Make a hole and put the cup in).

--Say one of the following statements for each cup after the third one.

--THIS IS A ROUGH ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

--THIS IS A MIDDLE ONE, SO I'LL TRY IT IN THIS PART OF THE ROW.

--THIS IS A SMOOTH ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

--During the modeling make each of these comments once.

****SEE, I USE THE SAME HAND EVERYTIME, SO I WON'T MAKE A MISTAKE.

****SEE, I PICK ANY CUP FROM UP HERE (Point). IT DOESN'T MATTER WHICH ONE I TAKE.

Fig. E7.--INS Strategy Protocol for Texture.

****SEE, I CHECKED ON EACH SIDE OF THIS ONE TO MAKE SURE IT GOES HERE.

--When finished, say:

NOW I WANT YOU TO PUT SOME CUPS IN A ROW FROM ROUGHEST TO SMOOTHEST, DOING IT EXACTLY LIKE I DID. OKAY?

--Present the cups and say:

PUT THESE CUPS IN ORDER FROM ROUGHEST TO SMOOTHEST. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND?

--If Yes, Continue.

--If No, Repeat Instruction.

--If still No, Count as one trial and repeat strategy model.

Fig. E7.--Continued.

NOW I WANT YOU TO PUT A DIFFERENT SET OF CUPS IN A ROW FROM ROUGHEST TO SMOOTHEST. WHEN YOU ARE FINISHED, I'LL TELL YOU HOW WELL YOU DID. DO YOU UNDERSTAND WHAT TO DO?

--When the child is finished go down the line and explain his mistakes, asking the child to feel each pair of objects wrongly placed. Ask him if they are in the right place. If he says no, tell him to put them right. If he says yes, mix the two up and ask again. If he still insists he was correct, then count as if correct.

--When finished with errors, say the following:

I WANT YOU TO TRY TO PUT THE CUPS IN A ROW AGAIN. THIS TIME BE VERY CAREFUL AND TRY NOT TO MAKE ANY MISTAKES.

Fig. E8.--CON Treatment Protocol for Texture.

I PUT THESE CUPS IN A ROW ACCORDING TO THEIR WEIGHT. SOME ARE LIGHT AND SOME ARE HEAVY. PICK UP EACH CUP LIKE THIS (Pick one up) TO SEE HOW HEAVY IT IS (Point to heaviest).

--SEE HOW EACH ONE IS LIGHTER THAN THE ONE BEFORE IT? I PUT THEM IN A ROW FROM HEAVIEST TO LIGHTEST.

--IN A MOMENT I WANT YOU TO PUT SOME CUPS IN A ROW ACCORDING TO THEIR WEIGHT. DO YOU UNDERSTAND WHAT TO DO?

--Present the cups.

PUT THESE CUPS IN A ROW ACCORDING TO THEIR WEIGHT. DO YOU UNDERSTAND WHAT TO DO?

Fig. E9.--Pretest Protocol for Weight.

I AM GOING TO SHOW YOU A WAY TO PUT THESE CUPS IN A ROW FROM HEAVIEST TO LIGHTEST. PAY VERY CLOSE ATTENTION--OKAY?

I WANT TO FIND THE HEAVIEST ONE OF ALL OF THESE CUPS (Point).

--Pick two and heft them.

--IT'S NOT THAT ONE (While discarding). THIS ONE IS HEAVIER (Heft heavier one).

--Pick another and compare to heaviest one so far.

--IT'S NOT THAT ONE (While discarding). (Say once or twice per round.)

--When finished with round one, say:

THIS IS THE HEAVIEST ONE OF ALL OF THISE (Point), SO I'LL PUT IT DOWN HERE TO START THE ROW.

NOW, I WANT TO FIND THE HEAVIEST ONE OF ALL THE CUPS THAT ARE LEFT.

--Repeat the procedure for all the remaining rounds.

THIS IS THE HEAVIEST ONE OF ALL OF THOSE LEFT (Point), SO I'LL PUT IT NEXT IN THE ROW.

--During the modeling, make each of these three comments once.

****SEE, I USE THE SAME HAND EVERYTIME, SO I WON'T MAKE A MISTAKE.

****SEE, I CHECK EACH CUP EVERYTIME. THAT'S TO MAKE SURE I DON'T MAKE A MISTAKE.

Fig. E10.--EVS Strategy Protocol for Weight.

****I ALWAYS PUT THE LIGHTER ONES ASIDE AFTER I'VE CHECKED THEM.

--When you place the last cup, say:

WHEN I HAVE ONLY ONE CUP LEFT, I PUT IT AT THE END OF THE ROW.

--When finished say:

NOW I WANT YOU TO PUT SOME CUPS IN A ROW FROM HEAVIEST TO LIGHTEST. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND WHAT TO DO?

--Present the cups and say:

PUT THESE CUPS IN ORDER FROM HEAVIEST TO LIGHTEST. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND WHAT TO DO?

--If Yes, Continue.

--If No, Repeat Instruction.

--If still No, Count as one trial and repeat strategy model.

Fig. E10.--Continued.

I AM GOING TO SHOW YOU A WAY TO PUT THESE CUPS IN A ROW FROM HEAVIEST TO LIGHTEST. PAY CLOSE ATTENTION--OKAY?

PICK ANY CUP. IT GOES FIRST IN LINE. (Place it first in line and heft it.)

PICK ANOTHER. (Put it in front of first.) IT'S HEAVIER/LIGHTER THAN THIS ONE. SO IT GOES ON THIS SIDE (Place to one side or another).

--Pick new cups one at a time. Go to the proper position in the ordered row and compare the new one to those in the row and say:

THIS ONE IS HEAVIER/LIGHTER THAN THAT ONE (Point), BUT LIGHTER/HEAVIER THAN THIS (Point). SO WE HAVE TO MAKE A HOLE TO PUT IT IN BETWEEN. Make a hold and put the cup in.

--Say one of the following statements for each weight after the third.

--THIS IS A LIGHT ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

--THIS IS A MIDDLE ONE, SO I'LL TRY IT IN THIS PART OF THE ROW.

--THIS IS A HEAVY ONE, SO I'LL TRY IT AT THIS END OF THE ROW.

--During the modeling make each of these comments once.

****SEE, I USE THE SAME HAND EVERYTIME, SO I WON'T MAKE A MISTAKE.

****SEE, I CHECKED ON EACH SIDE OF THIS ONE TO MAKE SURE IT GOES HERE.

Fig. E11.--INS Strategy Protocol for Weight.

****SEE, I PICK ANY CUP FROM UP HERE (Point). IT DOESN'T MATTER WHICH ONE I TAKE.

--When finished say:

NOW I WANT YOU TO PUT SOME CUPS IN A ROW FROM HEAVIEST TO LIGHTEST, DOING IT EXACTLY LIKE I DID. OKAY?

--Present the cups and say:

PUT THESE CUPS IN ORDER FROM HEAVIEST TO LIGHTEST. REMEMBER, DO IT JUST LIKE I TAUGHT YOU. DO YOU UNDERSTAND?

--If Yes, Continue.

--If No, Repeat Instruction.

--If still No, Count as one trial and repeat model.

Fig. E11.--Continued.

NOW I WANT YOU TO PUT A DIFFERENT SET OF CUPS IN A ROW FROM HEAVIEST TO LIGHTEST. WHEN YOU ARE FINISHED, I'LL TELL YOU HOW WELL YOU DID. DO YOU UNDERSTAND WHAT TO DO?

--When the child is finished go down the line and explain his mistakes, asking him to feel each pair of objects wrongly placed. Ask him if they are in the right place. If he says no, tell him to put them right. If he says yes, mix the two up and ask again. If he still insists he was correct, then count as if correct.

--When finished with errors, say the following:

I WANT YOU TO TRY TO PUT THE CUPS IN A ROW AGAIN. THIS TIME BE VERY CAREFUL AND TRY NOT TO MAKE ANY MISTAKES.

Fig. E12.--CON Treatment for Weight.

APPENDIX F

SCORE SHEETS

APPENDIX F

SCORE SHEETS

Different types of score sheets were used during the pretest, training and post-test sequence. A copy of each of these scoring forms follows. The Pretest score sheet was used for the Piaget Stick Task, the training score sheet for all training sessions and the Post-test score sheet for the post-tests.

Pretest Score Sheet

Name________________________ Birth Date________________

School______________________ Tester____________________

Date________________________

Sequence____

Object Number____

Coding____

Insertions 3_____ 1__ ___ 5_____ 2_____ 4_____

= O.K.

no = Incorrect

Stage_________

Fig. F1.--Pretest Score Sheet.

Training Score Sheet

NAME____________________ STRATEGY____________________

SCHOOL____________________ TESTER____________________

DATE____________________ DAY 1_____ 2_____ 3_____

PRE-TEST

Sequence____________________
Object Number____________________
Coding____________________

TRAINING SESSIONS -

1. Sequence____________________
Object Number____________________
Coding____________________

2. Sequence____________________
Object Number____________________
Coding____________________

3. Sequence____________________
Object Number____________________
Coding____________________

4. Sequence____________________
Object Number____________________
Coding____________________

5. Sequence____________________
Object Number____________________
Coding____________________

NOTES:

Fig. F2.--Training Session Score Sheet.

Post-Test Score Sheet

NAME____________________ STRATEGY____________________

SCHOOL____________________ TESTER____________________

DATE____________________

Variable____________________ Task Score____________________

Sequence____
Object Number____________________________________
Coding____

Variable____________________ Task Score____________________

Sequence____
Object Number____________________________________
Coding____

Variable____________________ Task Score____________________

Sequence____
Object Number____________________________________
Coding____

Variable____________________ Task Score____________________

Sequence____
Object Number____________________________________
Coding____

Fig. F3.--Post-Test Score Sheet.

APPENDIX G

MATERIAL PLACEMENT MAPS

APPENDIX G

MATERIAL PLACEMENT MAPS

In order to equalize the tasks given during the pre-tests, training sessions and post-tests, a series of maps was constructed which standardized the relative order of placement of the materials to each child.

For repeated trials, the map was often rotated 180°. In each case the objects were randomly ordered so as to minimize the possibility of a child ordering the objects by chance. The following are the maps used.

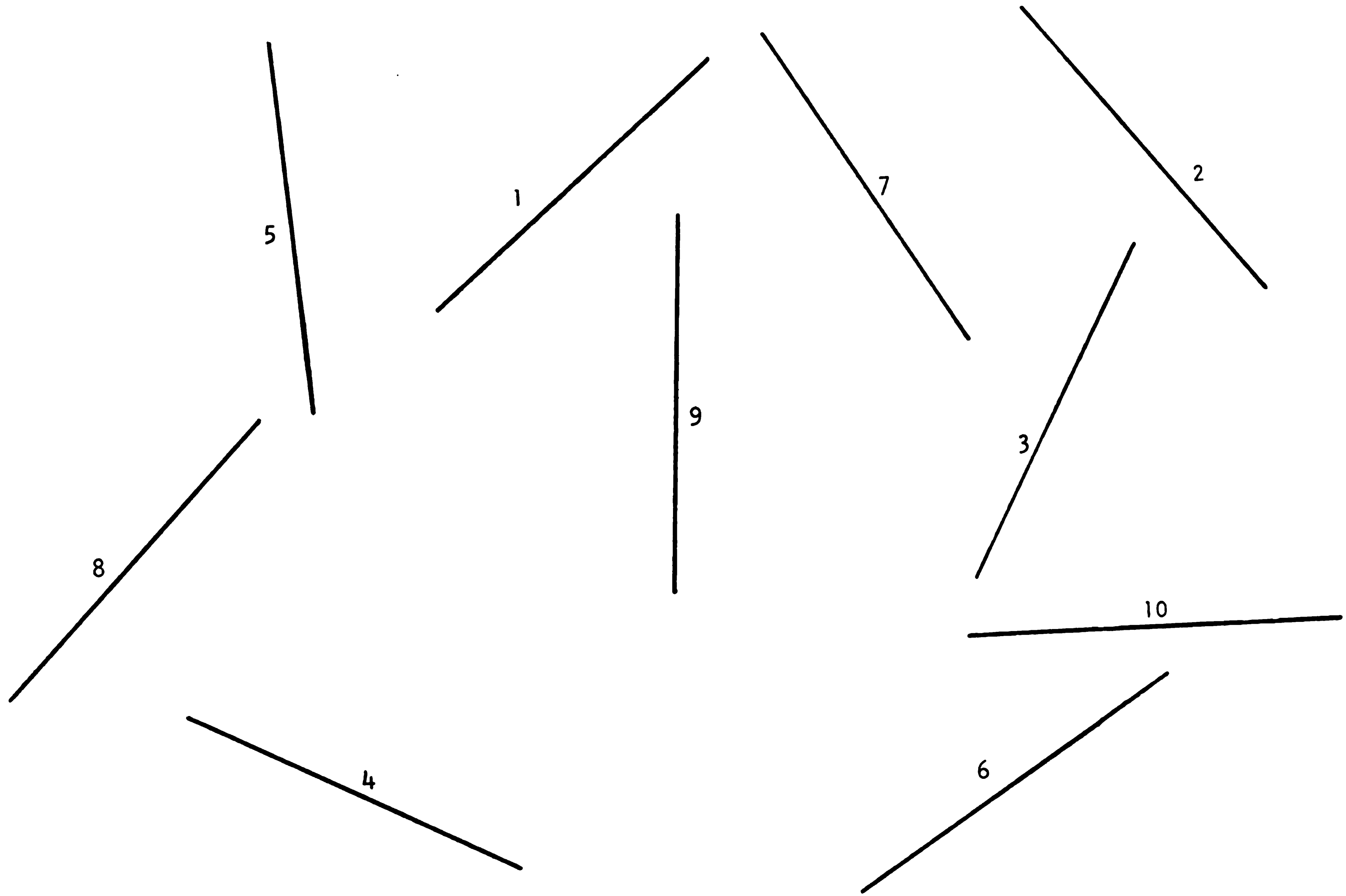

Fig. Gl.--Map Placement of Sticks.

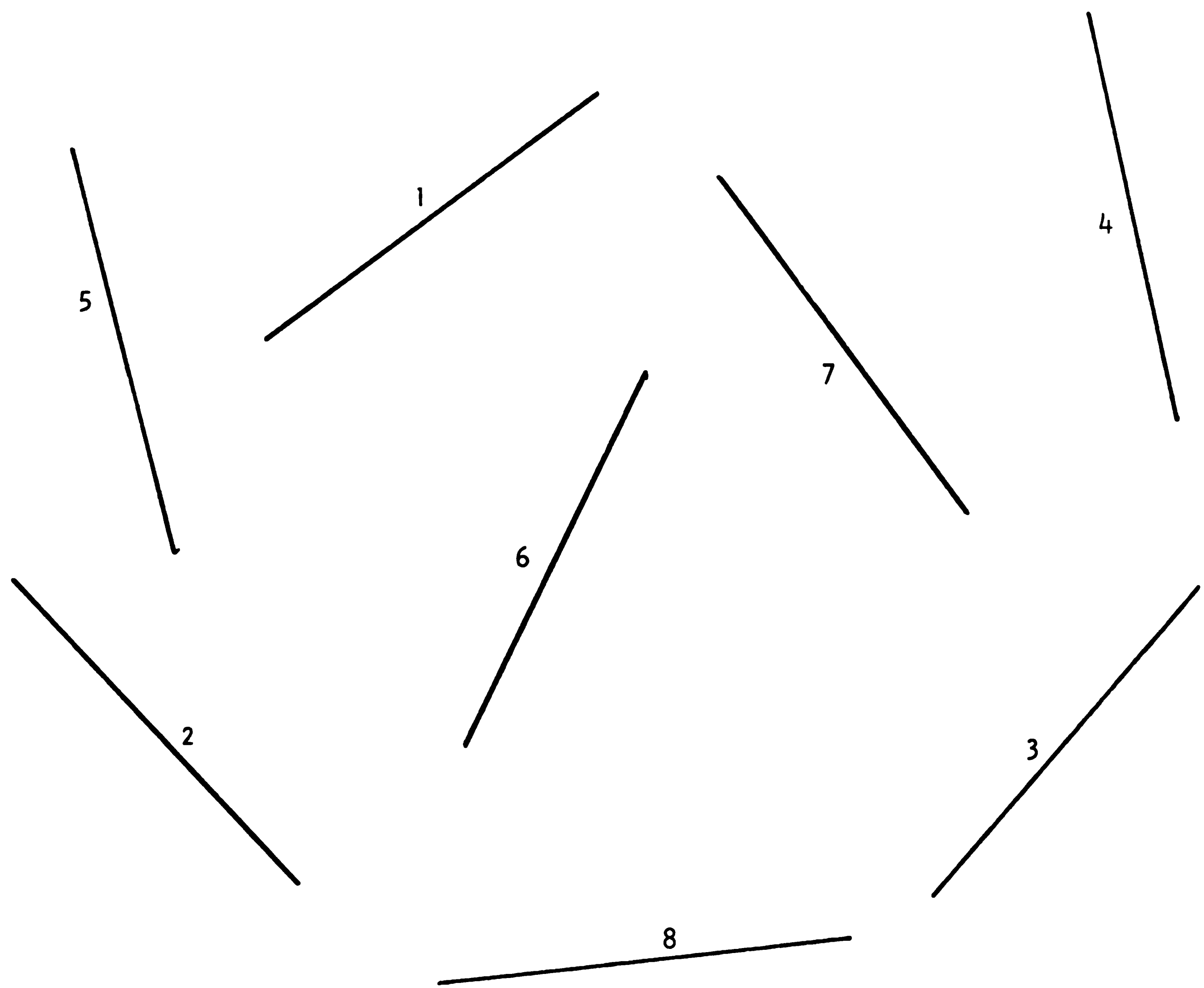

Fig. G2.--Map for Placement of Pull Toys.

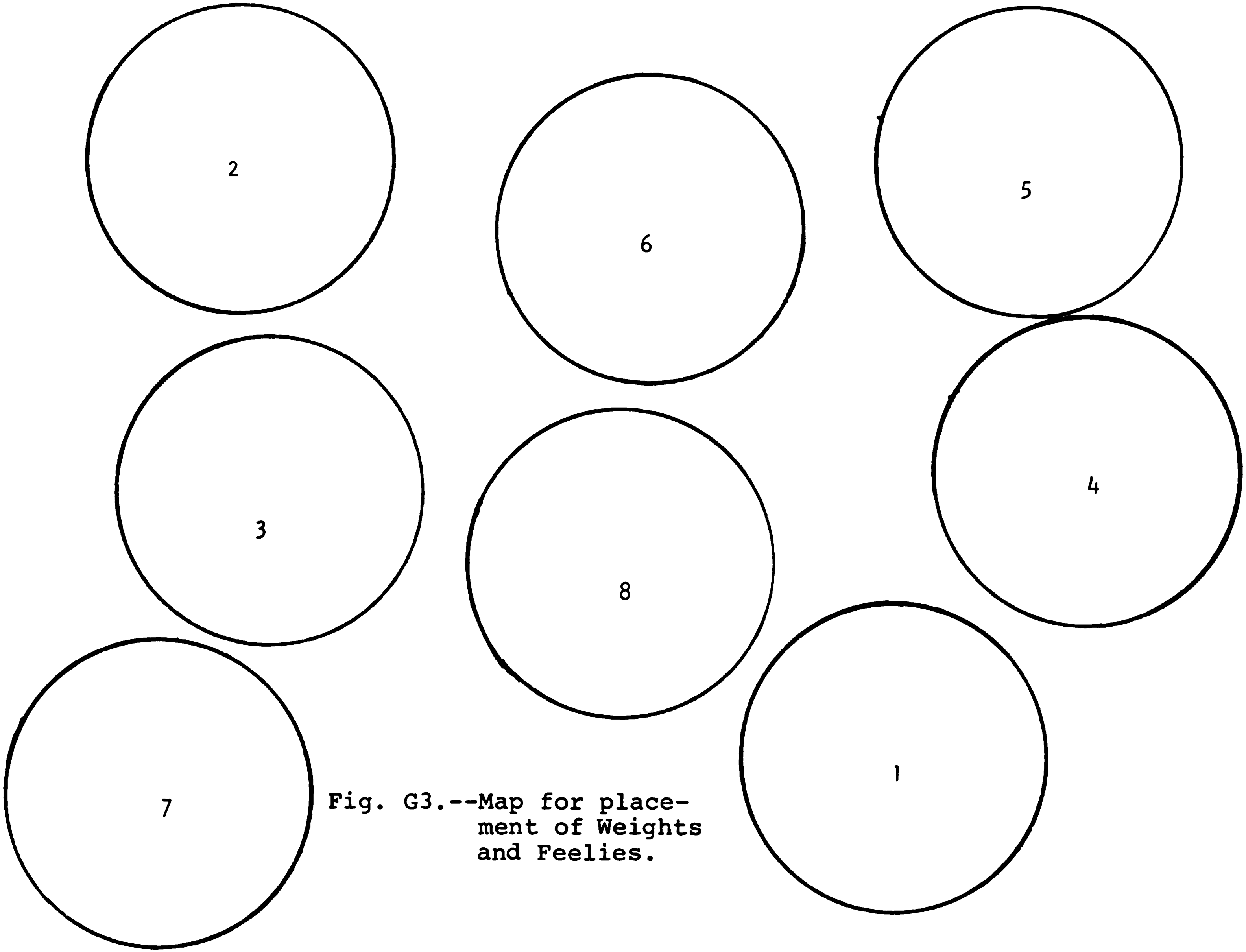

Fig. G3.--Map for placement of Weights and Feelies.

APPENDIX H

THE STRATEGY INFORMATION PROCESSING MODELS

APPENDIX H

THE STRATEGY INFORMATION PROCESSING MODELS

The purpose of this appendix is to present the information processing models of the strategies taught in this work. In order to do so, it is necessary to list and discuss the basic processes which make up these models. Some of these processes are original to this work; others come from Smith *et al*. (1972). Because of the volume of processes used from Smith's work, it seems wasteful to reprint every one. Therefore, only the more complex and original processes will be described. If the reader wishes a more thorough explanation of those not described, it is available in Smith *et al*. (1972).

Three different types of processes are available for use in constructing the information processing strategy models and these are called primary, secondary and tertiary processes. The primary processes are the basic building blocks available for use and are considered to be a unitary skill; examples are choose, designate and scan. "Secondary processes are frequently recurring sequences of primary processing steps, e.g., the comparison process. Tertiary processes may be defined in terms of both primary and secondary processes" (Smith et al., 1972). Examples of tertiary processes include the MAXPIC and EDGUESS routines.

The following list of processes is based on a long term memory model described by Frijda (1972). Smith et al. (1972) explains this model well.

> According to this view, information stored is an associative network of items or nodes, each leading to any number of other nodes--the associations of the first node. The stored items or nodes are generally considered to be concepts or ideas themselves rather than names used to refer to them or images exemplifying them. Although this is a somewhat vague position, the important point seems to be that what is stored is not words or images but rather information from which words, images and actions are reconstructed, as proposed by Neisser (1967). Thus, once activated or accessed, a node makes immediately available a number of operational options. Nodes are accessible by way of other nodes to which they are linked, by way of items or stimuli that in some sense resemble them (i.e., that resemble some level of reconstruction), or through the decoding of labels that refer to them (Smith et al., 1972).

The Primary Processes

The following is a list of primary processes used in this work.

Decode
Retrieve
Scan
Choose
Act
Select
Encode
Compare
Discard
Position
Present
Designate
Choose 1
Retrieve 1

Only the last two processes were originally described for this work and their definitions follow. All of the others are taken from Smith et al. (1972).

CHOOSE 1 is a primary process similar to CHOOSE in nature, but differing from CHOOSE in that some criterion is used for the choice. CHOOSE implies a certain randomness of choice, or at least a choice based on such non-salient factors as proximity to the chooser or visual accessibility. CHOOSE 1 implies a choice which is non-random, which is based on some salient criterion. CHOOSE 1 might compare a value for one element which is encoded and stored in short term memory to a series of perceived values of elements and choose the one element from the series which best approximates the value of that one element. In this case CHOOSE 1 has provided an approximation of the value of the original element.

RETRIEVE 1 is a primary process similar to RETRIEVE in that it is a directing process that insures that the appropriate node(s) is activated. However, RETRIEVE 1 deals in part with short term memory as well as long term memory. It involves the retrieval of values from long term memory and the retrieval of the salient characteristics of the objects to which the values belong as well as the connection between the values and the objects.

Secondary and Tertiary Processes

Certain secondary and tertiary processes were used in the construction of the strategy models. The following are descriptions and diagrammatic representations of those processes. The first two, comparison and seriation, follow Smith et al. (1972) and the last two are original to this work.

COMPARISON

This is a secondary process which takes as input a variable concept (i.e., the node activated by decoding of variable name or an appropriate retrieval process) and an ordered pair of elements. It compares the elements on the given variable and outputs a comparative concept applicable to the ordered pair of elements. Thus, the COMPARISON process does not produce a verbal report although it makes such a report immediately possible. Alternative steps might be carried out next instead. The identities of the elements and the comparison variable are maintained. Figure 4 indicates a parallel execution of processing steps. This indicates the desirability of near simultaneous observation of the two elements. "Parallel processing" in the technical psychological sense is not implied. Furthermore, feedback from the selecting and encoding steps to the ACT step undoubtedly occurs creating an active subsystem. Such feedback systems are very

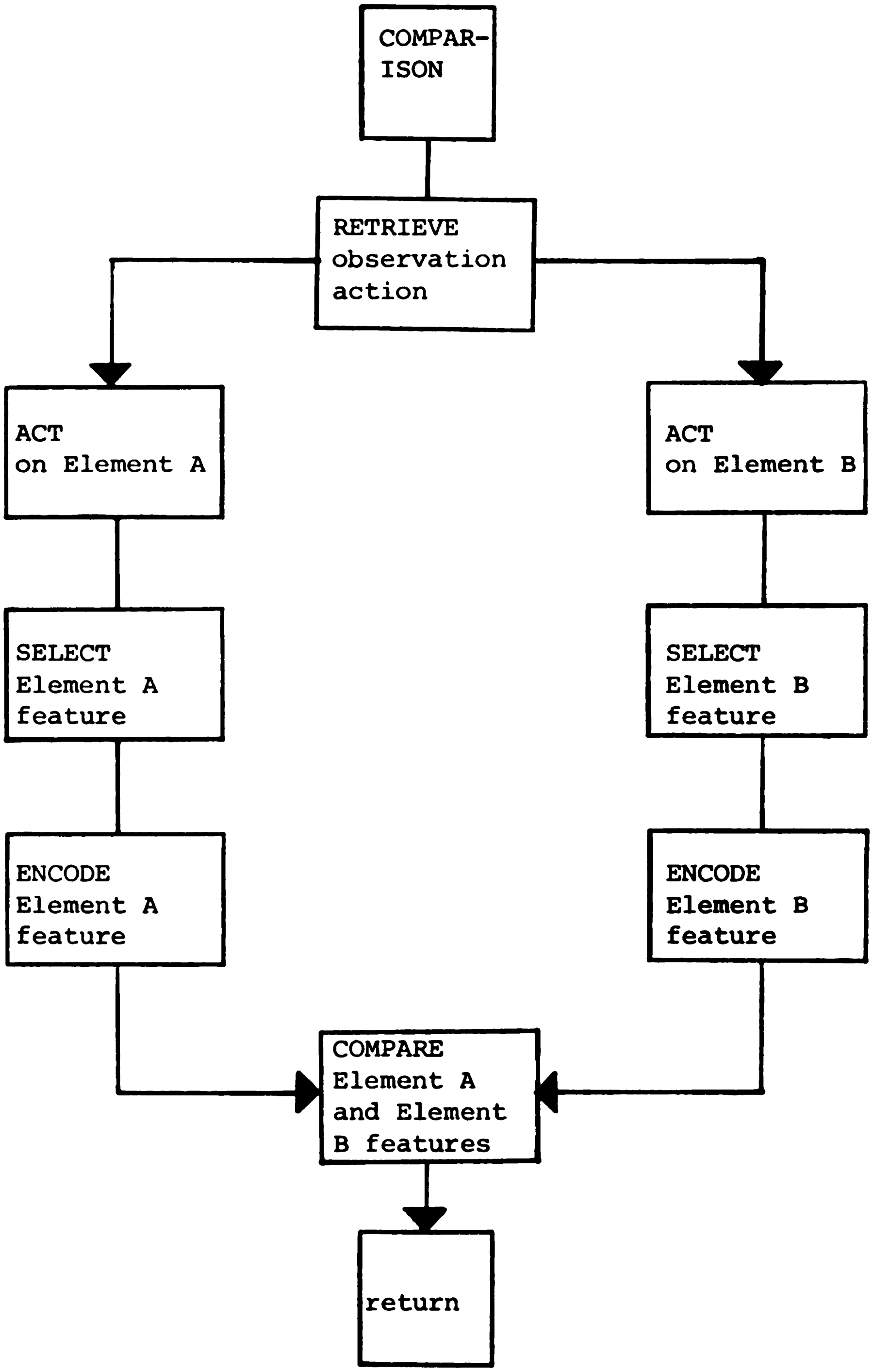

Fig. H1.--The COMPARISON Secondary Process.

common, but to avoid excessive complexity, are not always diagrammed.

SERIATION

This tertiary process uses as input a variable concept and a pair of elements. It initially processes the elements utilizing the COMPARISON process. If the elements are of the "same" magnitude on the variable observed, SERIATION outputs a comparative concept applicable to the elements. If the elements are not of the same magnitudes, SERIATION assesses the relative magnitudes of the elements using the ORDER process. This process outputs an ordinal concept, "greater than" or "less than." The identities of the elements must be maintained and coordinated with the ordinal concept. The SERIATION process does not produce a verbal report although it makes such a report immediately possible. Motor manipulation and sequential ordering of the elements themselves are also possible. The identity of the seriation variable is maintained.

EDGUESS is a tertiary process which positions an element in its proper place in a row based on the value of one variable. It is the basic subroutine in the insertion seriation strategy. It involves an initial educated guess as to the proper position of an element in a row and continues with the refinement of that educated guess until the proper position for an element is found.

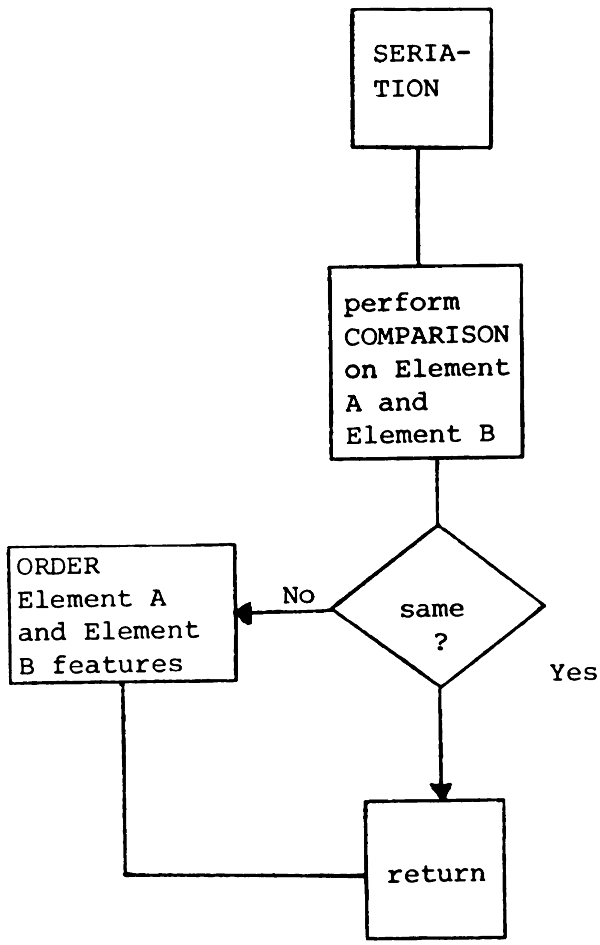

Fig. H2.--The SERIATION Tertiary Process.

MAXPIC is a tertiary process which acts upon a set of elements and chooses the element displaying the maximum value on some designated variable. It is the basic subroutine in the extreme value selection strategy and it involves the repeated comparison of each element in a set to the maximum element found so far. Input requirements are a set of elements differing on the named variable and the variable concept. The element displaying the maximum values for the chosen variable is the output.

The Strategy Models

The primary, secondary and tertiary processes just described can be combined to produce information processing models of the two strategies used in this work. The following is a verbal description and diagrammatic representation of those two strategies.

The extreme value selection (EVS) strategy uses the MAXPIC subroutine to choose an element displaying the maximum value of a variable and then places it at the end of a row. This process is repeated with the unordered elements until all have been placed into an ordered row. Because of the repetitive nature of this strategy it tends to be a slow, methodical and quite sure seriation strategy.

The insertion (INS) strategy uses the EDGUESS subroutine to position all elements relative to each other in a row until all elements are placed in the ordered row. Because each element need not be acted upon every time an

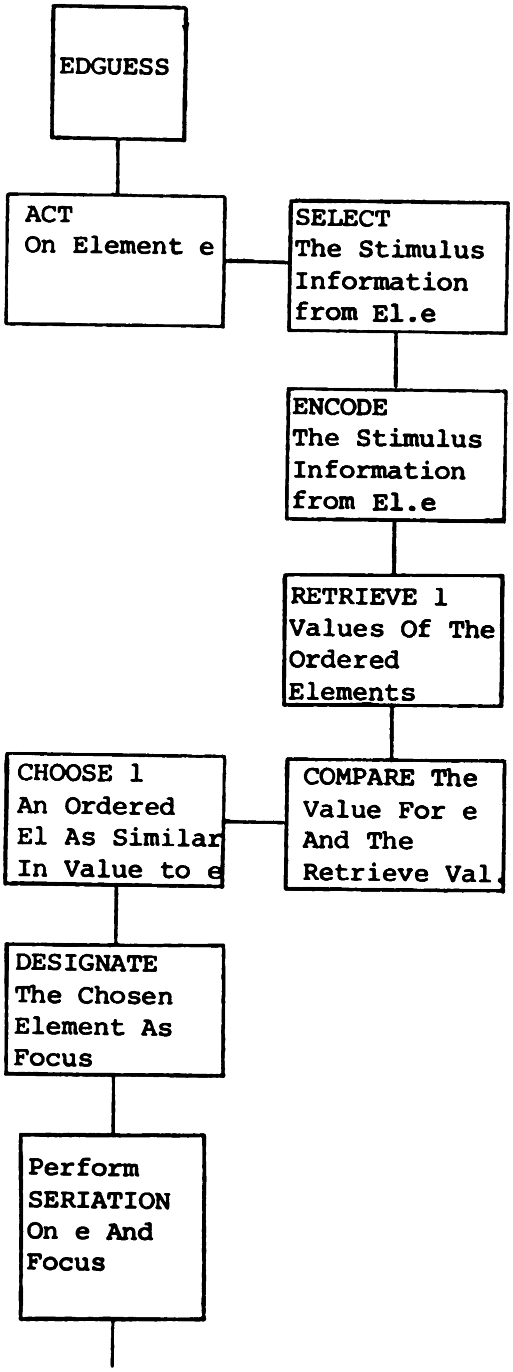

Fig. H3.--The EDGUESS Tertiary Process.

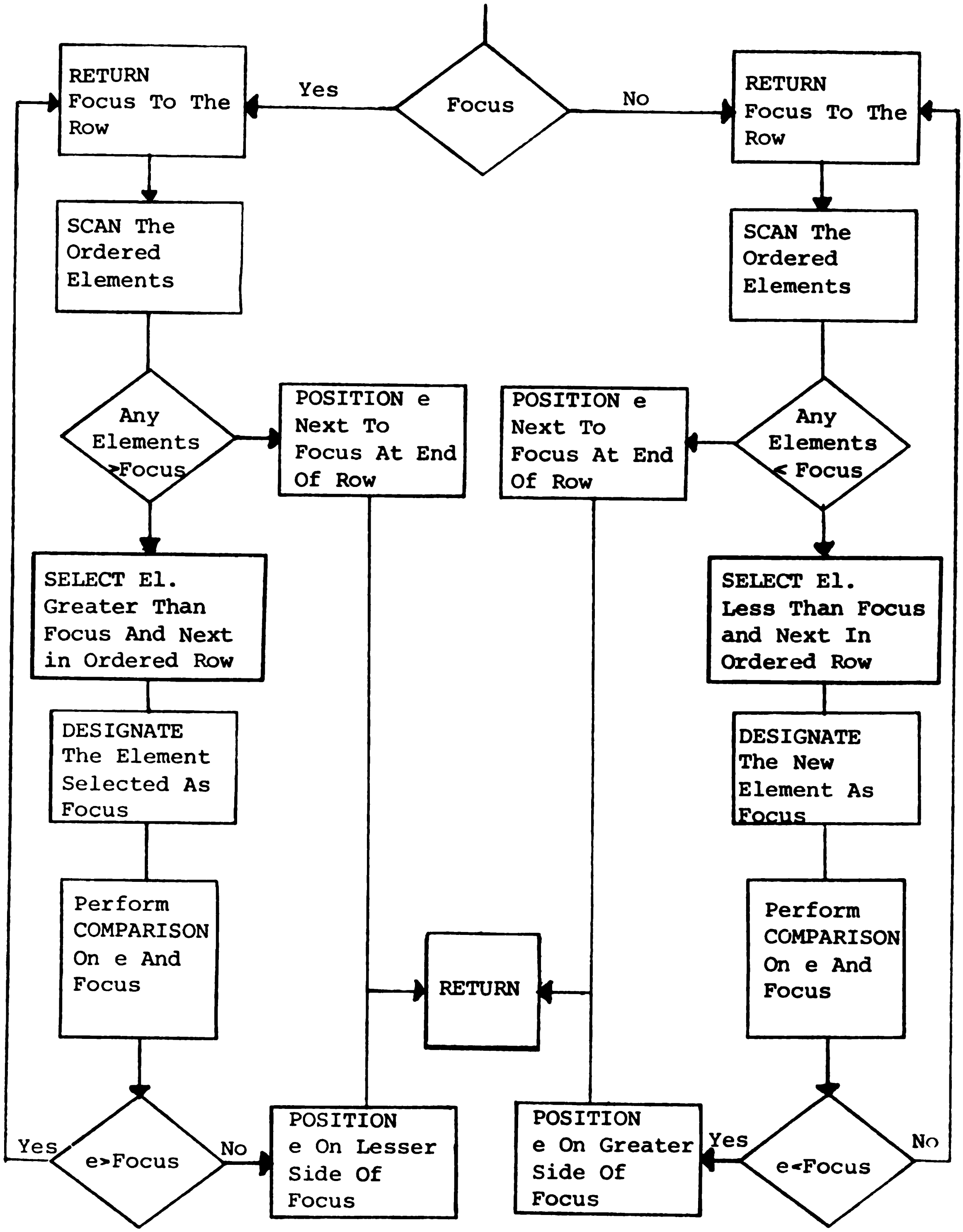

Fig. H3.--Continued.

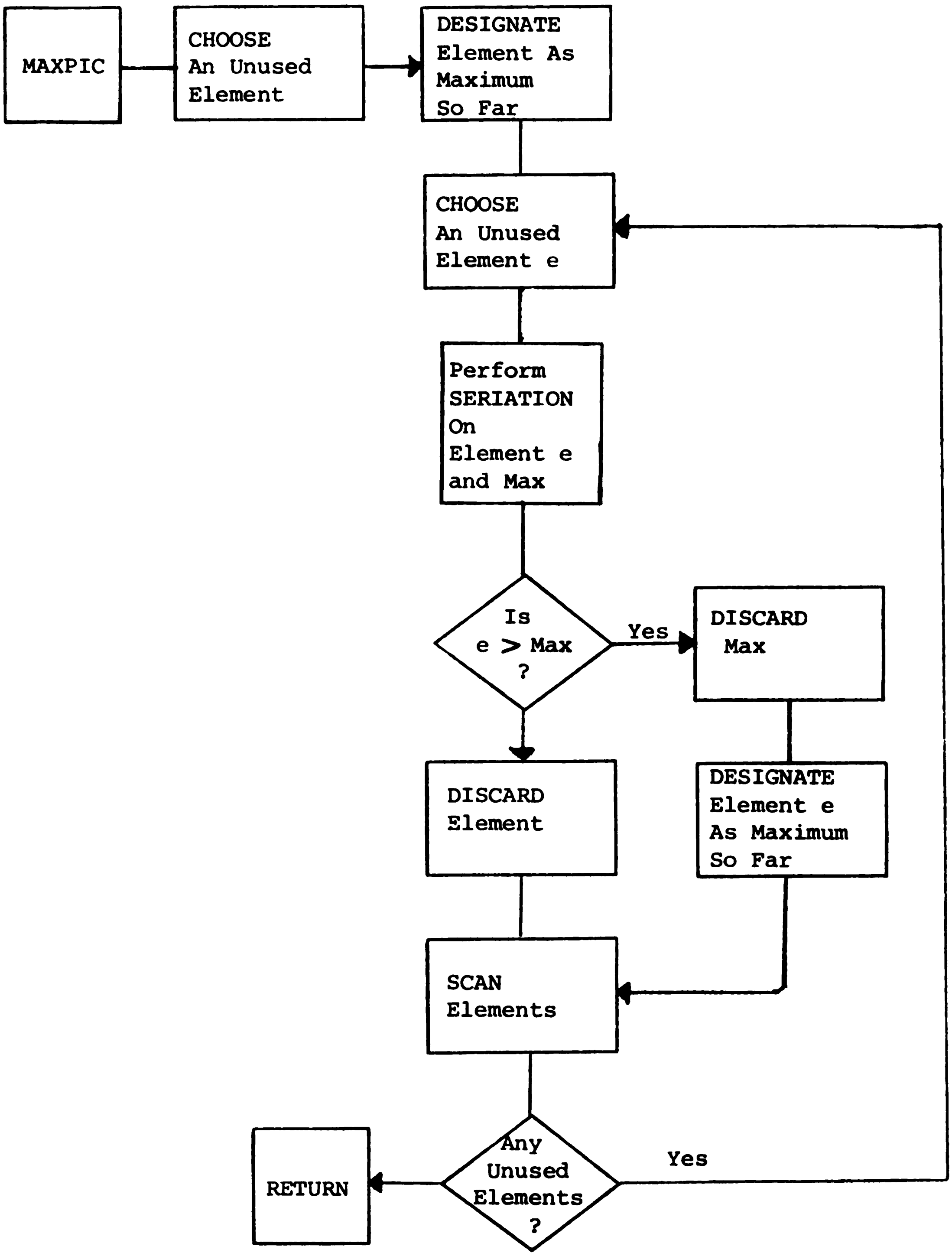

Fig. H4.--The MAXPIC Tertiary Process.

element is positioned, this strategy tends to be quicker than the EVS, although just as sure. However, since the basis for this strategy, the EDGUESS subroutine, involves a series of mental comparisons which are not necessarily repeatable for each element that is ordered, the INS strategy tends to be somewhat more confusing to young children.

The following two figures are diagrammatic representations of the Extreme Value Selection and Insertion Strategies.

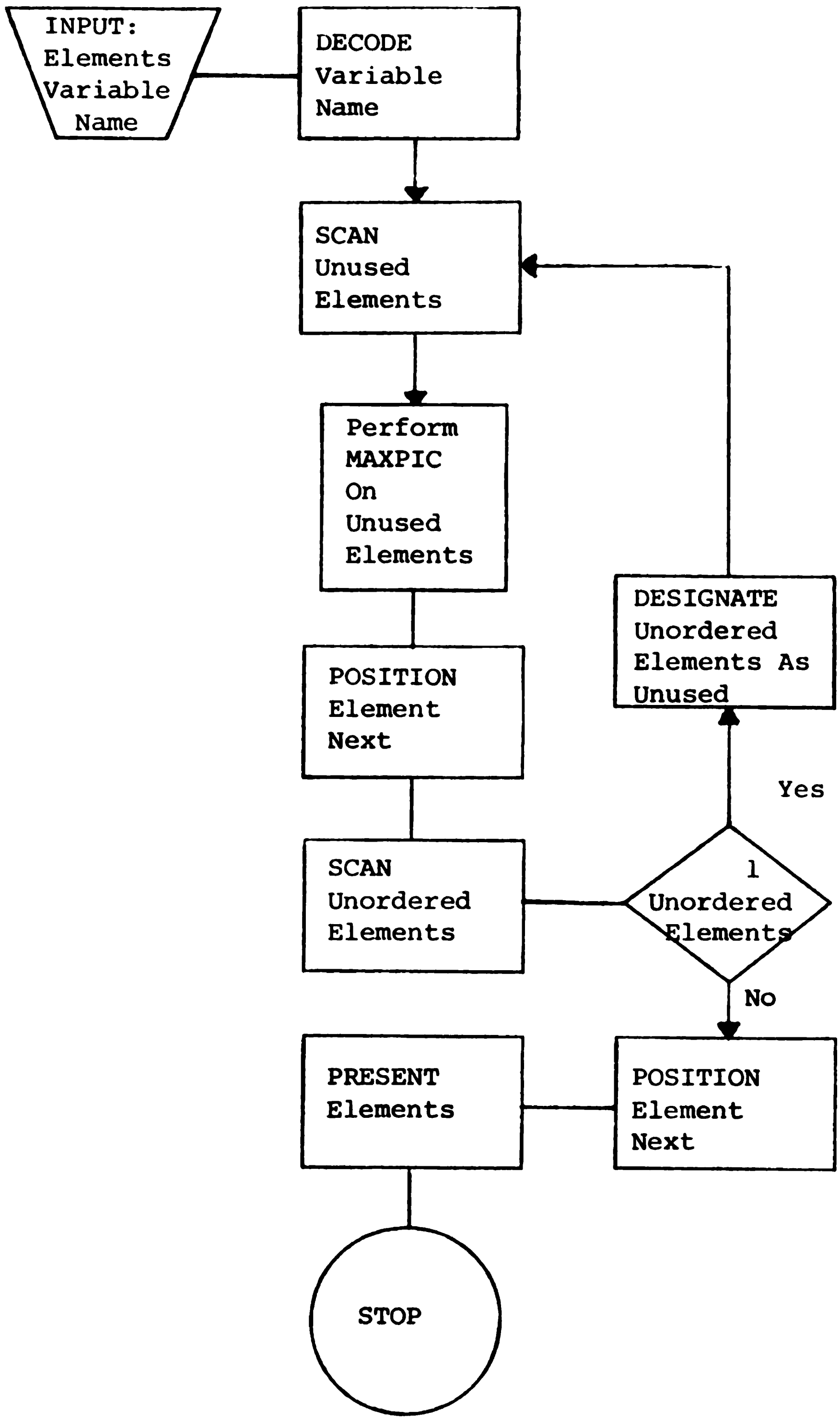

Fig. H5.--The Extreme Value Selection Strategy Model.

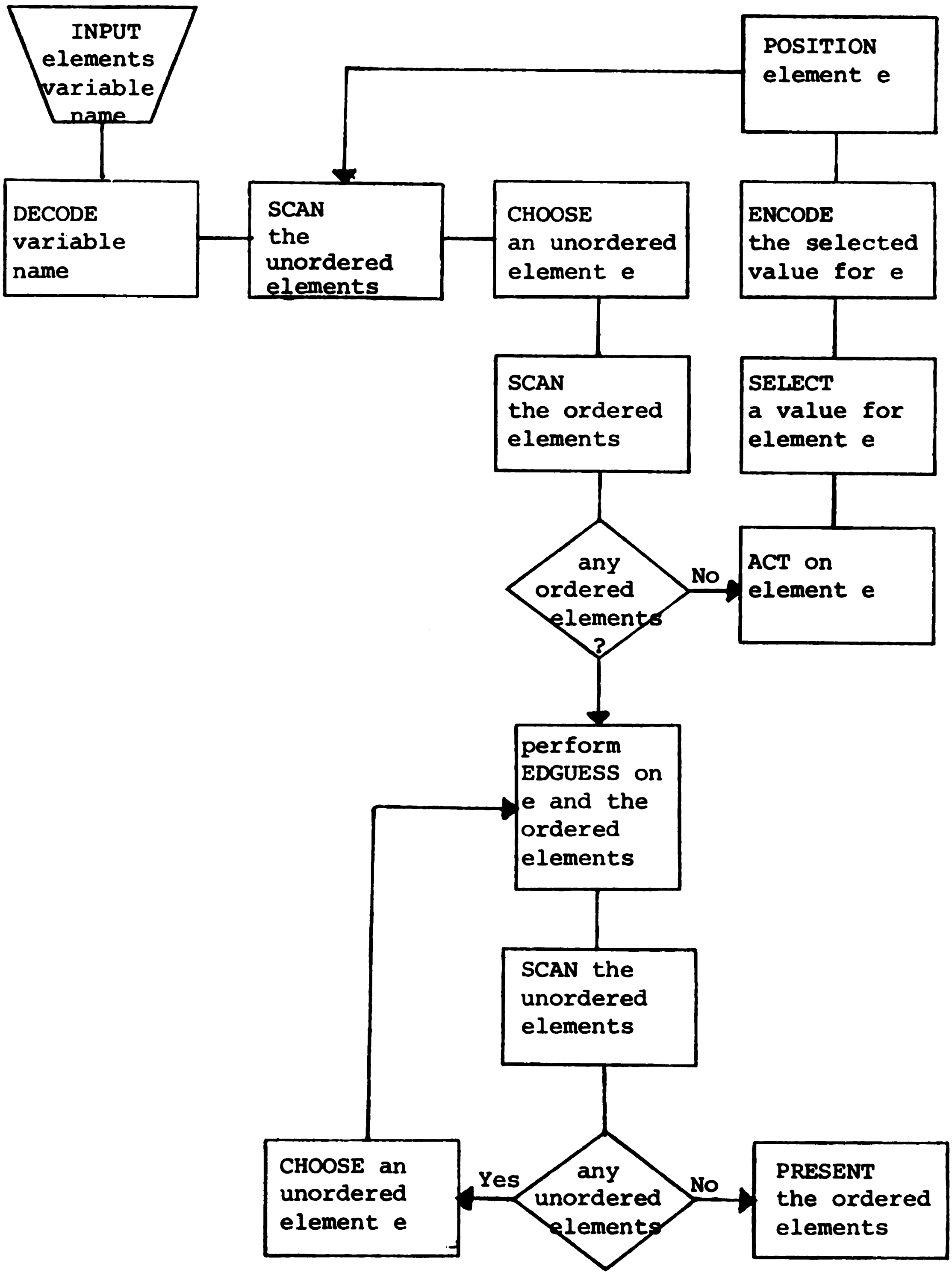

Fig. H6.--The Insertion Strategy Model.

APPENDIX I

ANALYSIS OF THE TASK SCORE TO CRITERION MEASURE (TSTC)

APPENDIX I

ANALYSIS OF THE TASK SCORE TO CRITERION MEASURE (TSTC)

Besides the trials to criterion (TTC) measure, the task score to criterion (TSTC) was also available to test both relative and absolute facilitation of learning. This measure reflects a combination of number of training trials and accuracy of performance during trials. Since the results of this analysis closely paralleled those obtained with the TTC, they were not included in the analysis chapter. For those interested, this appendix reports the results of the analysis of this measure.

Table I1 contains the means and standard deviations of the TSTC by treatment/stage group across trials. Each group increased its TSTC across trials indicating improved performance except for the CON I group which decreased slightly from trial 1 to trial 2.

A multivariate analysis of covariance (MANCOVA) was performed on the TSTC scores covarying on pretest 1 task score. Main effects were produced for stage, treatment within Stage III and treatment within Stage I. As before multivariate F, univariate F and step down F ratios for

Table I1.--Means and Standard Deviations on the TSTC for Each Treatment/Stage Group.

Treatment/ Stage Group	Trial 1	Trial 2	Trial 3
EVS III	$\bar{X}$ = .917 S.D. = .127	$\bar{X}$ = .939 S.D. = .097	$\bar{X}$ = .994 S.D. = .017
INS III	$\bar{X}$ = .931 S.D. = .083	$\bar{X}$ = .973 S.D. = .055	$\bar{X}$ = .980 S.D. = .049
CON III	$\bar{X}$ = .923 S.D. = .092	$\bar{X}$ = .958 S.D. = .087	$\bar{X}$ = .983 S.D. = .037
EVS I	$\bar{X}$ = .871 S.D. = .136	$\bar{X}$ = .943 S.D. = .076	$\bar{X}$ = .987 S.D. = .023
INS I	$\bar{X}$ = .705 S.D. = .151	$\bar{X}$ = .795 S.D. = .181	$\bar{X}$ = .842 S.D. = .121
CON I	$\bar{X}$ = .858 S.D. = .193	$\bar{X}$ = .856 S.D. = .218	$\bar{X}$ = .918 S.D. = .123

each main effect were available. The univariate F and step down F ratios were again used to test absolute and relative facilitation of learning for treatment within each stage.

Table I2 reports the sample correlation matrix among the dependent variables and the covariate as well as the resulting correlation matrix after the covariate is removed. Table I3 reports the variance and standard deviations of the same measures before and after the covariate has been eliminated. Table I4 reports the statistics for regression analysis. The overall effect of

Table I2.--Sample Correlation Matrix of the TSTC Variables With and Without the Covariate Removed.

	TSTC 1	TSTC 2	TSTC 3	PRE 1
TSTC 1	1.00			
TSTC 2	.74	1.00		
TSTC 3	.56	.71	1.00	
PRE 1	.36	.29	.28	1.00
	With Covariate Removed			
TSTC 1	1.00			
TSTC 2	.71	1.00		
TSTC 3	.51	.68	1.00	

Table I3.--Variance and Standard Deviations of the TSTC Variables Before and After Covariates Are Removed.

Variable	Variable	Standard Deviation
TSTC 1	.0183	.135
TSTC 2	.0176	.133
TSTC 3	.0057	.076
PRE 1	.0660	.257
	With Covariate Removed	
TSTC 1	.0162	.127
TSTC 2	.0164	.128
TSTC 3	.0055	.073

Table I4.--Statistics for Regression Analysis With One Covariate for TSTC.

F Value for Test of Hypothesis of No Association Between Dependent and Independent Variables = 3.4120

D.F. = 3. and 63.0000 P less than .0228

Variable	Square Mult R	Mult R	F	P less than	Step Down F	P less than
1 TSTC1	.1295	.3598	9.6683	.0028	9.6683	.0028
2 TSTC2	.0855	.2923	6.0737	.0164	.1197	.7306
3 TSTC3	.0804	.2835	5.6810	.0201	.6340	.4289

Degrees of Freedom for Hypothesis = 1
Degrees of Freedom for Error = 65.

the covariate on all three measures is significant ($p < .023$).

The multivariate F, univariate F and step down F ratios for stage main effect are reported in Table I5. The multivariate F ratio is not significant at the .10 level even though the univariate F ratio for TSTC 1 and TSTC 3 are significant ($p < .10$ and $p < .023$, respectively). When TSTC 1 and TSTC 2 are used as covariates, the step down F ratio for TSTC 3 is significant ($p < .084$). This indicates a strongly independent difference between the two stages on trial 3. Table I6 reports the mean TSTC scores by stage across trial as well as the overall mean TSTC for each stage. It is obvious from this table that the significant differences reported above favor the Stage III children since they outperform the Stage I children consistently.

Table I5.--Stage Main Effects for TSTC.

F-Ratio for Multivariate Test of Equality of Mean Vectors = 2.0123

D.F. = 3. and 63.0000 P less than .1213

Variable	Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1 TSTC1	.0454	2.8036	.0989	2.8036	.0989
2 TSTC2	.0324	1.9766	.1646	.0923	.7623
3 TSTC3	.0290	5.4176	.0231	3.0870	.0838

Degrees of Freedom for Hypothesis = 1
Degrees of Freedom for Error = 65.

1 Covariates Have Been Eliminated

Table I6.--Mean Task Score to Criterion Across Stages I and III.

	TSTC 1	TSTC 2	TSTC 3	Mean TSTC
Stage I	.811	.865	.916	.864
Stage III	.924	.957	.986	.956

The multivariate F, univariate F, and step down F ratios for treatment within Stage III are reported in Table I7. None of the above tests was significant indicating as did the TTC results no differences among the treatments for Stage III children.

The multivariate F, univariate F, and step down F ratios for treatment within Stage I are reported in Table I8. As with the TTC a strong multivariate significance ($p < .0002$) indicates a treatment difference across all three measures for Stage I children. The step down F for TSTC 3 is significant ($p < .003$), indicating that when facilitation of learning is considered in the relative sense by covarying on TSTC 1 and 2, a treatment difference exists. A very strong TSTC 3 univariate F significance ($p < .0001$) shows that a treatment effect is also obtained when the facilitation of learning is viewed in an absolute sense, i.e., not relative to the difficulty of the original learning task.

When the least square estimates of effects adjusted for covariates (Appendix D contains these figures) are

Table I7.--Treatment Within Stage III for TSTC.

F-Ratio for Multivariate Test of Equality of Mean Vectors = .3757

D.F. = 6. and 126.0000 P less than .8934

Variable	Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1 TSTC1	.0030	.1855	.8311	.1855	.8311
2 TSTC2	.0058	.3527	.7042	.2242	.7999
3 TSTC3	.0007	.1337	.8751	.7262	.4878

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 65.

1 Covariates Have Been Eliminated

Table I8.--Treatment Within Stage I for TSTC.

F-Ratio for Multivariate Test of Equality of Mean Vectors = 4.8825

D.F. = 6. and 126.0000 P less than .0002

Variable	Hypothesis Mean Sq	Univariate F	P less than	Step Down F	P less than
1 TSTC1	.0963	5.9432	.0043	5.9432	.0043
2 TSTC2	.0722	4.4017	.0162	2.2966	.1089
3 TSTC3	.0640	11.9470	.0001	6.2440	.0034

Degrees of Freedom for Hypothesis = 2
Degrees of Freedom for Error = 65.

1 Covariates Have Been Eliminated

considered, the above differences can be attributed to specific treatments. For trial 3 the EVS group mean TSTC scores are significantly ($p < .05$) higher than the CON group and the CON group scores are significantly ($p < .05$) higher than the INS group. Thus it can be inferred that the EVS mean is significantly higher than the INS mean even though no contrast is available to test this. Figure I1 is a graph of the TSTC score improvement across trials for each treatment group within Stage I. Although the covariate effect cannot be shown, this graph indicates the trend of improvement and the relative differences among treatments. Figure I1 is a graph of the Stage I and III mean TSTC across trials. Only the EVS Stage I children approach the scores obtained by the Stage III children indicating again the superiority of that treatment with Stage I children.

Thus the TSTC results verified those obtained with the TTC score. No differences were evident within Stage III groups. However, the Stage I analyses showed the EVS group was significantly better than the CON and the INS from both the relative and absolute points of view.

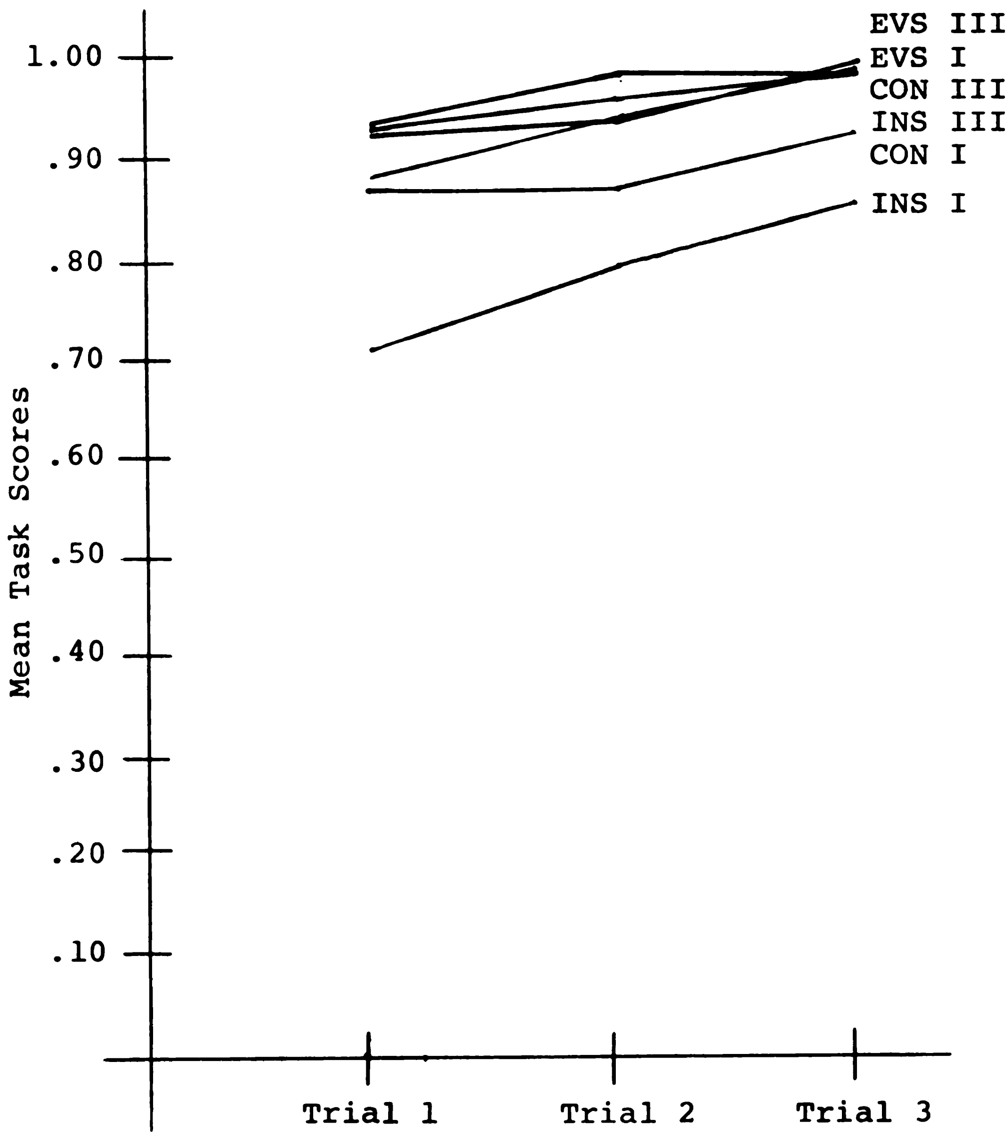

Fig. Il.--Mean TSTC for Each Treatment/Stage Group Across Trials.

APPENDIX J

PIAGET STICK TASK RESULTS

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During the post test session each child was asked to order the set of ten sticks used in the initial pretest. If the child ordered the ten sticks correctly, then he was asked to insert five more one at a time into the ordered row. Table J1 displays the results of the stick task. While all 36 Stage III children could order the sticks on the pretest, only 34 could do so on the post test, a loss of two. No Stage I children could order on the pretest but sixteen of them could do so three weeks later on the post test. And these sixteen also inserted an average of 3.8 sticks correctly. In fact three EVS I children and five CON I children ordered and inserted the sticks perfectly on the post test.

Table J1.--Pre and Post Test Stick Task Results.

Treatment/ Stage Group	No. of Children With Pretest TS = 1.00	Mean No. of Correct Insertions	No. of Children With Post Test TS = 1.00	Mean No. of Correct Insertions
EVS III	12	4.58	11	4.82
INS III	12	4.58	11	4.45
CON III	12	4.17	12	4.33
EVS I	0	0	7	3.43
INS I	0	0	2	2.00
CON I	0	0	7	4.71