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ABSTRACT

Reported is a study of the teaching and transfer of seriation strategies using non-visual variables with first-grade children. Sixty first-grade children were administered Piaget's stick seriation task and classified as stage I (non-seriators) and stage III (seriators). From this group 24 were chosen and assigned to strategy treatment groups. Treatment group one, Extreme Value Selection Strategy (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 objects were in order. Treatment two, Insertion Strategy (INS), was taught to seriate by choosing randomly and then placing in proper position. Treatment group three, the control (CON), simply practiced the seriation task with feedback on correction. Groups were taught in three separate sessions. Data were collected on number of trials to criterion which was defined as the successful completion of the task using the exact strategy taught. A Kendall's Tau correlation was computed on posttest results to judge the degree of correctness for each task. Multivariate analysis indicated significant differences (p less than .05) with the EVS strategy group's mean scores superior to the INS or CON groups, and the INS group superior to the CON group. Analysis of trials to criterion (TTC) data showed no difference between stage I and stage III children. (Author/EB)

THE TEACHING AND TRANSFER OF SERIATION STRATEGIES USING NON-VISUAL VARIABLES WITH FIRST GRADE CHILDREN

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Transfer of knowledge is considered by many to be a major objective of formal Education. Robert Gagne (1970) states "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) makes it clear that "Learning should not only take us somewhere; it should allow us later to go further more easily." However, while many agree on the importance, relatively few concur on the mechanism of transfer. The purpose of this study was to investigate the learning and transfer of one possible mechanism for transfer, the strategy.

Smith (1974) and Smith and Bessemer (1972) have argued for the expression of educational objectives in terms of a three dimensional model encompassing the task, the content and the strategy, that is, the specific way the task is to be completed. They argue that in designing instruction to optimize transfer, the strategies to be acquired should be considered. Only when this is done, can transfer be reliably predicted.

In this study first grade children were taught strategies for a seriation task with various sets of objects differing on the nonvisual variables of. weight, texture, and force. Piaget (1969) investigated children's visual seriation abilities as did many other researchers. In addition, Piaget (1941) also investigated the seriation of weight using a balance and reported ages averaging almost 9 years for operational seriation of ten weights. In addition to these and other seriation attainment studies, several researchers attempted to move children through Piaget's stages (Coxford, 1964 Schafer, 1969). The present study, while attempting to teach children to seriate, does so primarily to focus on children's transfer of strategies across content areas. That is, it focuses on the question whether teaching strategies for the seriation task result in more accurate performance and greater transfer than simply practicing the tasks with outcome feedback. Only secondarily does this study assess the non seriators increase in seriation abilities due to instruction.

In a study conducted prior to this present work Smith and Padilla (1975) found that many first grade children who were able to seriate sets of sticks and weights used one of two systematic strategies to complete the task. Baylor and Gascon (1974) found similar strategies in use by children 6-12. Both these papers suggest that an attempt to teach the strategies to children might prove fruitful.

In this study first grade children were divided into two groups based on their ability to order a set of sticks. One-third of each group received one of three treatments, that is, instruction on one of two strategies or practice on the task only. Measures of accuracy and efficiency of learning were taken to test hypotheses concerning the effects of strategy training on learning and transfer.

METHOD

One hundred and twenty first grade children from two Lansing Public Schools, chosen because of similar middle class student populations, were given a seriation pre-test individually. Each child was asked to order a series of ten wooden 1/4" dowels, varying from 9 cm to 16.2 cm in length each differing from the next 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.

Before the task the children were shown an ordered model set of five dowels ranging from 9 cm to 15.4 cm, each differing from the next by 1.6 cm. They were told that the sticks had been put in order according to length and that "when the bottoms are even, the tops form stair steps." They were then advised that they would be asked to put a set of sticks in order according to their length in a minute. Each child was asked if he understood. Every one said he understood what to do. The model was then removed and the child was given the set of ten dowels and told to "put them in a row from longest to shortest."

When the child had finished the ordering of the sticks and if he had done so correctly, he was told that the experimenter had made a mistake and had forgotten to give him all of the sticks. The child was then given five sticks one at a time and was asked to insert the sticks into the ordered row. Each of the five sticks fit exactly into one spot in the row, with the end result of a perfect seriation and insertion being a series

A B a C D b E F c G H d I J e.

The capital letters indicate the ten original sticks and the lower case letters indicate the inserted sticks.

From this task, the children were divided into one of three categories. These are Stage I children who could not seriate or insert the dowels; Stage II children who would seriate the dowels with difficulty using a trial and error method but could not insert; and Stage III children who could both seriate and insert. A group of thirty-six Stage I and another group of thirty-six Stage III seriators were randomly selected from among the 63 Stage I and 40 Stage III children for inclusion in the study. The remaining Stage I and III seriators and all of the Stage II children were not given any further testing or training.

The Materials

Three different sets of materials were used for the training sessions. The first of these, the weights, was a set of styrofoam coffee cups filled with lead shot and paraffin. These weights differed on mass. The second set, the feelies, was a set of cylinders with different materials glued to the inside of the cylinder. Each feelie differed on the texture of this glued material. The last set, the pull toys, was a set of pipes with handles which differed on the amount of force necessary to pull the handle a specific distance. Each set of materials was thoroughly tested during a series of pilot projects with both adults and children and each was considered to represent equal and discriminable intervals between objects. A full description of the materials can be found in Appendix A.

The Treatments

The children were taught to seriate sets of eight objects using two distinct strategies or were part of a control group given only practice on the task with outcome feedback. The first strategy, 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 methoa will produce a complete 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 ordered row at all, nor does he decide where in that ordered row the next greatest element should be placed. See Appendix B for an example of this strategy.

The second strategy 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. See Appendix B for an example of the INS strategy.

The third treatment is no strategy training at all, but rather a control group which simply practices the task. This group is given the same instructions on how to observe the objects in order to find out about the variable of interest, and also feedback on mistakes made on the task. They do not receive specific training on how to perform the task, however; this was left to their own inventiveness.

The Training Sessions and Post Tests

The children were trained in three sessions separated by either two or three days of no training between sessions. During each training session each child was individually administered one of the three treatments. A different set of materials was used for each session.

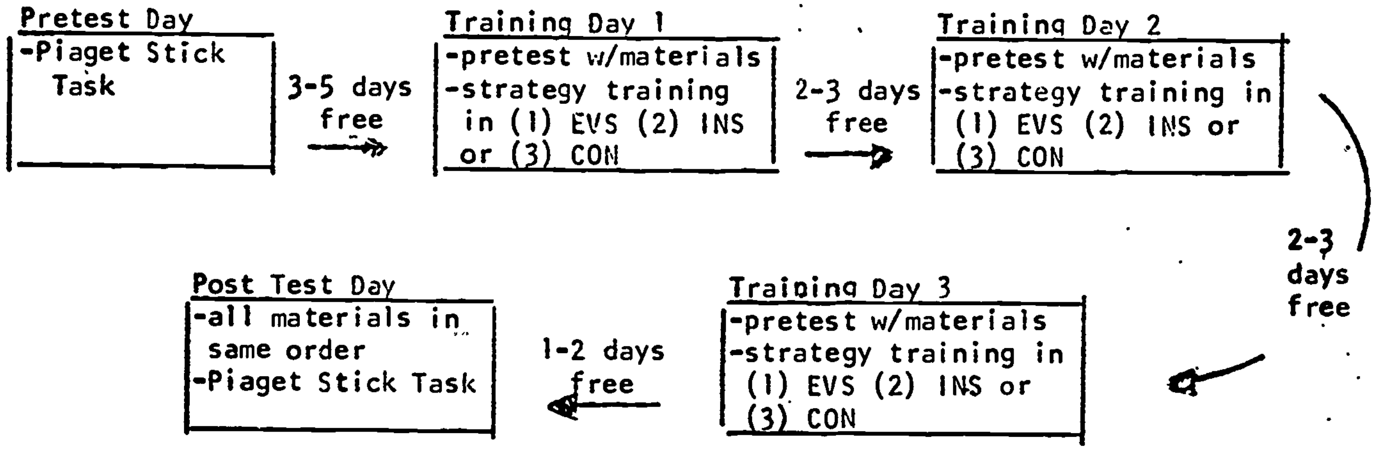
The sessions began in a similar fashion, with the experimenter explaining the task and the materials to the child by showing him a model set of five objects which had been put into the proper order before the session had begun. After the child had observed the model set and when the child said that he 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 "from roughest to smoothest" or "from 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. The experimenter recorded his performance during the pretest.

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 from roughest to smoothest" or "heaviest to lightest" or "hardest to easiest to pull." 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. 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 to reach criterion. In addition, each child was given much encouragement after each successful or unsuccessful attempt.

The Control (CON) group received no specific strategy training, just feedback and encouragement like the INS and EVS groups. 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. However, they did not receive any training on how to put the objects in order. They were given the same maximum number of trials to reach criterion (in this case, just perfect seriation) and the session ended when S reached criterion or failed to do so in five trials.

After the three training sessions were completed a series of post tests were given to each subject(s). The post tests were given two or three 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 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. Sequence and placement data were collected for each post test.

As a review of the sequence and relative amounts of time between pretests, training sessions and post tests, the following diagram is presented:



Measures

During the pretests, the trial sessions and the post tests, data was collected on the sequence of placement of the objects, as well as the final position of each object (see Smith and Padilla, 1975). Both of these sets of data were collected as a sequence of numbers.

A correctness score, called the task score (TS) was constructed by computing a Kendall's Tau correlation between the final position recorded and a perfect record. Absolute values alone were considered and the scores ranged from 0 to 1.00.

From the sequence of placement data two strategy scores called the Tau Sequence Score (TSS) and the Sequence Score (SS) were computed. The TSS measures the degree of agreement between the sequence of placement and the final position of the objects and is computed by a Kendall's Tau correlation between the two sets of data. It measures the degree to which the objects, when they were placed, were the extreme value. That is, a high TSS (TSS $>$ .90) indicates a strong tendency toward choosing the extreme value of the unplaced objects and putting it next in the row. A low TSS (TSS $<$ .40) showed that little attention was paid to choosing a maximum to place next in the row, but rather a random choice was made from the unordered objects and that object was placed where it belonged in the ordered row. Thus, for a correct seriator, a high TSS score would indicate a strong probability that the EVS strategy had been used, whereas a relatively low TSS would indicate the absence of EVS and probable presence of the INS strategy.

The SS is the proportion of sequentially placed objects and is derived from the sequence of placement data. It is a positive indicator of the EVS strategy since objects are sequentially placed in that strategy. It is also an indicator of the INS strategy since a lack of sequence indicates that objects were positioned relative to each other in the row with no regard given to picking the maximum value and placing it next in the row. The score is defined as the proportion of adjacent numbers in the sequence of placement row which are consecutive digits. Since there are n-1 or seven possible consecutive pairs, the score is computed by dividing the number of adjacent pairs by seven. A high SS (SS $>$ .70) was considered a sign of EVS use, a low SS (SS $<$ .55) considered a sign of INS use.

Both the TSS and SS were combined with the TS to form a three dimensional chart (Figure 1). Certain decision rules, were used to form groups which aided in inferring which cells indicated which strategy. The TSS was primarily used for the distinctions made among EVS, INS and unknown strategies. The SS helped to distinguish cases in which task errors and apparent strategy errors were confounded with cases of simple discrimination errors but correct strategy use.

In addition to the above measures, another score, the number of trials to criterion (TTC), was computed for each training session. Scores ranged from 0, indicating perfect seriation using the taught strategy on the pretest, to 5, indicating criterion was reached on the fifth and last attempt of the session. Several children, however, did not reach criterion and were given scores of 7 so that a definite distinction could be made between them and those who reached criterion on the fifth trial.

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

FIGURE 1
The Strategy Chart
Low and non performers were not considered as strategy users.

Design and Hypotheses

A three by two design was used. The independent variables were instructional treatment (three levels) and Stage (two levels). The dependent variables used in the analyses include the trials to criterion for each training session, the pretest task scores and the post test mean task scores.

Four major hypotheses were of interest in this study. They ranged from the learning of the strategies to post test task performance to relative transfer among strategy groups. The following is a list of those hypotheses.

1. At least 80% of each strategy/stage group subjects (i.e. EVS Stage I, EVS Stage III, INS Stage I, INS Stage 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.

2. The three treatment groups will differ on the mean post test task score 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.

3. Autotransfer effects will be greater for both the strategy groups (EVS and INS) than for the CON group. That is, the mean task scores on pretests 2 and 3 will be significantly higher for the strategy groups than for the control group. This will be measured by analysis of covariance (ANCOVA) of the task scores of pretest 2 covaried on pretest 1 and by analysis of covariance (ANCOVA) of pretest 3 covaried on pretest 1.

4. Facilitation of learning effects will be greater for both the strategy groups (EVS and INS) than for the CON group. That is the mean trials to criterion scores on trials 2 and 3 will be significantly <u>lower</u> for the strategy groups than for the control group. This will be measured by analysis of covariance (ANCOVA) on the TTC scores of trial 2 covaried on TTC scores of trial 1 and by analysis of covariance (ANCOVA) on the TTC scores of trial 3 covaried on TTC scores of trial 1.

Assignment to Groups

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. Knowledge of the stage of a child was withheld from the trainers for the duration of the study. In addition, each trainer presented the training sessions in three different material sequences. Each of the children assigned to each trainer were therefore randomly assigned to one of the three training 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 variables during the training sessions. Because of the latin square design of the sequence, each set of materials was equally balanced across 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 strategies or treatment groups, the EVS, the INS or the CON.

Effects of the variables of trainer, sequence and material were controlled by the equal balancing of these variables across treatments and stages. Since the effects of these variables, while of some peripheral interest, were not the major concern in this study they were eliminated from the design and therefore were not part of the analysis. Too, the variance due to trainer was reduced by an extended training period of more than twelve hours of individual practice over a period of one month for each trainer. Pilot work indicated that the materials were approximately equivalent in difficulty and also showed no tendency toward a difference due to sequence.

RESULTS

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 I shows the results of this analysis. At least 80% of the children in each of the four strategy/stage groups performed the post test tasks using the taught strategies with a task score greater than .70. The first hypothesis is therefore supported.

The analysis of variance on the post test task score means, covaried on pretest I showed no significant differences among treatments even though mean differences favored the EVS over the INS and the INS over the control (EVS mean = .940, INS mean = .893, CON mean = .870). However, a significant stage by strategy interaction effect was evident ($P < .084$) (See Table II). Graphing the interaction showed that the EVS treatment performed much better than the other two treatments with the Stage I children on the post tests (See Figure 2). To further test if this was, in fact, the relationship which caused the significant interaction, a one way ANCOVA on the Stage I children's post test scores covarying on pretest I was performed. As expected a main effect for treatment was significant ($P < .075$) with the EVS group mean higher than the other two treatments (See Table III) (EVS Post test mean = .929 vs INS = .830 vs CON = .803). Analysis of least squares estimates showed that the EVS was significantly different from the CON ($P < .025$). Thus the second hypothesis concerning post test task performance was not accepted as stated since no main effect across stage was significant.

STAGE/ STRATEGY GROUP	% USING EVS	% USING INS	% USING EVS OR/ INS
EVS III	88.92	8.33	97.25
EVS I	91.67	0	91.67
INS III	2.75	88.92	91.67
INS I	0	80.58	80.58

TABLE I
% of children using either the EVS or INS strategy with a TS .70 on the Post test tasks.

SOURCE OF VARIANCE	DEGREE OF FREEDOM	MEAN SQUARES	F RATIO	P
Stage	1	.0335	2.4173	.125
Strategy	2	.0295	2.218	.127
Interaction	2	.0357	2.575	.084*
Within	65	.0138		
Total	71	*=Significant		

TABLE II
3 x 2 ANCOVA TABLE
Mean Post Test Task Scores

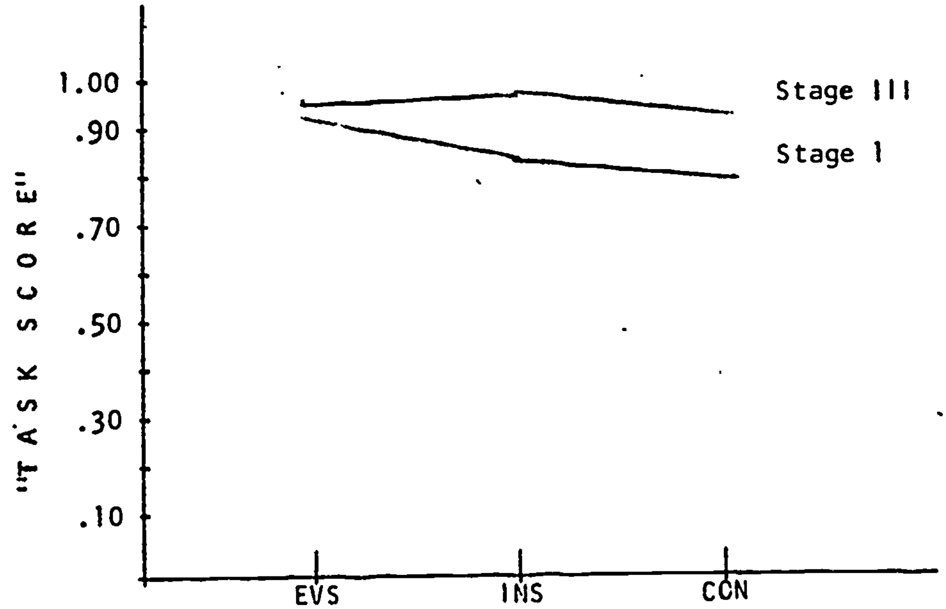


Figure 2
STAGE by Treatment Interaction

SOURCES OF VARIATION	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	P
Treatment	2	.0706	2.812	.075*
Within	32	.0251		
Total	34	*=Significant		

TABLE III

Stage I ANCOVA Table of Post Test Scores

However a modified version of that hypothesis involving only the Stage I children seemed plausible and was supported.

One further post hoc analysis relevant to this question was performed. Comparison of the percent of all post test tasks completed with a TS = 1.00 was done for all strategy/stage groups. The EVS Stage I children performed 53% of the post test tasks perfectly, compared to only 23% for the INS Stage I group and a lower 19% for the CON Stage I group. In addition, a further analysis of the mean numbers of tasks on the post tests completed with a TS > .70 shows that the EVS Stage I children not only outperformed the other Stage I groups but also had a slight advantage over all of the Stage III groups (See Table IV).

STRATEGY/ STAGE GROUP	% OF POST TEST TASKS COMPLETED WITH TS = 1.00	% OF POST TEST TASKS COMPLETED WITH TS .70
EVS III	61	89
INS III	64	89
CON III	48	78
EVS I	53	92
INS I	23	81
CON I	19	69

TABLE IV
Percent of Post Test Tasks Completed with TS = 1.00
The Total Number of Tasks = Three Per Child X Twelve Children Per Group = 36

Analysis of covariance on the pretest 2 and pretest 3 scores covaried on pretest 1 showed no significant differences in either case for treatment. Only a stage main effect ($P < .024$ for pretest 2 and $P < .025$ for pretest 3) was evident. (See Tables V and VI). Graphing of the pretest 1 to pretest 2 and pretest 1 to pretest 3 task score gains shows that all groups showed the same relative increase in scores for each case. Thus, one could say that while the autotransfer hypothesis across pretests was rejected, there seemed to be transfer from one pretest to the next for all groups regardless of treatment group.

SOURCE OF VARIANCE	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	P
Stage	1	.1775	5.33	.024*
Treatment	2	.0439	1.32	.274
Interaction	2	.0169	.51	.645
Within	65	.0323		
Total	70	*=Significant		

TABLE V

3 X 2 ANCOVA Table on Pretest 2 Task Scores

SOURCE OF VARIANCE	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	P
Stage	1	.1195	5.29	.025*
Treatment	2	.0261	1.16	.321
Interaction	2	.0130	.57	.566
Within	65	.0228		
Total	70	*=Significant		

TABLE VI

3 X 2 ANCOVA Table of Pretest 3 Task Scores

Analysis of covariance on mean trials to criterion for trials 2 covaried on trial 1 showed no significant treatment differences. The same analysis on trial 3 showed a significant difference among the treatments at $P < .075$ with the mean EVS TTC = 1.33, the mean INS TTC = 3.17, and the mean CON TTC = 2.29 on this trial. Analysis of Least Squares estimates showed that the EVS was significantly better than the CON and the CON was significantly better than the EVS (Both $P < .10$).

An alternative to the TTC was proposed. This variable called the task score to criterion (TSTC) was computed by adding up the task scores for each trial for each subject. If a child reached criterion on the third trial, then perfect scores of 1.00 were added for the fourth and fifth trials not attempted. Thus, a child's TSTC on achieved task scores of .86, .93 and 1.00 on the first three trials would be computed by adding the three scores to two 1.00 scores to total 4.79. Analysis was completed on the mean task score per attempt, which in the example would be

$$\frac{4.79}{5} = .96.$$

Analysis of covariance on this dependent variable for trials 2 and 3 covaried on trial 1, showed no significant differences for trial 2, however a main effect for treatment ($P < .013$) and a main effect for stage ($P < .034$) were obtained. (See Table VII for ANCOVA Table). Analysis of Least Square estimates was completed which showed that the EVS group was significantly different from the INS group ($P < .025$). Thus, while the simple measure of

SOURCE OF VARIANCE	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO	P
Stage 1	1	.0190	4.712	.034*
Treatment	2	.0187	4.659	.013*
Interaction	2	.0082	2.040	.138
Within	65	.0040		
Total	70	*=Significant		

TABLE VII

ANCOVA Table for TSTC 3

trials to criterion and the more sophisticated measure of TSTC showed no difference between strategy groups and control group on trial 2, both showed that the strategy groups outperformed the control group on trial 3.

These results led to a partial rejection of the facilitation of learning hypothesis (trial 2), that strategy groups will show a greater decrease in trials to criterion than the control group. But an acceptance (on trial 3) of this hypothesis based on the TTC scores and the TSTC scores.

Some further post test results deserve comment here. After the post tests on all the training materials were completed, each child was asked to order the sticks from the pretest and to insert the same five sticks if the ordering was correct. As expected all but two of the Stage III children ordered and inserted the sticks. The two not completing the task made minor errors. However, of the 36 Stage I seriators none of whom could seriate during the pretest, sixteen could now seriate the sticks correctly (See Table VIII). While leaving open the question of the role of the stage placement, these data clearly imply that work with non visual materials for seriation aids performance in the Piaget Stick Task.

STRATEGY/ STAGE GROUP	# OF CHILDREN WITH PRETEST TS = 1.00	# OF CHILDREN WITH POST TEST TS = 1.00
EVS III	12	11
INS III	12	11
CON III	12	12
EVS I	0	7
INS I	0	2
CON I	0	7

TABLE VIII

Number of Children Successfully Ordering the Sticks.

Discussion

The analyses completed for the four major hypotheses suggest several conclusions. First, strategies can be learned by young children, when the strategies are simple enough. Both the EVS and INS strategies were learned by the children in this study. Roughly nine out of ten in every strategy/stage group performed the task using the taught strategy except for the INS I group which had a ratio of eight out of ten.

But while strategies appear learnable, the ANCOVA of Post Test Scores indicate that only the Stage I children profited more from the strategy training than from practicing the task. Clearly the EVS strategy training showed itself to be superior for Stage I children. This result is even more interesting in the light of Piaget's (1969) statements that children tend to use an EVS-like strategy in their first successful seriation attempts with sticks. Perhaps strategies which build on children's natural inclinations and follow their natural development should be investigated further. Too, the INS strategy was not an easy one to master. In order to insert an object correctly, a child must keep the relationship that the object to be inserted is less in value than one object, but greater than the next. This is not an easy accomplishment and is perhaps too difficult for Stage I children.

The post hoc analysis showing the percent of post test tasks completed perfectly by each strategy/stage group sheds more light on the role of a strategy in producing a more consistently correct seriation. Compared to the CON III, a greater proportion of the EVS III and INS III children performed at a high level of accuracy (TS > .70 or TS 1.00). Possibly this indicates that strategy training for even Stage III children is advantageous, if the goal is to produce as many children as possible who make no mistakes. On the other hand, this analysis produced the same results for Stage I children as did the analysis of variance of post test scores. Namely, the EVS strategy training was superior to both INS strategy training and CON training.

Interpretation of the data concerning the two transfer questions shows mixed results. The authors predicted that autotransfer as measured by the pretests would favor the strategy groups and this hypothesis was not supported. It is possible that the extra load of applying a specific and newly learned strategy on a new set of materials proved to be a difficult task. That a group show improved correctness scores on these transfer tasks after only 2 training sessions may be asking too much. A more appropriate measure might have been a fourth variable given as the last post test task. Only the Stage I EVS group showed improvement between the pretest for training session 3 and the post tests. This suggests that an advantage for that group might have been apparent had such a fourth variable been available.

The analyses of the facilitation of learning question show transfer effects favoring strategy instruction only on trial 3. The trial 2 effects were not significant, indicating that both the strategy training groups and the control training group improved at a similar rate. But the trial 3 effects do show that the EVS training proved superior to both of the other groups in decreasing the number of attempts needed to reach criterion. Perhaps the difference in results from trial 2 to trial 3 indicates that the trial 2 training was necessary for the children to learn the EVS strategy well enough to facilitate learning.

In conclusion it seems that the notion of teaching a strategy was supported. However, this does not imply total support for teaching any strategy to any group of children. One must carefully coordinate well chosen strategies with specific groups of children. Future studies should further explore other trait treatment interactions of this type.

While several major questions were answered through this study, there seems to be several new research directions suggested by the results. Certainly further analysis of the present CON group strategy data is important. What strategies if any did the control group use? Did the control children consistently use the same strategy or did they fluctuate from one to another? Did the consistent strategy users perform more accurately (high post test TS, low TTC) than the inconsistent ones? Analysis of this data can shed some light on the tenative conclusions suggested above. In addition, new data concerning the long term retention of the strategy groups vs. the control will provide interesting results about the retention of taught strategies vs. self developed strategies. Perhaps replication of the present study with more material variables would illuminate the autotransfer question as discussed above. And lastly the post test stick task results of the Stage I seriators raises the question of stage advancement using the non visual materials. Future studies might assess the ability of Stage I children to perform other related tasks following instruction like that used in the present study.

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APPENDIX A

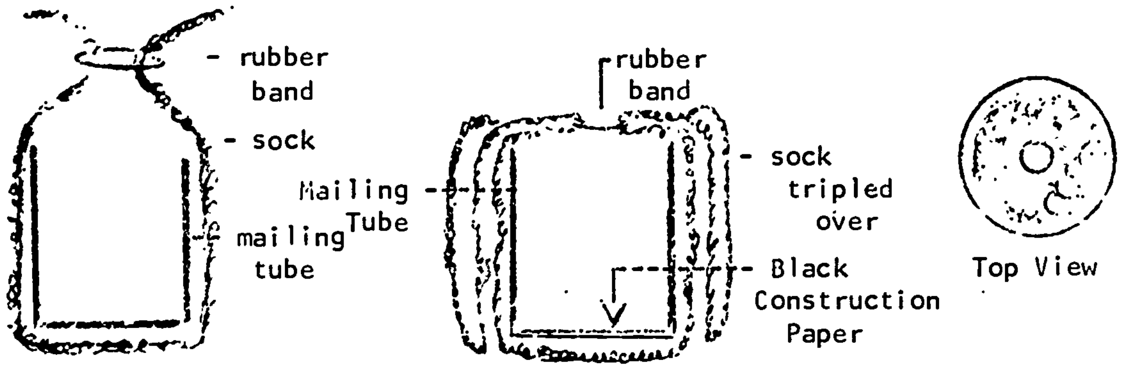
The Materials

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

Number	Mass	√mass	Number	Mass	√Mass
#1	10 gm	3	#5	529 gm	23
#2	64 gm	8	#6	784 gm	28
#3	169 gm	13	#7	1089 gm	33
#4	324 gm	18	#8	1444 gm	38

The particular values of the weights were calculated using a formula proposed by Bessemer (1973). His research showed that children from 3 to 6 years old were able to discriminate among objects whose masses differed by a degree of five on the square roots. The square root of each object listed above differs from the square root of the preceding object by five and these values were found to be discriminable by first grade children in the pilot work.

The second set of materials was a set of cylinders with different textured materials glued to the inside of each cylinder. The children ascertained the relative roughness of each cylinder by feeling the inside with their fingers. The cylinders 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 1). A rubber band was placed around the neck of the sock which was



Side View
Figure 1

Side View
Figure 2

Figure 3

Figures 1, 2, and 3

then tripled back around the tube (Figure 2). The rubber band held the sock tightly 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 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
#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 particular texture values were settled upon after pilot testing with both adults and children and represent a close representation of equal and discriminable intervals.

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 4).

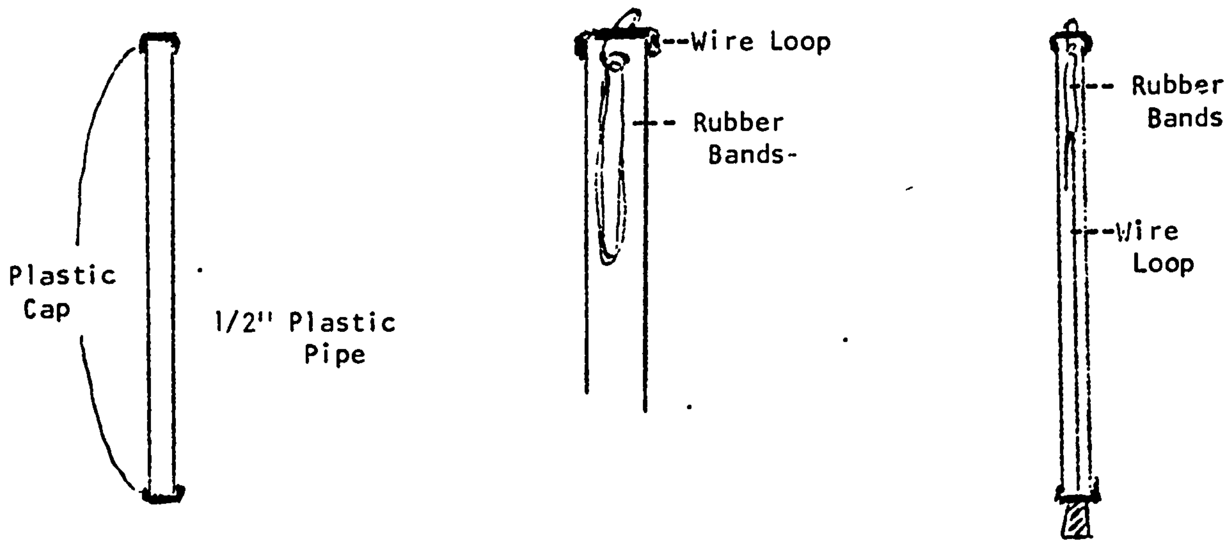


Figure 4

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 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 + or -10% was allowed due to the difficulties in standardizing a series of rubber bands, in standardizing pieces 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 chosen values were selected because each differed from the next by a factor of 1.4. That is, #2 is 1.4 times as difficult to pull as #1, and #3 is 1.4 times as difficult to pull as #2. This relationship was chosen in order to ensure equal intervals between specific pull toys and it proved to be discriminable by both adults and children. Pull toys constructed using a lesser difference were found to be indiscriminable at the lower forces; those created using a greater difference proved too difficult to pull for the higher forces.

APPENDIX B

Examples of the EVS and INS Strategies

In order to better understand the EVS strategy, an example of how a child might find and place the extreme value of a set of weights can be explained using Figure 5.

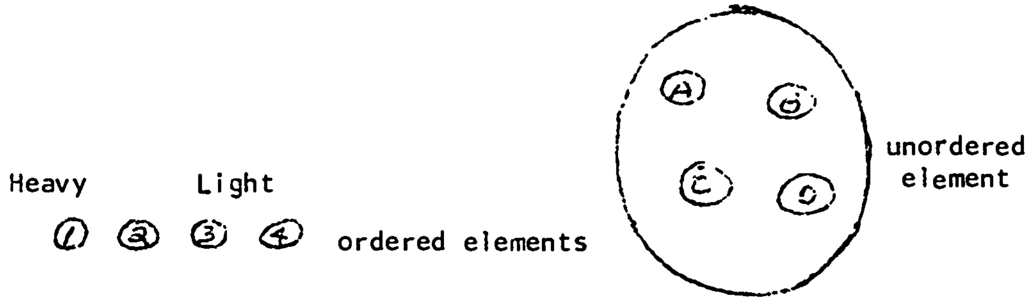


Figure 5.

In this diagram the child has already used the EVS 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. 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, and finding C 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 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 INS strategy, too, can be simply explained using a diagram. If a child has ordered five of eight weights and has three more to put in the line, then Figure 6 would show the position of all the weights.

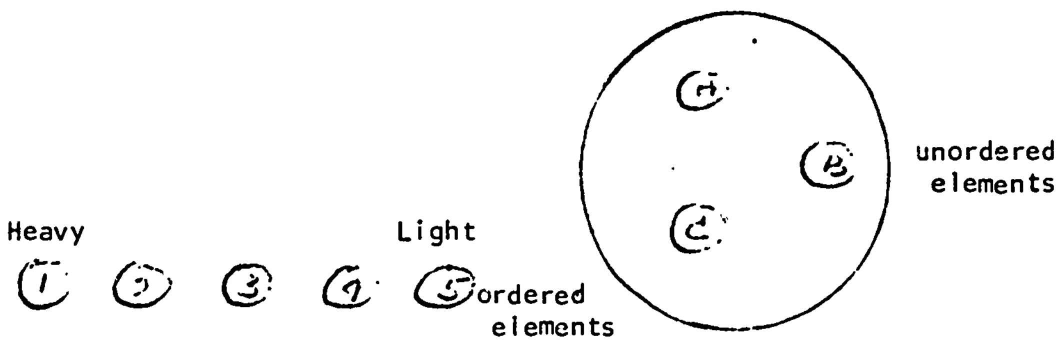


Figure 6

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 a hole or space and places c between 4 and 5 in the ordered row. Thus, are all of the placements made. If the child makes aslight miscalculation on his educated guess, he may have to compare the object to be inserted to more than 2 objects. But if he follows the strategy correctly he will always be able to place an object in its correct position.