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ABSTRACT

Reported is a test of retention related to a weight, texture, and force experiment performed by a group of 120 first grade students who had been randomly grouped into three treatment strategies. The results of the retention task, accuracy test, an analysis of the strategies used on both posttests and retention tests, and some miscellaneous post hoc analyses are reported. One strategy in which the students were directed to arrange the objects with those of most value at the end of the row until all were in order, proved to be significantly more effective in training. The method used for the study is presented as well as some of the statistical data gathered in the study. (Author/EB)

RETENTION TEST AND STRATEGY ANALYSIS OF A NONVISUAL SERIATION TASK PERFORMED BY FIRST GRADE CHILDREN

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Young children's seriation or serial ordering behavior has been studied by many because of the intimate connection of the ordering task with the development of the concept of number. In addition the logical thought operations hypothesized as underlying the correct seriator's actions have been a source of major theoretical concern. Piaget (1965) is most notable in this study and he has defined three stages in the development of a child's visual seriation ability. Stage I children cannot order a set of ten sticks by length or insert sticks into an ordered row. Stage II children can order the sticks correctly, but cannot correctly insert an additional ten sticks into an already ordered row. Stage III seriators can both order and insert correctly and are considered operational seriators.

Several researchers (Elkind, 1964; Shantz, 1967; Schafer, 1972) have undertaken the replication and expansion of Piaget's work. Most have dealt solely with research materials which have differed on visually discriminable parameters, eg. length, width, volume, color. In one digression from this pattern, Piaget himself along with Inhelder (1941) investigated children's weight seriation abilities and found this task to be much more difficult than seriation with visually discriminable materials. They quote an average age of 8 to 9 years before operational seriation appears with weight; this compares with 5 to 7 years for length. Of late other studies have employed materials differing on nonvisual parameters. Baylor and Gascon (1974) studied the strategies children used in seriating weights similar to those described by Piaget. Smith and Padilla (1975) also studied children's strategies in weight seriation and compared them to those found in length seriation, finding that weight was a significantly more difficult seriation parameter ($p < .0001$).

This author (Padilla,1975) hypothesized that at least some of this difficulty arose from the lack of a simple strategy for dealing with such relatively complex materials, i.e.,the nonvisual materials. It was found that most 6 and 7 year olds who were operational with respect to visual seriation could easily learn to order sets of objects differing solely on weight, texture and force. Additionally, many 6 and 7 year old children not operational in visual seriation could also learn to order the nonvisual objects to a very high degree of accuracy if the proper strategy was employed.

The purpose of this paper is to report further findings relevant to the weight, texture and force experiment. The results of a retention task accuracy test, an analysis of the strategies used on both post tests and retention tests as well as some miscellaneous post hoc analyses will be reported. The original post test task accuracy data had shown that teaching stage III seriators to order nonvisual materials by using the strategies of interest to be to no particular advantage. A control group given only practise with the materials did almost as well on the post test task accuracy scores. However, one strategy, the extreme value selection (EVS), proved to be significantly more effective in training the stage I seriators than the control method described above. In fact, the task accuracy scores of the EVS-trained stage I children approached that of the stage III children.

This result raised some interesting questions regarding advancement of children through seriation stages. Had the stage I EVS children been trained in a method that allowed them to more easily advance to the operational level of nonvisual seriation? Would a retention task accuracy test show a regression to past behaviours and non-operational seriation?

In addition, some interesting questions regarding retention of strategies can be asked. Will the strategies be retained? Will those who retain the use of their taught strategy perform more accurately than those who do not?, Do children who use a consistent strategy perform more accurately? What strategies will the control group form on their own? Will the results of a stick seriation task (the task used by Piaget to define stages of visual seriation development) change in any way after training with nonvisual materials?

Method

One hundred and twenty grade 1 children from two Lansing, Michigan elementary schools, all between 73 and 86 months of age ($\bar{x}$ = 82 mo.) were pretested using Piaget's stick task and separated into groups of stage I seriators (non-performers) and stage III seriators (operational performers). Twelve children from each group were randomly chosen and assigned to one of three treatments (N = 72). The children in the first treatment, called the extreme value selection (EVS), were taught to order the nonvisual objects by choosing the extreme valued object (eg. the heaviest) and placing that object to start the row. Then the next extreme object would be selected and set beside the first, and so on until all objects were placed and the row was ordered. This method followed the most commonly observed natural seriation behavior described by Baylor and Gascon (1974) and Smith and Padilla (1975). The children in the second treatment, called the insertion (INS), were taught to choose an object randomly from the unordered pile and to place it to start the row. Successive objects were also randomly chosen and placed in the ordered row relative to those already present by using a series of successive approximations. This strategy also closely followed descriptions by Baylor and Gascon as well as Smith and Padilla, but was not so commonly observed by these researchers as was the EVS. The children in the third treatment group, called the control (CON), were not taught any specific seriation strategy, but were allowed to form their own methods of ordering the objects during the training sessions.

The children were trained to criterion (perfect seriation using the taught strategy, or just perfect seriation for the CON group) in three separate training sessions with a different set of materials each time. Each session was preceded with a single attempt to order the new materials in a pretest. A maximum of five non-criterion attempts were allowed before termination in a training session. The first of the three sets of materials was a set of eight cups, each filled with a different mass of lead shot and called "weights". The second was a set of eight cups, each lined with different textured materials and called "feelies." The last was a set of eight pipes with handles which required a different amount of force to pull, called "pull toys". The objects in each material set were the same on all parameters, except the variable of interest. The variables of training material and sequence of material presentation in training session were controlled by a latin square design involving the three training sessions, the three sets of materials and three sequences of presentation. The trainers were all given the same amount of intensive preparation and were not considered to be a significant source of variation.

A post test was administered consisting of one attempt at seriating the three sets of training materials. Approximately four months later the post test was readministered as a retention post test. No cue, verbal or otherwise, regarding either strategy, was given to any subject. Scores were calculated which reflected task accuracy and certain aspects of strategy use. Decision rules developed by Smith and Padilla (1975) were applied to these scores to decide which, if any, of the designated treatment strategies was used during a given attempt.

Results

Task accuracy scores were calculated for all children's retention tasks. These means and standard deviations as well as the original post test task accuracy means and standard deviations and the difference between the post test mean scores and the retention mean scores are reported in Table 1. All the groups dropped in task accuracy from post test to retention test. But the CON I group and the EVS I group regressed to a greater degree, the CON I losing .058 and the EVS I losing .183.

Table 1 -- Means and Standard Deviations for the Post Test and Retention Task Accuracy Scores

	Post Test	Retention Test	Difference
EVS III	$\bar{X}$ = .951 S.D.= .039	$\bar{X}$ = .929 S.D.= .053	-.022
INS III	$\bar{X}$ = .955 S.D.= .061	$\bar{X}$ = .936 S.D.= .055	-.019
CON III	$\bar{X}$ = .938 S.D.= .036	$\bar{X}$ = .908 S.D.= .054	-.030
EVS I	$\bar{X}$ = .929 S.D.= .069	$\bar{X}$ = .746 S.D.= .238	-.183
INS I	$\bar{X}$ = .830 S.D.= .148	$\bar{X}$ = .808 S.D.= .177	-.028
CON I	$\bar{X}$ = .802 S.D.= .241	$\bar{X}$ = .744 S.D.= .296	-.058

An analysis of covariance (ANCOVA) was performed on the retention test task score means covarying on the pretest 1 task score which was a measure of each child's pretraining seriation ability. The independent variable of stage was held constant in this analysis so that treatment effects within each stage were available as well as an overall test of stage. Table 2 reports the ANCOVA statistics for the main effect of stage which is significant ($p<.07$).

Table 2 -- ANCOVA Statistics for the Main Effect of Stage. Retention Task Accuracy Score Mean is the Dependent Measure.

Sources of Variation	Degrees of Freedom	Mean Squares	F Ratio	P<
Stage	1	.3402	3.577	.064
Error	65	.0951		
Total	66			

Table 3 -- ANCOVA Statistics for Treatment within Stage III. Retention Task Accuracy Score Mean is the Dependent Measure.

Sources of Variation	Degrees of Freedom	Mean Squares	F Ratio	P<
Treatment	2	.0000	.0246	.976
Error	65	.0007		
Total	67			

Table 4 -- ANCOVA Statistics for Treatment within Stage I. Retention Task Accuracy Score Mean is the Dependent Measure.

Sources of Variation	Degrees of Freedom	Mean Squares	F Ratio	P<
Treatment	2	.0215	.900	.412
Error	65	.0239		
Total	67			

Thus the Stage III children performed significantly higher than the Stage I children on the retention test. This result was disappointing since no significant differences were found between the two stages on the post test.

Tables 3 and 4 report the ANCOVA statistics for treatment within each stage. As with the post test results, no significant differences were apparent for any treatment with the Stage III children on the retention test. No significant differences were found for any treatment with Stage I children as well, even though a significant difference has been reported for the post test results. Thus the observed advantage of the EVS treatment with Stage I children disappeared over the four months from post test to retention test.

Table 5 represents the percentage of the EVS and INS groups which performed the post test tasks and retention test tasks using either the EVS or INS strategy. The results show an overwhelming percentage of children in each treatment group using the taught strategy on the post tests (90% of all EVS used EVS; 84% of all INS used INS). This indicates that immediate learning and use of the taught strategy was accomplished to a high degree by children in both stages.

Table 5 — Percentage of EVS and INS Groups Using Either EVS or INS Strategies on the Post Test and Retention Test

Treatment/ Stage Group	Strategy Used	% Using a Specific Strategy on Post Test	% Using a Specific Strategy on Retention Test	% Change from Post Test to Retention Test
EVS III	EVS	89	80	-9
	INS	8	17	+9
INS III	EVS	3	14	+11
	INS	89	69	-20
EVS I	EVS	92	58	-34
	INS	0	5	+5
INS I	EVS	0	25	+25
	INS	82	39	-43

Table 6 - Percentage of CON Group Using Either EVS or INS Strategies on the Post Test and Retention Test

Treatment/ Stage Group	Strategy Used	% Using a Specific Strategy on Post Test	% Using a Specific Strategy on Retention Test	& Change from Post Test to Retention Test
CON III	EVS	55	58	+3
	INS	22	30	+8
CON I	EVS	69	50	-19
	INS	0	6	+6

The retention tests also show an advantage for the taught strategy, although a diminished one. The slight loss of 9% by the EVS III group shows a high degree of retention of the learned strategy. This coupled with a minimal loss in task accuracy (Table 1) indicates a strategy well suited for these certain children. The 20% loss shown by the INS III group seems reasonable, given the apparent difficulty of the strategy as evidenced during the training period. The Stage I results are not so encouraging. The EVS I and INS I were found to have lost considerable ground in the four month period (EVS I lost 34%; INS I lost 41%). Perhaps one should be satisfied that the Stage I children learned, much less retained, any strategy at all.

The CON groups post test and retention strategy results (Table 6) shed light on both Stage III and Stage I children's ability to self develop strategies. When allowed to form their own strategies, the Stage III children used the EVS fully two and one half times more frequently than the INS on the post test and almost twice as frequently on the retention test (Post Test 55% EVS vs. 22% INS; Retention Test 58% EVS vs. 30% INS). The Stage I children used only the EVS strategy on the post test and overwhelmingly favored the EVS on the retention test (Post Test 69% EVS vs. 0% INS; Retention Test 50% EVS vs. 6% INS). These results concur with those of Smith and Padilla (1975) and Baylor and Gasson (1974) that an EVS-like strategy is most readily developed and used by young children. An interesting note in CON strategy development is that only the Stage III children were able to develop a fairly accurate INS strategy. This makes sense when one considers the Piagetian reasoning that the insertion task is not fully understood by the Stage I children, while it is a prerequisite ability for Stage III behavior as defined by Piaget. This task is the basis of the INS strategy. Piaget does not consider this understanding, that an element can simultaneously be lesser in value than a second element and greater in value than a third element, to be teachable. Rather, a broad set of undefined experiences is the necessary prerequisite knowledge. The evidence from this study cannot dispute this argument and in fact concurs with it.

When strategy scores were initially conceived by Smith & Padilla, it was thought that a conservative estimate of strategy would be most beneficial. Thus two distinct scores which reflect the placement of the seriation objects were used in conjunction with the task accuracy score to construct the strategy score. It was thought that each placement score added a slightly different perspective and that a child could not be correctly using a strategy unless he came up to a certain level of task accuracy. While this conservative method helped in defining strategies, it hindered post hoc analysis because it assigned strategies to only reasonably correct seriators. Thus a new score, the Attempted Strategy Score, was calculated which used only the scores relating to the placement of objects. This new score allowed the assignment of an attempted strategy to each subject for each try at seriating and this score reflects the attempted seriation strategy without regard for correctness.[1]

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[1] The attempted Strategy Score employs the Sequence Score (SS) and the Sequence Score (TSS) in the following way (for a full description of the SS and TSS, see Padilla, 197[illegible] or Smith and Padilla, 1975):

a) if SS $< .55$, then the Attempted Strategy is INS
b) if SS $> .70$, then the Attempted Strategy is EVS
c) if SS $> .55$, and $< .70$, then the TSS is used to decide

1) if TSS $< .70$, then the Attempted Strategy is INS
2) if TSS $> .70$, then the Attempted Strategy is EVS

Using the Attempted Strategy Score consistent strategy users were defined as those who attempted to use the same strategy across all three post tests and all three retention tests. An inconsistent strategy user made one or more changes during these tests. When the mean task score across the post and retention tests was calculated for these two groups (Table 7), an interesting pattern came to light. Both of the EVS groups showed a slightly higher mean task score for consistent strategy users than for

Table 7 -- The Number of Consistent and Inconsistent Strategy Users and their Mean Score Across Post and Retention Tests. The Strategy Used Was the Strategy Taught.

Treatment/ Stage Group	Consistent Task Score/# of Subjects	Inconsistent Task Score/# of Subjects
EVS III	.953/8	.914/4
INS III	.933/7	.963/5
EVS I	.867/8	.778/4
INS I	.767/5	.856/7
CON III	.921/7	.925/5
CON I	.753/6	.794/6

Table 8 -- Pretest, Post test and Retention Test Stick Task Results Showing the Number of Subjects with Perfect Task Accuracy Scores (TS) and the Mean Number of Correct Insertions Out of Five.

	Pretest		Post Test		Retention Test	
	# with TS = 1.00	mean # of correct insertions Max.= 5.00	# with TS = 1.00	mean # of correct insertions Max.= 5.00	# with TS = 1.00	mean # of correct insertions Max. = 5.00
EVS III	12	4.58	11	4.82	11	5.00
INS III	12	4.58	11	4.50	11	5.00
CON III	12	4.50	12	4.33	12	4.92
EVS I	0	-	7	3,43	7	4.14
INS I	0	-	2	2.00	4	3.00
CON I	0	-	7	4.71	7	5.00

inconsistent users (+ .039 for EVS III and + .089 for EVS I). On the other hand both the INS groups showed a slight advantage for the inconsistent strategy users (-.030 for INS III and -.089 for INS I). This pattern could indicate again the greater difficulty the subjects experienced with the INS strategy and the relative ease and facility inherent in the EVS. Consistent users of a strategy that works easily could be expected to score higher than those who change strategies often. Contrariwise, users of a difficult strategy who attempt to stick to that strategy even in confusing situations may be expected to perform poorer than those who may periodically change to an easier strategy at these times.

The stick ordering task, used by Piaget to define developmental stages of visual seriation, was given to each subject as a pretest and the results were used to group children into stages. This same task was readministered during the post test and the retention test. Table 8 reviews the results of all three tests by treatment stage group. By definition all Stage III children and no Stage I children performed the pretest task correctly. Quite surprisingly 16 of the Stage I children performed the ordering of the sticks perfectly on the post test with all of these able to insert some of the sticks correctly. In three weeks of working with nonvisual materials many had jumped to Stage II and some to Stage III capabilities. Could it be that these materials had forced the subjects to view the logic of ordering in a manner which was more easily digestible to their way of thinking?

At first the treatment does not seem to be of prime importance here, but it becomes important when it is noted that all of the CON I group who correctly ordered the sticks on either test used the EVS as the predominant seriation method during the post and retention tests. And all but one used the EVS in ordering their sticks correctly. Thus it is possible that training with nonvisual materials when coupled with a strategy that easily highlights the logic of seriation may help to induce Stage III seriation behavior.

The retention test stick task results show similar figures with a slight gain in number of correct insertions by each group. A gain of two correct stick seriators in the INS I still left this group with less operational seriators of sticks. This strategy, which the Stage I children had great difficulty mastering, proved to be less beneficial to them in understanding the logic of ordering, than the EVS was to the CON and EVS groups. Perhaps this points a way toward operational seriation which uses as a teaching basis the understanding of the logic of order and not the teaching of the insertion task.

Summary

First grade children identified as either Stage I or III seriators were trained to order sets of nonvisual materials using either the EVS or INS strategies or were allowed to self develop a strategy. While post-test task accuracy results showed a significant difference favoring the EVS treatment with the Stage I seriators, this difference disappeared on a retention test given four months later. No differences were apparent for Stage III seriators on either post or retention test.

Strategy analysis of the post and retention tests showed that the taught strategy was both learned and retained by the Stage III children. The Stage I children performed the post test tasks using the taught strategy, but some (especially those taught the INS) failed to retain the taught strategy on the retention test. Analysis of the CON self developed strategies showed an overwhelming advantage for the EVS, especially among the Stage I children. These results serve to underline the difficulty of learning the INS strategy especially for Stage I children. When the task accuracy scores of consistent vs. inconsistent strategy users were compared, an interesting interaction became evident. For both stages the consistent EVS users outperformed the inconsistent users, while the opposite was true for the INS users. This leads to more speculation regarding the nature and the difficulty of the two strategies.

Results of a stick seriation task, performed at three different times during the experiment, show an EVS strategy to be quite advantageous in moving Stage I children to Stage II or III. This result concurs with the natural development of seriation as described by Piaget (1965).

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