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ABSTRACT

The purposes of this study were to: (1) determine the influence of a series of experiences involving the equivalence relation "same length as" and the asymmetric transitive relations "longer than" and "shorter than" on the ability of first and second grade children to classify and seriate objects on the basis of length; (2) investigate the influence of such experiences on the child's ability to conserve and use the transitive properties of the length relations; (3) determine if the subject's ability to use the transitive property of the equivalence relation "same length as" was related to his ability to classify on the basis of the relations; (4) investigate the relationship between the child's ability to use the transitive property of the relations "longer than" and "shorter than" and his ability to seriate on the basis of these relations; and (5) determine if the ability to seriate linear objects is material specific or relation specific. The subjects were 39 first grade and 42 second grade children. Two instructional units were written and taught to acquaint the students with relations used in the study. Tests administered were: Criterion Test, Conservation of Length Relations Test, Transitivity of Length Relations Test, Seriation Test, and Classification Test. The results clearly confirm the hypothesis that seriation ability of "linear" objects can be improved by training. (DB)

The Effects of Selected Experiences On The Classification And Seriation Abilities Of Young Children

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Present-day elementary school mathematics curricula include few activities in classification and seriation. Bruner (1963) believes such activities may be crucial to mathematics learning. He has stated that "it might be interesting to devote the first two years of school to a series of exercises in manipulating, classifying, and ordering objects in ways that highlight basic operations of logical addition, multiplication, inclusion, serial ordering and the like. For surely these logical operations are the basis of more specific operations and concepts of all mathematics ..." [p.46]

The failure of current mathematics curricula to include activities such as proposed by Bruner may be due, in part, to the almost non-existence of research showing how such activities are related or are prerequisite to the learning of specified arithmetic content. Guidelines are needed on which to base curriculum innovations. Such guidelines can be given through research that describes cognitive capabilities of elementary children, as is pointed out by Sigel and Hooper (1968).

The acts of classifying and ordering objects may be analyzed both psychologically and mathematically. Piaget (1964) has attempted to explain these acts psychologically by postulated models of cognition called "groupings". Eight major groupings are postulated, with the differences in the groupings residing in the various operations which are to be organized. Grouping I, addition of classes, and grouping V, addition of asymmetrical relations, provide models for the cognitive acts of combining individuals in classes and assemblin the asymmetrical relations which express differences in individuals, respectively. More specifically, groupings I and V provide models for classifying and seriating. A complete discussion of the groupin structures can be found in Flavell (1963).

Mathematically, the act of classifying a set of objects into disjoint subsets on the basis of some criteria involves the use of an equivalence relation. For instance, given a set A of linear objects (e.g. sticks, strings, etc.), with the instructions "put all objects having the same length together", by using the relation "same length as" (R) it can be found that for arbitrary elements a, b, and c contained in A (1) aRa (2) if aRb, then bRa and (3) if aRb and bRc, then aRc. "Same length as" satisfies the mathematical properties of reflexivity, symmetry, and transitivity and is by definition an equivalence relation; one of the many equivalence relations encountered by elementary school children.

On the other hand, linear order relations are involved in seriation. While these relations are transitive, they do not possess th mathematical properties of reflexivity and symmetry. "Longer than" and "shorter than" are both linear order relations and are commonly found in elementary mathematics.

Inhelder and Piaget (1969) were among the first to systematically investigate classificatory behavior in young children. They report behavior related to classificatory acts ranging from "graphic collections" in which the child forms spatial wholes to true classification. True classification resulted when the child was able to coordinate both the intension and extension of a class, which first appears somewhere around 8-9 years of age. Similar behavior was found in a series of studies by Lovell, Mitchell, and Everett (1962). In th aforementioned studies children were asked to group objects on the basis of shape, size or color. The fact that verbal and pictorial stimuli can also influence a child's strategy for grouping was pointe out by Olver and Hornsby (1966). While this may be the case, they also report that young children base their groupings on perceptible properties whereas older children use more functional based equivalence, regardless of type of stimuli.

Since every object is multidimensional, it seems logical that a child has a choice of criteria for classification. Maccoby and Modiano (1966) report that the criteria employed in forming classes are functions of cultural convention. It has been shown that with classification training underpriviledged children increased significantly in their variety of criteria used for classification as well as improved in their ability to group items (Olmstead, Parks, and Rickel, 1970). Other investigators (Clarke, Cooper and Loudon, 1969; Darnell and Bourne, 1970) report that conditions of training, such as making the child aware of natural relationships or orderings amon a set of stimuli attributes, may affect the way children learn equiva lence relations.

Piaget (1952) has identified three stages of behavior related to seriation. Stage one children make pairs or small groups, each ordered but incapable of being coordinated together. Stage two children complete the series after many attempts (trial and error). In stage three, the child discovers a systematic method which consists of putting down first the smallest (largest) of all the elements, the smallest (largest) of all the remaining elements, etc. The ability to correctly insert a new element into an existing series without trial and error is also characteristic of stage three behavio The findings of replication studies (Lovell, Mitchell, and Everett, 1962; Elkind, 1968) have been in agreement, for the most part, with the observations of Piaget.

Very few studies have been found in which special training was given in an attempt to facilitate seriation ability. Coxford (1964) showed that selected instructional activities improved the seriation ability of children who were in a transitional stage. Holowinsky (1970) reported success in improving the seriation ability of five- and six-year-olds with special training (procedures not specified). In general, the question of training effectiveness has not been settled.

Thus, the current literature indicates that various factors influence the ability of a child to determine criteria for classification. In general, the training research has not approached classification mathematically. Consequently, the relationship between the child's knowledge of the mathematical properties of an equivalence relation and his classification skills based on that relation has not been explicated.

The current literature also indicates that seriation ability has not in general been interpreted from the mathematics viewpoint. Specifically, does a relationship exist between the child's knowledge of the mathematical properties of an asymmetrical, transitive relation and the child's ability to seriate on the basis of that relation Furthermore, is seriation ability relational specific and/or material specific? Or conversely, since to classify and seriate involves using mathematical relations, does classification and seriation training increase an understanding of the mathematical properties of the relations, specifically, the transitive property? Does such training improve the ability to conserve these relations? According to the literature, very little has been done toward answering these questions.

The ability to correctly insert an object into an existing serie has been taken by Piaget as a necessary condition for operatory seriation. According to the literature, a child is usually required to insert an element into a series he has constructed in which the members of the series are adjacent, possibly touching, and a perceptible baseline is evident. A question arises as to whether this ability generalizes to tasks in which the members of the series are not touching and no baseline can be established? Furthermore, can we establish the relative difficulty of these tasks?

Finally, it has been shown that the ability to classify and seriate occurs naturally with age, however, it is equivocal whether training facilitates these abilities. Thus, one purpose of this study was to determine the influence of a series of experiences involving the equivalence relation "same length as" and the asymmetric transitive relations "longer than" and "shorter than" on the ability of first and second grade children to classify and seriate objects on the basis of length. A second purpose was to investigate the influence of such experiences on the child's ability to conserve and use the transitive properties of the above length relations.

Other objectives were to determine if the subject's ability to use the transitive property of the equivalence relation "same length as" was related to his ability to classify on the basis of the relation; to investigate the relationship between the child's ability to use the transitive property of the relations "longer than" and "shorter than" and his ability to seriate on the basis of these relations; and to determine if the ability to seriate linear objects is material specific or relation specific.

Method

The Subjects

Eighty-one subjects, comprised of thirty-nine first grade and forty-two second grade children were chosen for this study. Twenty-three first grade and twenty-four second grade children were from the W. H. Crogman Elementary School, while sixteen first grade and eighteen second grade children were enrolled at the Cleveland Avenue Elementary School; both schools in Atlanta, Georgia. At the beginning of this study, March 16, 1971, the mean age for first grade was 80.8 months and for second grade 91.8 months.

The W. H. Crogman Elementary School is located near downtown Atlanta in a Model Cities area. All subjects from W. H. Crogman School who participated in this study were Negro. Cleveland Avenue Elementary School is located in Southwest Atlanta and serves a predominately Caucasian, middle-class student population. Of the thirty-four children in the sample from this school, thirty-two were Caucasian and two were Negro.

Description of Instructional Units

Two instructional units were written for this study, Unit I consisted of six lessons designed to acquaint the students with the relations "same length as", "longer than" and "shorter than" and to make proper comparisons based on these relations. Unit II consisted of ten lessons designed to give experiences in classifying on the basis of the equivalence relation "same length as" and seriating on the basis of the order relations "longer than" and "shorter than". For example, lessons 1 and 3 of Unit II were primarily concerned with classifying sticks, straws, pipecleaners, and ropes on the basis of length. In lesson 2 the child was asked to determine the longest and, or the shortest object from the collection of objects given to him. The procedure followed was to make pair-wise comparisons until the longest (shortest) object was determined. In the remaining lessons, the child was asked to seriate both mixed collections (sticks, strings, straws, pipecleaners) and collections composed only of sticks using a procedure consistent with Piaget's stage three behavior. At least two lessons required that the child insert additional objects into series already formed.

Instructional Schedule and Modes of Instruction

Instruction on Unit I began at W. H. Crogman School on the morning of March 18, 1971. Similar instruction began at Cleveland Avenue School on March 19, 1971. Because of having to alternate between the schools on consecutive days, twelve days were required for the completion of Unit I. Instruction on Unit II began on April 14, 1971 with instruction being given at W. H. Crogman School in the morning and at Cleveland Avenue School in the afternoon. Ten days were required for the teaching of Unit II, ending on April 27, 1971. All instruction was carried out in groups of approximately six students in 20 minute sessions. Unit II was taught only by the investigator while teacher aides helped with the instruction of Unit 1.

Tests

Instruments were constructed to measure the subjects (Ss) knowledge of the length relations, ability to conserve and use the transitive property of the relations, ability to seriate using the order relations, and ability to classify using the equivalence relation.

Criterion Test. A nine-item test was constructed to determine if, at the end of Unit I, the subjects understood the relations and terms used in the conservation and transitivity tests to be administered as pretests. To meet criterion on this test, the child had to meet criterion on each of the three relations, which was defined as correctly performing on two of the three questions asked about each relation. For example, the child would be asked (from a pile of sticks with a standard stick placed before the pile) to "find a stick the same length as the standard stick", "find a stick longer than the standard stick", and "find a stick shorter than the standard stick". Similar instructions were given for the other six items which include both sticks and strings. All questions were asked in random order to each child.

Conservation of Length Relations Test (CLRT). This test consisted of six items; two each concerning the relations "same length as", "longer than" and "shorter than". Two perceptual situations were given for each relation; neutral and conflict. All of the materials were red and green sticks 3/8" in diameter. In the neutral situation a red and green stick would be displayed and the child was asked "Is the red stick the same length as the green stick?" or "Is the red stick longer than the green stick?" or "Is the red stick shorter than the green stick?" The question asked would depend on whatever relation did hold between the two sticks. After the child had determined which relations did hold, one stick was moved right or left so that the left end of one stick coincided with the right end of the other. Three questions were now asked in random order. "Is the red stick the same length as the green stick?", "Is the red stick longer than the green stick?", "Is the red stick shorter than the green stick?"

The conflict items were administered slightly different from the neutral items. After the child had determined the relation that existed between the red and green sticks, they were moved to form a "T" (T) and the three questions asked.

To receive a score of one on an item, the child had to answer th four questions correctly. The correct sequence of answers depended on the item being given. This test was given both as a pretest and a a posttest.

Transitivity of Length Relations Test (TLRT). This test consisted of six items; two each for the "same length as", "longer than" and "shorter than". Two perceptual situations were present; neutral and screening. All materials in this test consisted of red, blue, and green sticks all 3/8" in diameter. In each item, the child had first to determine the relation that existed between the red and blue sticks, then the blue and green sticks. To make an inference about the relation that existed between the red and green sticks the child was again asked three questions in random order as in the CLRT. On the screening items the final inference about the length of the red and green sticks had to be made with the sticks in boxes and not visible by the subjects. This test was used both as a pretest and a posttest with scoring as in the CLRT.

Seriation Test. A 12-item test was constructed designed to assess the child's ability to seriate on the basis of "longer than" and "shorter than". Items 1-6 were based on the relation "longer than"; items 7-12 were based on "shorter than". Item 1 and item 7 required the child to seriate six sticks (free seriation), all 3/8" in diameter, differing in length by 1/8" with the shortest stick being 5½" long. Item 2 and item 8 required the child to seriate six string (free seriation) of the same length as the sticks in item 1 and item 7.

For the free seriation items, a point was given for each stick o string judged to be in the "correct place" with respect to the relation given. For example, when the child had indicated that his series was formed, he was then asked to show how the objects were in order from longest to shortest (shortest to longest). Now, if, for instance, he was basing his ordering on "longer than", and he indicated that his series was formed from left to right, a point would be given for a stick b if b was shorter than the stick it immediately succeeded and at the same longer than the stick it immediately preceeded. A maximum of four points was awarded for each of the free seriation items.

Items 3, 4, 5, 9, 10, and 11 required the child to insert a stick into a series already formed. However, the sticks in the serie were glued on cardboard, spaced and staggered so that a baseline was not visible. Items 6 and 12 were also insertion items but the existing series had a visible baseline and the sticks could be moved about. One point was given for each correct answer.

Classification Test. This test consisted of 3 items; two requiring the child to group sticks on the basis of length and one in which the child had to determine the criteria used for sticks already grouped.

The materials for item 1 consisted of 12 green sticks, each of 3/8" diameter with four of length 5", four of length 5¼" and four of length 5½". One stick of each length was mounted on a piece of paper-board. The three mounted sticks were pointed out to the child who was then instructed to "find all of the sticks that would go with this stick (5"), this stick (5¼") and this stick 5½"). The nine sticks to be grouped were in disorder before the child.

The materials for item 3 consisted of ten red sticks all 3/8" diameter, three of length 4", three of length 4¼", three of length 4½" and one of length 4 3/4". The ten sticks were given to the child and he was instructed to "put all of the sticks together that belong together". A record of the child's actions was kept by the experimenter.

Item 2 required that the child determine the criteria used for grouping. The materials for this item consisted of fifteen sticks; five each at lengths 6", 6¼", and 6½". The sticks were placed into three distinct piles about 15 inches apart on a table. Within a pile, sticks differed in color and diameter; with length being constant. The child was instructed to "Tell me why I have all of these sticks together in this pile (6"), in this pile 6¼"), and in this pile (6½")? If a correct answer was given, the child was asked to justify his answer. Upon justification, he was then asked, "Why do I have these sticks in different piles?". Again a justification for a correct answer was asked for. A record of all answers was kept by the experimenter.

<u>The Experimental Design and Statistical Analysis</u>. Two treatment conditions within two grade levels within two schools produced eight comparison groups. Table 1 is a diagram of the design. S_1 and S_2 represents W. H. Crogman Elementary School and Cleveland Avenue Elementary School, respectively. The numerals 1 and 2 represent grades 1 and 2. The letters E and C represent experimental and control groups, and G_i ($i= 1, ..., 8$) represents the eight different groups.

Insert Table 1 About Here

Since the main purpose of the criterion test was to eliminate subjects who did not have a knowledge of the relations, no test of significance was performed on the criterion test data.

A 2 x 2 x 2 factorial design utilizing analysis of variance (MUGALS)[1] was used to determine the effect of the two classification and treatment variables on the seriation test. An analysis of covariance (MUGALS) was used to analyze the conservation and transitivity posttest scores using the respective pretests as covariates. An item by item analysis was performed on the classification test data using contigency tables and Chi-square tests of independence. To determine relationships between transitivity, seriation and classification, a series of contingency tables was constructed and tested with Chi-square tests of independence and contigency coefficients were computed.

Results of the Study

The analysis of covariance given in Table 2 revealed that the main effects of School and Grade were both significant on the CLRT posttest ($p < .05$). No significance was indicated due to treatment. A suggested interaction was found between School and Grade ($p < .10$) Since the CLRT pretest was a highly significant covariate ($p < .0001$), the adjusted means for school and grade are presented in Table 3.

[1]MUGALS (Modified University of Georgia Least Squares Analysis of variance) Athens, Georgia, University of Georgia Computing Center, 1966.

Insert Table 2 About Here

Insert Table 3 About Here

Table 4 shows that the main effect of School was significant ($p < .05$) on the transitivity posttest. All other main effects were nonsignificant. No significant first or second order interactions were detected.

Insert Table 4 About Here

The analysis of variance for the seriation test is reported in Table 5. Both Grade ($p < .0005$) and Treatment ($p < .001$) were significant main effects. No differences could be detected due to School. All first and second order interactions again were insignificant.

Insert Table 5 About Here

Table 6 contains test statistics for the seriation, conservation and transitivity tests. The internal consistency coefficients indicated good homogenity of the test items on all tests except TLRT pretest. Test correlations are given in Table 7. All correlations differed significantly from the zero correlation ($p < .01$) except the correlations between the seriation test and CLRT pretest and TLRT pretest.

Insert Table 6 About Here

Insert Table 7 About Here

On item 1 of the classification test a slight relationship was found between classification performance and grade level ($\chi^2 = 6.98$, $p < .10$). All Ss performed comparably across treatment conditions and schools. On item 2, less than one-fourth of the Ss discovered the criteria for grouping. A relationship was found between performance on item 2 and treatment condition only ($\chi^2 = 9.26$, $p < .10$). No relationships between school, treatment or grade and performance on item 3 were found.

Tables 8, 9 and 10 contain Ss' classification responses on items 1, 2, and 3 grouped by transitivity score. Levels of classification performance were determined for each item. For example, for item 1, four levels were identified. They were (1) S did not attempt to group the sticks; (2) S made some partial groups but did not exhaust the set of sticks to be grouped; (3) S exhausted the set but made some incorrect choices; (4) S correctly grouped all sticks. The transitivity score was a result of S_s performance on the transitivity items involving "same length as" on the transitivity posttest. Zero, one and two were assigned as transitivity scores depending upon whether S correctly answered none, one or both transitivity items. In order to increase cell frequencies, rows indicating intermediate levels of performance were combined.

Insert Table 8 About Here

Insert Table 9 About Here

Insert Table 10 About Here

The low contingency coefficients (.26, .24, .15) indicated a small degree of association between performance on the classification test and transitivity ability of "same length as".

Tables 11 and 12 indicate little relationship between seriation ability involving "longer than" and "shorter than" and transitivity ability involving these relations. The seriation score for each orde relation ranged from zero to twelve, whereas the transitivity score ranged from zero to two.

Insert Table 11 About Here

Insert Table 12 About Here

Ability to seriate sticks and strings with both the relations "longer than" ($\chi^2 = 54.54$, $p < .001$, $c = .63$) and "shorter than" ($\chi^2 = 41.03$, $p < .001$, $c = .58$) was highly related. The ability to insert a stick into an existing series with a baseline was related to inserting into a series without a baseline ($\chi^2 = 13.83$, $p < .01$, $c = .38$). However, seventy-four per cent of the Ss who correctly inserted the stick into the two non-baseline items also correctly inserted the stick into the two baseline items while only fifty-four per cent of the Ss who inserted correctly into the two baseline items could also insert correctly into the two non-baseline items.

Discussion

The results of this study clearly confirms the hypothesis that seriation ability of "linear" objects can be improved by training. The experiences provided in the study to the first grade children were sufficient to cause their mean performance (12.04) on the seriation test to be comparable to the mean performance of the second grade children who did not have such experiences (13.49).

The extent of the subjects' seriation ability, in terms of being operational in a Piagetian sense, must be questioned when one considers the overall performance on the transitivity test. The treatment appears to have had no effect on transitivity ability. According to Piaget (1966) operational seriation implies transitivity. In this study children were able to seriate sticks, strings, insert sticks correctly into existing series, both with and without a baseline and in general perform at Piaget's stage three level of seriation behavior but could not use the transitive property of the order relations involved in the seriation activity. Such responses would indicate that the seriation training was successful in training the children to use an algorithm which was not part of an operational scheme. However, the same type of performance was found in the control group, where the relationship should have been natural, according to Piaget. It is also possible that true transitivity ability was not assessed with the short transitivity test. Another possibility, although remote, was that the seriations made were based only on visual perception. In any case, the apparent lack of relationship between seriation and transitivity of "longer than" and "shorter than" was an unexpected result.

The results of the classification test indicated that it was easier for children to group sticks on the basis of self-selected criteria than to discover the criteria used for sticks already grouped. In addition, second grade children were able to form a class with one element more consistently than first grade children. This finding was consistent with Piaget's observation that the concept of a singular class appears in a child around eight or nine years of age.

Many hypotheses can be put forth in an attempt to explain the lack of relationship between classification ability and transitivity ability of "same length as". As in the case of seriation, it is possible that the two-item test did not give a true assessment of transitivity ability. Past research reveals that much controversy exists over methodological issues and the age at which children acquire the transitive property. It is further possible that transitivity was not needed to do the classification tasks. This is clear in item 1 where over half of the subjects who received a score of zero on the transitivity test performed at the highest level of classification (Table 8).

More than 95 per cent of the children who correctly seriated the strings could also seriate the sticks but only about half of the children who correctly seriated sticks could also seriate the strings. It was expected that differences in seriation would be detected when different materials were used. This trend in difficulty was true across relations. Perception was clearly a more contributing factor in the seriation of sticks than with the strings. It was also clear that a visible baseline aids in correctly inserting a stick into an existing series.

In summary, it is not at all clear what kind of experiences children should have between the ages of four and eight in order to facilitate development of logical mathematical structures needed in forming classes and in ordering objects. The present study has raised questions concerning relationships between classification, seriation, and transitivity which should be investigated further. The study should be replicated with a more consistent effort being made to determine operatory classification, seriation and transitivity ability. It would be interesting to know if the approach to seriation training used in the study was successful with other relations and other materials, and the effect it may have on the learning of related mathematics in elementary school.

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Table 1

Outline of the Design

School	Grade Level	Treatment	Crit Test	CLRT Pre	TLRT Pre	Seri Test	Class Test	CLRT Post	TLRT Post
			Tests						
S_1	1	E	G_1	G_1	G_1	G_1	G_1	G_1	G_1
		C	G_2	G_2	G_2	G_2	G_2	G_2	G_2
	2	E	G_3	G_3	G_3	G_3	G_3	G_3	G_3
		C	G_4	G_4	G_4	G_4	G_4	G_4	G_4
S_2	1	E	G_5	G_5	G_5	G_5	G_5	G_5	G_5
		C	G_6	G_6	G_6	G_6	G_6	G_6	G_6
	2	E	G_7	G_7	G_7	G_7	G_7	G_7	G_7
		C	G_8	G_8	G_8	G_8	G_8	G_8	G_8

Table 2

Analysis of Covariance for Conservation of Length Relations Test Scores (Posttest)

Source of Variation	df	MS	F
S (School)	1	14.45	6.39*
G (Grade)	1	10.68	4.72*
T (Treatment)	1	.67	<1.00
S x G	1	8.98	3.97
S x T	1	.42	<1.00
G x T	1	.34	<1.00
T x S x G	1	.98	<1.00
Cons. Pretest	1	127.22	56.27**
Error	72	2.26	

** ($p < .0001$)   * ($p < .05$)

Table 3

Interaction Table: School x Grade for
Conservation of Length Relations Posttest (N = 81)

School	Grade 1	Grade 2
Crogman	2.83	4.42
Cleveland	3.41	4.87

Table 4

Analysis of Covariance for Transitivity of Length Relations Test Scores (Posttest)

Source of Variation	df	MS	F
S (School)	1	14.96	6.31**
G (Grade)	1	2.12	<1.00
T (Treatment)	1	.59	<1.00
S x G	1	.001	<1.00
S x T	1	8.14	3.43*
G x T	1	.12	<1.00
T x S x G	1	1.40	<1.00
Transitivity Pretest	1	9.61	4.06**
Error	72	2.37	

** ($p < .05$) * ($p < .10$)

Table 5

Analysis of Variance for Seriation Test Scores

Source of Variation	df	MS	F
S (School)	1	35.66	< 1.00
G (Grade)	1	648.79	17.22**
T (Treatment)	1	452.92	12.02*
S x G	1	42.70	1.13
S x T	1	.25	< 1.00
G x T	1	.02	< 1.00
S x G x T	1	48.41	1.29
Error	73	37.68	

** ($p < .0005$) * ($p < .001$)

Table 6

Test Statistics for Seriation, Conservation and Transitivity Tests (N = 81)

Test	Number of Items	Mean	SD	Reliability
Seriation	12	12.5	7.03	.81**
CLRT (pretest)	6	2.58	1.98	.77*
CLRT (posttest)	6	3.84	1.98	.85*
TLRT (pretest)	6	2.03	1.47	.46*
TLRT (posttest)	6	2.11	1.66	.63*

** Alpha Coefficient   * KR-20

Table 7

Test Correlations

	Seriation	Con. Pre.	Con. Post	Tran. Pre.	Tran.Post
Seriation		.21	.25*	.15	.26*
Con. Pre.			.65*	.45*	.38*
Con. Post				.43*	.33*
Tran. Pre.					.31*
Tran. Post					

* ($p < .01$)

Table 8

Contingency Table: Classification Performance (Item 1) vs Transitivity Ability (same length as- Posttest)

Classification Performance	Transitivity Score 2	1	0
4	25	16	21
1-3	3	4	12

$\chi^2 = 5.73$ $p < .10$ $c = .26$

Table 9

Contingency Table: Classification Performance (Item 2) vs Transitivity Ability (same length as- Posttest)

Classification Performance	Transitivity Score		
	2	1	0
4-5	10	2	5
1-3	18	17	29

$\chi^2 = 5.72$ $p < .10$ $c = .24$

Table 10

Contingency Table: Classification Performance (Item 3) vs Transitivity Ability (same length as- Posttest)

Classification Performance	Transitivity Score		
	2	1	0
4	13	7	10
1-3	15	12	24

$\chi^2 = 1.91$ $p < .50$ $c = .15$

Table 11

Contingency Table: Seriation (longer than) vs Transitivity (longer than- Posttest)

Seriation Score	Transitivity Score		
	2	1	0
9-12	4	12	12
5-8	1	6	13
0-4	2	10	21

$\chi^2 = 3.91$ $p < .50$ $c = .21$

Table 12

Contingency Table: Seriation (shorter than) vs Transitivity (shorter than- Posttest)

Seriation Score	Transitivity Score		
	2	1	0
9-12	2	10	12
5-8	5	11	14
0-4	7	5	15

$\chi^2 = 4.96$ $p < .30$ $c = .24$