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TRAINING CHILDREN ON MULTIPLICATIVE CLASSIFICATION

by

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ABSTRACT

Twenty-one Ss received a matrix training task which made cognitive demands similar to the reclassification test task and 17 Ss received WISC Block Design training which was not cognitively related to the test task. Results supported the hypothesis that cognitively related training significantly improves reclassification performance, and that non-cognitively related training does not. Neither the Matrix training group, nor the Block Design training group generalized to a second reclassification task. The improvement of some Ss and not others is explained as the result of the variance in the competence and performance level of cognitive structures.

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INTRODUCTION

This thesis compares the effect of cognitively and non-cognitively related experience on the performance of second and third-grade-children on a reclassification task, testing the hypothesis that a 15-minute training period on a cognitively related task will improve posttest performance on a reclassification task, while training on a non-cognitively related task will not.

Background

The present research is concerned with the behavior of 7 to 9-year old children in the period of concrete operations (Piaget, 1950). During this stage Piaget (1950, p. 123) notes that "operational groupings of thought concerning objects that can be manipulated or known through the senses" develop. The child of this stage is involved in a development of cognitive structures and in a movement towards an integrated system of action, leaving the child in command of a coherent and integrated cognitive system (Flavell, 1963). An integral part of the child's cognitive development is the formation of the schema into groupings which allows the child to act upon objects according to the similarities and differences existing between them. What the child attains, then, is a certain number of logico-mathematical structures to interpret and integrate reality.

Definition of Concepts

This thesis deals with grouping III called the bi-univocal multiplication of classes, where bi-univocal means that each component in a class is multiplied by each other component of a second class.

(Flavell, 1963) "Multiplicative classification consists of classing each element simultaneously in terms of two additive classes, B1 and B2" (Piaget, 1950, p. 152) and "obtaining a combination of objects from the product of two classes B1 and B2 = B1B2 ($A_1A_2 + A_1A_2^1 + A_1^1 A_2^1$)," (Piaget, 1950, p. 45). For example, the product of two classes, circle (B_1) and blue (B_2) yields four classes: blue circle (A_1A_2), non-blue circle ($A_1^1A_2$), blue non-circle ($A_1A_2^1$), and non-blue non-circle ($A_1^1A_2^1$). A matrix design best illustrates groupings III (see Figure 1). From Figure 1 it is easy to see that the object in each cell is the result of the product of two additive classes.

One of the necessary prerequisites of multiplicative classification is the ability to group objects into classes according to a single common feature such as placing all the blue objects in one group and all the red in another. An extension of this single criterion classification is reclassification of the those same objects according to a different criterion, for example, objects sorted as blue and red things on a first occasion may be regrouped as squares and circles on a second occasion. The reclassification of objects, although not based on the product of two additive groups bears a similarity to multiplicative classification. Like multiplicative classification, reclassification is based on a similar prerequisite ability, single criterion classification, and requires Ss to see objects as members of groups for various different reasons; once a S is able to see objects as members of different groups, he can move towards classifying objects as the product of two additive classes.

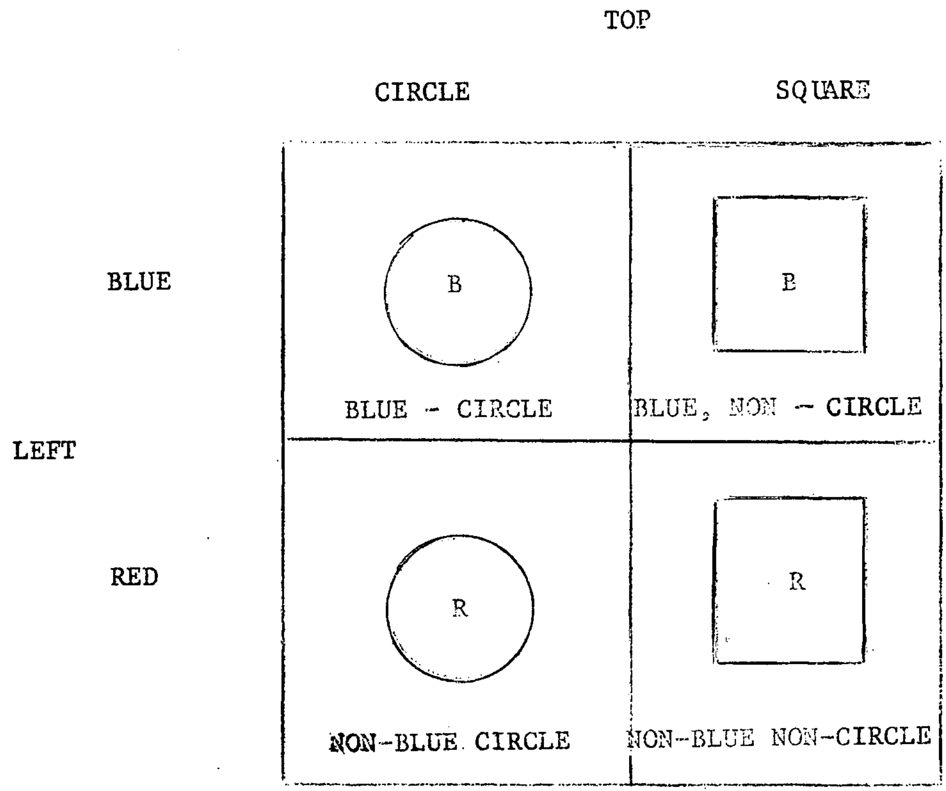


FIGURE 1

MATRIX DESIGN FOR TRAINING Ss

When two operations are directly related to a necessary prerequisite, they can be said to be cognitively related (see Figure 2). Thus, reclassification is cognitively related to multiplicative classification. As Piaget (1964, p. 209) says, "Once a child can divide the same objects according to two or three complete dichotomies, it is but a short step to being able to cross-classify them in accordance with a multiplicative schema."

Research Background

Inhelder and Piaget (1964) tested the multiplicative classification ability of children using matrices. In this study, as in many others, the S is presented a matrix as displayed in Figure 1 with one of the four cells blank, and must choose a correct solution from a number of relevant alternatives. Also, the S is required to construct a matrix from a number of objects so that the objects in adjacent cells will have one criterion common to them, distinguishing them from the other two cells. (Figure 1 shows how adjacent cells have common attributes. Each arrow indicates which cells have similar attributes.) In their research, Inhelder and Piaget discovered an increasing ability to successfully complete matrix tasks with increasing age. Interestingly, when the Ss' scores were divided into three age groups, the 4 to 5-year old Ss were more successful than the 6 to 7-year old Ss on three item matrices. (This involves three attributes on each side of the matrix making six cells.) Eight to 9-year olds completed many more matrices correctly than the 6 to 7-year olds and the 4 to 5-year olds. The better performance of 4 to 5-year olds on three item

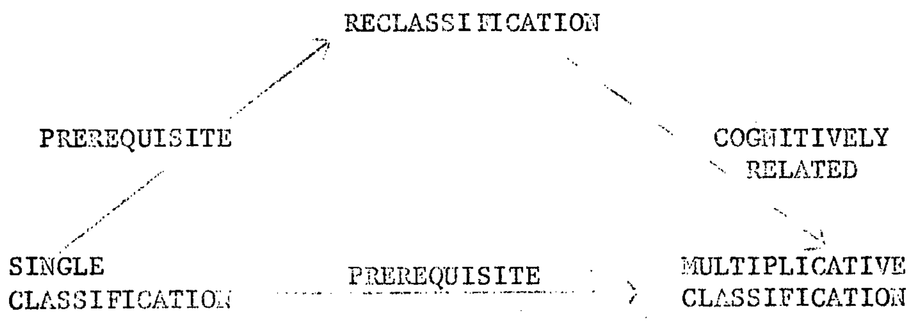


FIGURE 2

Diagram of Cognitive Relations Between Tasks matrices was explained as the result of perceptual factors which leave the matrix open to solution by means of graphic collections. The poorer completion percentage of the 6 to 7-year olds on the more difficult tests was a result of task variables interfering with the application of newly forming cognitive structures. Task variables also seem to affect the 8 to 9-year olds, who have stable cognitive structures on three item matrices, because their rate of success decreases from their two item matrix performance.

Following the extensive research of Inhelder and Piaget have been a number of studies analyzing the effect of perceptual factors in multiplicative classification. Parker, Parker and Day (1971) working with matrices found better matrix completion with increasing age -- 41% of 6-year olds, 57% of 7-year olds, 74% of 8-year olds and 79% of 9-year olds completed the matrices. They also found that performance on different types of matrix tasks, perceptual (color), functional (cutting), abstract (fruit) was related to the age of the S. "The 6-year olds performed more adequately on Perceptual x Perceptual matrices than on all other types of matrices. Eight-year olds were as successful with Functional x Functional,as with Perceptual x Perceptual matrices and 9-year olds performed equally well on all but the Abstract x Abstract matrices." (Parker, Parker and Day, 1971, p. 317). "The finding that children can combine certain atrributes and not others at particular ages fits Piaget's definition of "horizontal decalage" -- the ability to perform specific logical operations in some situations (or on some materials) before others....It is possible that some children might be able to identify common attributes and yet not be able to combine them because of less experience with categorizing on a functional and/or abstract level and therefore a failure to generalize the rule used wthh perceptual attributes to functional or abstract attributes." (p. 317) Thus, a S possessing an operative schema or a logical structure relevant to a number of attributes may not be able to apply that structure to all the relevant situations because the S lacks experience in working with certain attributes or situations and cannot apply the necessary operative schema.

Overton and Brodzinsky (1972) comparing perceptual and logical factors in multiplicative classification discovered better matrix completion performance with increased age. Reducing perceptual factors by altering a 2 x 2 matrix to form a 1 x 4 matrix significantly improved the performance of 6-year old Ss but not of 4 or 8-year olds on matrix completion. "During the transition phases (6 to 7 years) it seems that logical operational structures have developed, but their functioning can be partially masked by task variables such as the 2 x 2 perceptual instruction condition...." (Overton and Brodzinsky, 1972, p. 108.) It is hypothesized that an E can improve the reclassification ability of an S by giving that S cognitively-related training through matrix tasks. The training gives the S experience in applying his cognitive schema to many different task stimuli and so this should improve the ability of the S in applying his cognitive structure to different task stimuli. This is the major hypothesis of this thesis.

Training

According to Piaget (1964), experience is one of the four major factors which explain cognitive development from one stage to the next. Experience refers to the effects of the physical environment on an individual's cognitive structures. Piaget speaks of two kinds of experience: physical experience which "consists of acting upon objects and drawing some knowledge about the objects by abstraction from the objects," (p. 11), such as learning that knives have sharp edges; and logico-mathematical experience which is "not drawn from objects, but is drawn from the actions effected on the objects," (p. 12) such as counting a number of beads and discovering no matter what the arrangement of the beads, the number remains the same. Social transmission, another factor important to cognitive development, can only be effective once a child has developed certain prerequisite structures. Social transmission is the processing and handing down of experience through education and/or language of a society (Piaget, 1964). Experience and social transmission as factors in cognitive development are relevant to the purpose of this thesis. Through the use of education (training), E gives S logico-mathematical experience with objects to strengthen existing structures for further use. Piaget (1964) states that the learning of logico-mathematical structures is possible through training in simpler, more elementary, logico-mathematical structures. "In other words, learning is possible if you base the more complex structures on simpler structures; that is when there is a natural relationship and development of structures and not simply an external reinforcement. (Piaget, 1964, p. 17). Complex logico-mathematical structures are developed through the combination of simpler cognitive structures. As an extension of this idea, this thesis proposes increased probability of success on a task, by providing S with experience on a second task requiring similar logico-mathematical structures.

"All cognitive structures are subject to temporal effects. Any structure, whether perceptual or conceptual, tends to affect any of those that succeed it, provided there is sufficient degree of relationship between the two (e.g., analogy, nearness in time or space, etc.)". (Inhelder and Piaget, 1964, p. 197). If existent structures affect developing structures, then the application of a structure to one task should affect the future use of that structure on other tasks. A subject by using his cognitive schema to work on certain situations, will increase the probability of successfully recalling and using that schema later as a result of allowing the cognitive structure and be more easily and adequately expressed through performance.

A number of studies have been done to determine the effect of training on the performance of Ss engaged in multiplicative classification tasks -- many concerned with affecting success by training the Ss on prerequisite logico-mathematical structures. Jacobs and Vandeventer (1971) trained first graders on double classification tasks, by having the Ss identify first one, and then a second criterion and use both criteria simultaneously to arrive at a solution to either a 2 x 2 or

3 x 3 matrix. The training lasted for 30 minutes or until a certain level of performance was reached, whichever came first. The results indicated that the training group, compared to a control group involved in a game, showed more direct learning on a post-matrix task (color and form) and more transfer on a related matrix, but no difference in transfer resulted on Raven's Matrix problems which are only distantly related to the matrix test task. An extension of this experiment compared regular training (30 minutes) to extended training (1 month), finding significantly more transfer to far and moderately related tasks under the extended conditions. (Jacobs and Vandeventer, 1971). (Transfer across double-classification tasks is defined as the number of similar class categories or attributes contained in the posttest item not encountered in the training.) Transfer in the above experiments was a function of the length of the training period, which means that the degree of transfer is a function of the level of the cognitive structure with regard to both the use and state of development of that structure.

Resnick and Siegel (1971) investigating the differential effects of an optimal versus a non-optimal learning sequence, maintained that learning a harder task first (inferring the attributes of a matrix to complete the cells of a matrix) will result in almost immediate learning of an easier task (placing objects in the cells of a matrix with the attributes visible). Learning the easy task first (Optimal sequence) should mean that the harder task is learned in fewer trials than the non-optimal order (learning the harder task first). They found only an indication that learning of the harder task first resulted in quicker acquisition of the easier task and concluded that "exposure to a task does not guarantee or show a significant difference in doing an inferring task in less trials" (p. 147). They stated that the acquisition of more complex skills may be a matter of learning specific prerequisites rather than the result of entering into a general level or stage of development. Not denying the importance of learning prerequisites in the acquisition of complex structures, it should be noted that exposure alone does not guarantee improvement. It is through specific training that a S can be directed to overcome interfering task variables and attain the ability to look beyond the immediate task variables to the logico-mathematical relations existing between the stimuli.

Parker, Rieff and Sperr (1971) designed a hierarchical arrangement of multiplicative classification prerequisites as a training procedure and found an improvement in matrix performance of 6 and 7½-year olds, but not 4½ and 5½-year olds on the posttest. Training affected only the older Ss, which suggests that before training can be effective for a S, that S must have a certain basic cognitive level -- more advanced than the younger group of Ss. This suggests that only those Ss who have a necessary minimum level of competence will profit from a short-term cognitively related training session. Those Ss who improve on posttest reclassification behavior should have a higher pretest test score than those Ss who do not improve on the posttest. It is likely that the amount of training necessary to cause improvement in performance varies with the individual S -- some needing more than others -- and that the amount of training necessary is a function of the kind of training, but also the competence and performance level of the S.

An important distinction made by Flavell and Wohlwill (1969) applying to cognitive behavior, is the competence and performance distinction. "The competence model (refers to) the formal logical representation of the structure of the domain; a performance model represents the psychological processes by which the information embodied in competence actually gets assessed and utilized in real situations." (Flavell and Wohlwill, 1969, p. 71). This distinction is important to this thesis because the limited amount of training will have its specific effect on the performance variable -- the assessment and utilization of the structure in real situations. In order to cause a significant change in the competence of an individual which is reflected in performance, much more than a 15-minute training session is necessary.

Using the distinction described above, Flavell and Wohlwill constructed a general model describing conceptual development from never-in-competence to always-in-performance involving four stages. Completion of any task is considered to be a function of the product of the level of competence and the level of performance tempered by individual reactions to task variables. In the first stage, the child will always fail because competence equals zero. In the second stage, competence increases from zero to one (where one is the ideal state), but performance has a value of zero or very low, leaving the probability of task completion at a minimum. In stage three, competence is close to one and the effect of task variables begins to minimize, so that success is a function of each S's ability to look beyond the interference of task variables. In stage four, competence equals one, performance equals one and the interference of task variables is almost nil, so that the probability of success is nearly one. (Flavell and Wohlwill, 1969). Training in a multiplicative classification task should affect specifically those Ss near the end of stage 2 and into stage 3, since at these stages the interference of task variables is the primary reason for lack of success. This study intends to eliminate the effect of some task variables through horizontal training -- interrelation of cognitive structures at the same levels. "It seems likely that experience in these situations (training), where successful, operated to make functional an operation that probably was close to becoming established already, at the start, so that it required a certain amount of "priming" from the mediator utilized during the training session." (Flavell and Wohlwill, 1969, p. 108). A fifteen minute training session should prime the cognitive structure of a S so that the S may use that structure more effectively.

In this thesis Ss were divided into two groups: the cognitively-related training group and the non-cognitively related training group. All Ss were given a pre and post reclassification task and a generalization task. The Ss given cognitively related training received matrix training; the Ss given non-cognitively related training received the

WISC Block Design test. Subjects were alternatively placed in the WISC or Matrix condition and those Ss who successfully completed the pretest reclassification (obtaining a score of 5), were immediately given the generalization task, a reclassification task involving several different dimensions than any of the test or training task.

Summary of Hypotheses

1. Subjects who receive cognitively-related training should improve on a posttest reclassification task, but Ss who receive non-cognitively related training should not improve.
2. Subjects who improve under cognitively-related training will have a higher pretest score than those Ss who do not improve under the same training.
3. Subjects successfully completing the pretest should have significantly higher scores on the generalization task than the WISC or Matrix groups. The Matrix group should have higher scores on the generalization task than the WISC group.

METHOD

Subjects

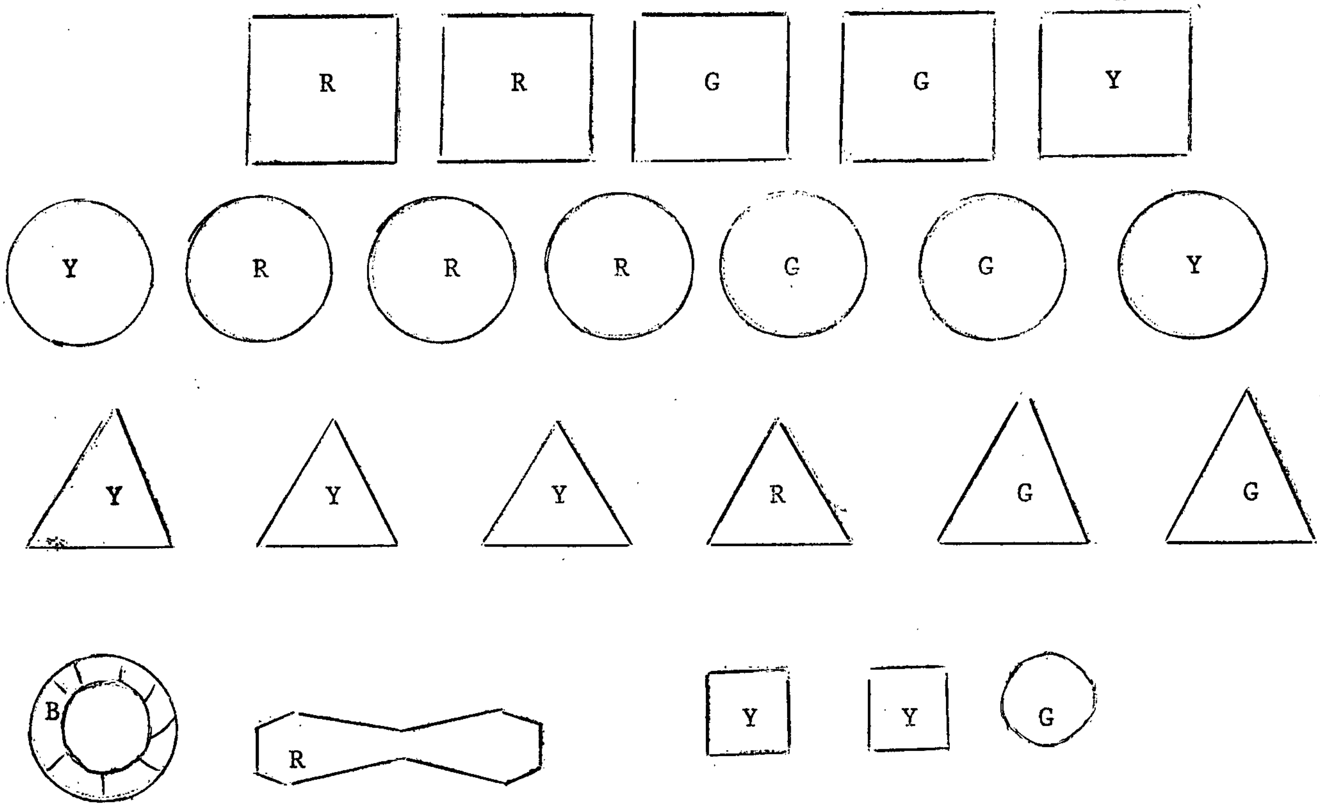
Subjects were 47 grade 2 students and 12 grade 3 students from private Catholic schools. There were 28 females and 31 males ranging in age from 75 months to 110 months with a mean age of approximately 96 months.

Test Materials

The reclassification task used for the pre and posttest consisted of two sets of nine styrofoam blocks varying according to color (red, yellow, green) and shape (square, circle, triangle). Five other blocks were also added to the original number for a total of 23 stimuli. These last five blocks consisted of a blue donut circle, a red odd-shaped form, two small squares (yellow and green) and a small yellow circle (see Figure 3).

There were seven matrix tasks used for the cognitively-related training group. The criteria on the matrices were as follows: (1) object (pens and brushes) X number; (2) object (fishes and birds) X orientation; (3) object (boys and girls) X expression (smiling and sad); (4) number (hearts) X shading; (5) object (beads and flowers) X number; (6) object (bracelets, rings, watches) X color (red and green); (7) object (checkers and sticks) X color (red and black). (See Figures 4 and 5.) The first, fifth, sixth and seventh matrices are constructed with real objects (see Figure 4) and the second, third and fourth matrices are on paper (see Figure 5).

The WISC Block Design Test (Wechsler, 1949) was used for the



R = Red
G = Green
Y = Yellow
B = Blue

FIGURE 3

Blocks for Reclassification Task (Pre and Post)

3 PENS	1 PEN
	1 BRUSH

MATRIX 1

ASSORTMENT OF PENS AND PENCILS AND BRUSHES

4 BEADS	
4 FLOWERS	2 FLOWERS

MATRIX 5

ASSORTMENT OF BEADS AND FLOWERS

RED BRACELET WATCH	GREEN BRACELET WATCH
RED BRACELET RING	

MATRIX 6

ASSORTMENT OR WATCHES, BRACELETS AND RINGS

?	?
?	?

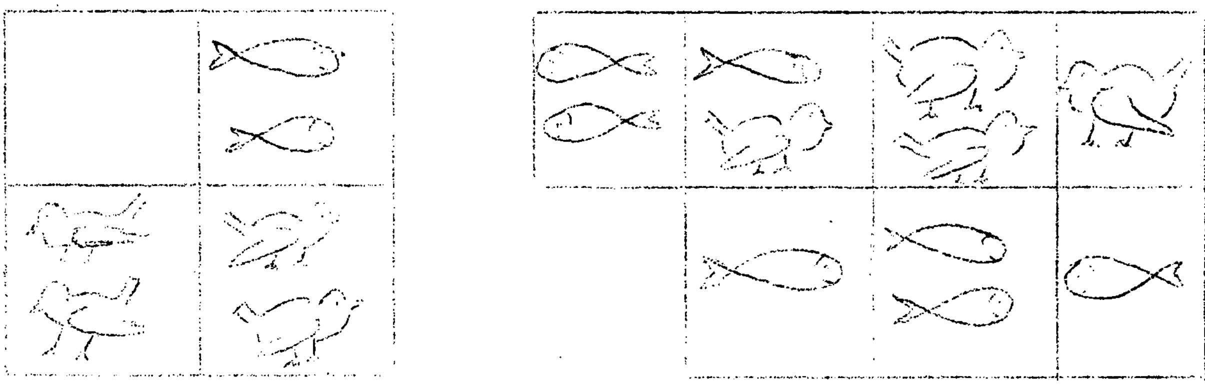
MATRIX 7

FOUR RED CHECKERS
FOUR BLACK CHECKERS
FOUR RED STICKS
FOUR BLACK STICKS

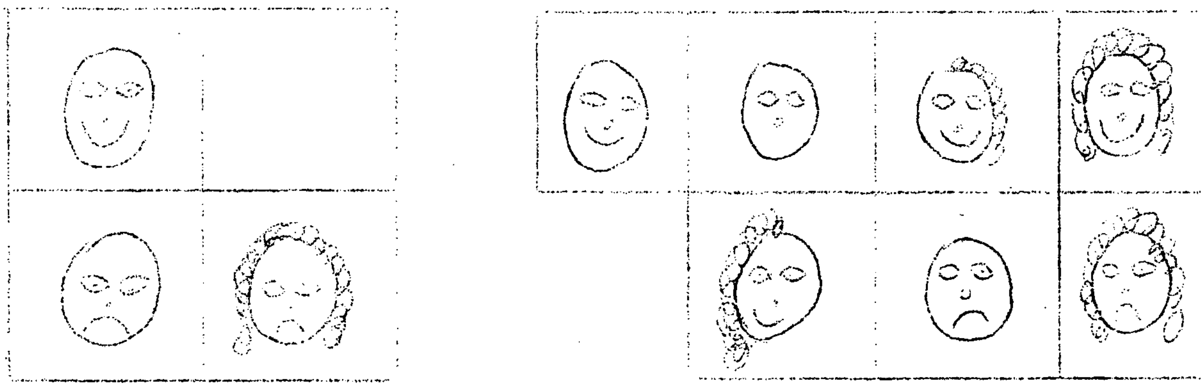
? MUST BE FILLED BY SUBJECT

FIGURE 4

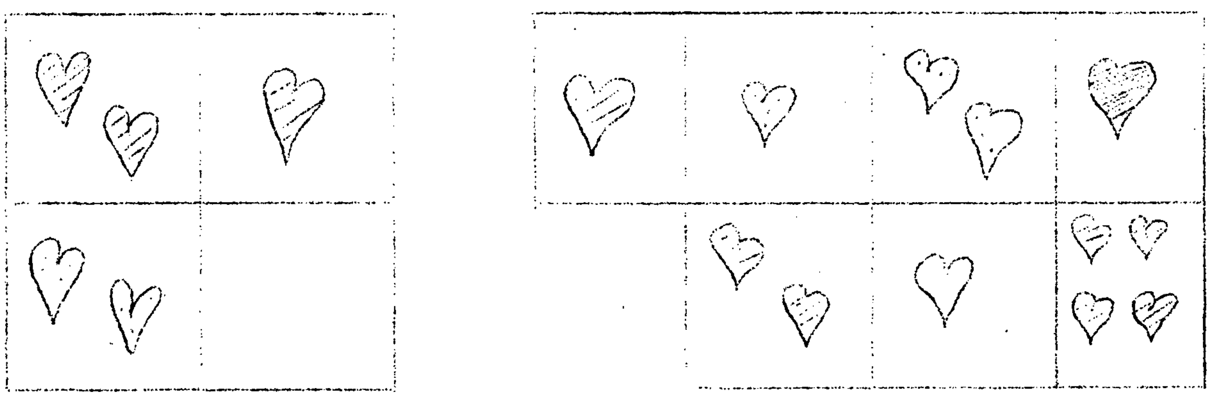
Matrices with Toys for Matrix Training



MATRIX 2



MATRIX 3



MATRIX 4

FIGURE 5

PICTURE MATRICES FOR MATRIX TRAINING

non-cognitively related training group.

The generalization task consisted of 16 cards of people classifiable according to a number of different categories: cartoon versus real, male vs. female, adult vs. child, on telephone vs. not on telephone, running vs. not running, square vs. rectangle, body vs. face, long hair vs. short hair, dressed vs. not dressed, and together vs. alone.

Procedure

All Ss were tested in a private room for a 25-minute session. Throughout all phases of the experiment Ss were seated at a desk facing the E. Successive Ss were alternately placed in either the control (WISC) or training (Matrix) group. Those who successfully completed the pretest (attaining a score of 5) formed a third group who were immediately given the generalization task. Subjects in the control condition proceeded to work on the WISC Block Design Test for 15 minutes and Ss in the training condition proceeded to work on the matrix tasks after the pretest.

For the pretest, 18 blocks (see Figure 3) were placed in a random arrangement on the desk in front of the child. The child was asked to arrange the blocks into three groups so that each block in each group would have something the same as the other blocks in that group. The experimenter clarified his meaning by arranging a random assortment of pens, pencils, and brushes into three groups, explaining that in each group (e.g., pens) all had something the same (e.g., they were all pens). Subjects were then instructed to begin. On completing the first classification and/or when the S indicated he was finished, the E rearranged the blocks and asked the S to sort the blocks into three groups again. This time the S was asked to arrange the blocks in a different way than he had done in the previous turn, remembering that the blocks in each group must have something the same as all the other blocks in the group (like the pens, pencils and brushes). After making three groups or some semblance thereof, the blocks were again mixed together and a block added. If the last classification was color, a donut circle was added before the odd-shaped form, and if the last classification was form, the odd-shaped form before the donut circle. This meant that with the addition of an extra block, the S had to change his criterion of classification. The donut circle fitted only the shape criteria and the odd-shaped form, only the color criteria. With the addition of either of the two blocks, S was asked to make three groups. Three small blocks were added for a final sorting -- either by color or shape. If S failed to correctly classify the blocks on any two consecutive attempts, the pretest was terminated.

Matrix Training

Subjects assigned to receive cognitively-related training proceeded to the matrix tasks after the pretest. The first training task was divided into three parts: (1) S filled in the fourth cell of a matrix by considering the attributes to the left of the matrix. (Figure 1 outlines attributes on both the left and top side of the matrix.) (2) S filled in the fourth cell of a matrix by considering attributes on top of the matrix. (3) S filled in the fourth cell of a matrix by considering both the attributes to the left and on top of the matrix. For this task and for the fifth and sixth matrices S was instructed to place objects selected by E in three cells of the matrix and to choose the objects for the fourth cell from a number of alternatives. For example, with the first matrix S was asked to place three pens in the bottom-left-hand cell of the matrix, one pen in the bottom-right-hand cell and, then, to choose the correct solution for the last cell from the pens and brushes beside the matrix.

For the next three matrices, S made his choice by "X-ing" one of the several alternatives. The experimenter asked the S whether two or three alternatives to the one chosen would be correct, after which E would point out the correct solution (if S had not already decided) and explained the two criteria necessary for the solution.

The subject was asked to justify his choice for the fifth and sixth matrix completion by explaining to the E which two criteria the solution had to meet. If S chose the incorrect objects or did not give the proper explanation, E pointed out the two criteria which the solution must meet.

For the seventh matrix, S was first asked to make four groups of things that go together or have something the same (four red checkers, four black checkers, four red sticks and four black sticks). These four groups were arranged on a flat piece of cardboard with four cells, so that adjacent cells had one common attribute. Once the matrix was completed, S was asked to explain the attributes common to adjacent cells. If the solution was incorrect, E solved the matrix and pointed out the common attributes. After completion of this task, Ss proceeded to the posttest administered in the same manner as the pretest.

WISC Training

Subjects assigned to this group received the WISC Block Design Test immediately after the pretest in the manner prescribed by the manual (Wechsler, 1949, p. 77). If S had finished the task before 15 minutes had elapsed, E helped S to complete one of the designs by placing one or two of the blocks in the correct perspective according to the example pictures. In this way, S was kept at his task for a full 15 minutes. After completion of this task, all Ss were given the posttest. All Ss were restricted to a 15-minute training session.

Generalization Task

For the generalization task, the 16 cards were displayed on the desk before S who was asked to make two groups of cards so that the cards in each group went together with all the other cards in that group; that is, they all had something the same. The experimenter illustrated how two groups could be formed by showing S ten white cards and making two groups, explaining that the cards in each group had something the same as the other cards in that group.

At the completion of any task, whether successful or unsuccessful, E responded with a "fine" or "okay" to equalize reinforcement across Ss.

Scoring

On the block sorting task, S was given one point for each correct classification for a maximum of five. Likewise on the matrix training tasks S received one point for each correct solution for a maximum possible of three. (Reason for a maximum possible of three will be explained in the discussion). On the generalization task one point was given for every correct classification with a possible maximum of 10.

RESULTS

Twenty-one Ss completed the initial task, 17 underwent the WISC condition and 21 Ss received matrix training. Table 1, Appendix A, and Table 2 give information on the raw data and means of the various groups for scores on the pre and post and generalization tasks.

An analysis of variance was computed on the pre and posttest scores taking into account the Condition (WISC or Matrix) and the Sex of the S. The posttest score ($\overline{X} = 2.18$) was significantly greater $F = 9.89$, $df = 1,34$, $p < 0.01$ than the pretest score ($\overline{X} = 1.72$). No other significant effects were found. The summary table for this analysis is in Table 3, Appendix A.

An examination of the data indicated more Ss improved from pre to posttest under the Matrix training than under the WISC condition ($n = 10$ and 2, respectively). A subsequent chi-squared analysis on these data was significant ($\chi^2 = 5.32$, $df = 1$, $p < 0.05$) illustrating the positive effect of matrix training.

Further observation revealed that one S in the WISC condition had increased her pretest score of one to a posttest score of four. This S's improvement may have resulted from the random arrangement of blocks on the posttest -- E noticed that one S had begun her classification on the posttest that five red blocks were beside one another (this arrangement led to a color classification by S which she had not done previously). Omitting the data of this S, an analysis of variance was again performed on the same pre and posttest scores with Condition (WISC and Matrix) and Sex as between S factors (see Table 4,

TABLE 2

MEAN SCORES FOR MATRIX, WISC AND COMPLETED GROUPS

	PRETEST	POSTTEST	GENERALIZATION TASK
WISC (17)	1.64	1.88	1.64
MATRIX (21)	1.80	2.47	1.76
(1) IMPROVED (10)	2.60	4.00	2.09
(2) NON-IMPROVED (11)	1.09	1.09	1.45
COMPLETED (21)	-	-	3.05

Appendix A). The posttest score ($\overline{X}$ = 2.09) was significantly greater ($F = 10.82$, df = 1,33, $p < 0.01$) than the pretest score ($\overline{X}$ = 1.72). The Pre-Post X Condition interaction was also significant this time ($F = 5.96$, df = 1,33, $p < 0.05$). An orthogonal polynomial analysis of the P X C interaction showed the posttest score to be significantly larger than the pretest score under the matrix training ($\overline{X}$ = 2.47, 1.80 respectively), ($F = 16.67$, $p < 0.01$), but not under the WISC condition ($\overline{X}$ = 1.71, 1.64 respectively).

An analysis of variance was done comparing Ss who improved under matrix training and Ss in the WISC condition with Pre vs. Post scores as the dependent variable. An orthogonal analysis of the significant Pre-Post X Condition interaction ($F = 12.52$, df = 1,25, $p < 0.01$) showed a significantly higher posttest than pretest score for the improved matrix Ss ($\overline{X}$ = 4.0, 2.60 respectively), ($F = 28.82$, df = 1,25, $p < 0.01$) but no difference for control Ss ($\overline{X}$ = 1.88, 1.64 respectively) (see Table 5, Appendix B).

To test the hypothesis that Ss improving with matrix training have a significantly higher pretest ($\overline{X}$ = 2.6) score, than Ss not improving ($\overline{X}$ = 1.09) a t-test was computed. The result was significant ($t = 2.36$, df = 19, $p < 0.025$) supporting the hypothesis.

An analysis of variance was also computed for Ss responses on the generalization task, taking into account the Sex and Condition of S. The completed group was significantly better than the WISC and Matrix training ($F = 10.38$, df = 2,53, $p < 0.01$) on the number of responses given. The WISC group did not differ significantly from

Matrix group (see Table 6, Appendix B). A further analysis of variance comparing WISC, improved Matrix, and non-improved Matrix _Ss_ revealed no significant difference (see Table 7, Appendix B), although the mean of the improved Matrix group is greater than the mean of both the WISC and the non-improved Matrix group ($\overline{X}$ = 2.09, 1.64, 1.45 respectively).

DISCUSSION

A review of training experiments by Flavell and Wohlwill (1969) revealed that generally one-half of the Ss benefitted or improved from training. This was the case in this experiment; matrix training improved the reclassification performance of 10 out of 21 Ss (48%). The number of Ss improving under the matrix training condition was significantly greater than under the WISC training condition and an initial analysis of variance showed a significant Pre- Posttest difference, but a non-significant Pre-Post Condition interaction. A possible explanation for this non-significant interaction was the ceiling effect of the posttest score; seven of ten Ss who improved with matrix training received a maximum of 5 on the posttest.

Subjects, trained on the matrices, who improved, had much higher pretest scores ($\overline{X} = 2.6$) than Ss who did not improve ($\overline{X} = 1.09$). This finding was as predicted, because only Ss who had a relatively stable competence structure (as indicated by their pretest score) should improve from a 15-minute training session. That is, the matrix training administered should be effective in reducing task variable interference thus improving performance, but should not be sufficient to effect a major alteration prematurely in a gradually developing competence structure.

A second possible explanation for some Ss improving on the posttest and not other Ss, was that improving Ss correctly understood the matrix tasks. If this were true, these Ss should have had significantly higher matrix completion scores. Although Ss who improved did show better matrix completion scores, the differences were not significant ($X^2 = 5.62$, df = 1, $p > 0.10$) (See Table 8, Appendix A). (Only the scores for correct responses on the last three matrices were compared because the first four matrices were meant to instruct S in what was required of him in completing a matrix.)

A third possible reason for some Ss improving under matrix training was their age. Table 9, (Appendix A) shows Ss divided into two groups according to age, and illustrates that the older group was only slightly more successful than the younger group on the matrix tasks, suggesting that age was an unimportant factor in determining which Ss improved.

The pretest scores of Ss who improved indicated that the level of a S's logico-mathematical structure rather than his age or his understanding of the matrix task requirements determined improvement. Those Ss who had a more developed competence structure were those who improved.

Matrix training did not significantly affect the performance of Ss on the Generalization task. The mean of improved matrix Ss was higher, but not significantly so than that of WISC trained or non-improved matrix trained Ss. The lack of generalization may be a result of the limited amount of training received by each S. Jacobs and Vandeventer (1971) discovered extended training (1 month) was much more effective in showing transference than a regular 30-minute training session.

That the generalization task is related to the pre and post reclassification task can be seen from the scores of the Ss who successfully completed the pretest. These Ss scored significantly higher than either Matrix or WISC trained Ss on the generalization task. These Ss have a competence structure close to one (on a scale from zero to one) with a performance value approaching one (Flavell and Wohlwill, 1969) so that the probability of completing a task is close to one. Thus the training time was too short to effectively remove the task variable interference of the generalization task. Perhaps the materials (magazine clippings on cards) used for the Generalization task may have been sufficiently different from the other tasks to confuse Ss. These materials probably present more task interference than the posttest so that the S could not overcome them as he did in the posttest. Also, the Generalization task was classifiable according to ten criteria; this great variety of possibilities may be a critical task interference factor.

Future Research

The present study suggests the possibility for further research in the area of training on multiplicative classification. A comparison should be made of a pre- and post-matrix task with reclassification training and a pre- and post-reclassification task with matrix training. This would show if the training procedures have reciprocal effects, that is, if matrix training causes an equal amount of improvement on reclassification tasks as reclassification training does on matrix tasks. This would help to clarify the nature of the relationship between the reclassification task and the matrix task. The results should be reciprocal since the tasks are closely related. Reclassification requires the S to classify a group of objects according to one criterion remembering but ignoring a previous criterion, and multiplicative classification requires the S to classify objects according to two criteria simultaneously. In each case S must be aware of the fact that objects can be grouped according to two different criteria.

A study should be conducted in which the ceiling effect was eliminated on the posttest reclassification task. Matrix trained Ss may attain a higher posttest score than five (the maximum possible in this study) if given a wider range of reclassification possibilities thus tapping the full effect of training.

Further, it is suggested that a similar study be done using three types of generalization tasks. One with dimensions closely related to those of the reclassification task, a second with one dimension related to the reclassification task, and a third with dimensions not similar to the reclassification task. Two groups of Ss should be tested one receiving 15-minute training and the other receiving 30-minute training. Thus the effect of the amount of training on a short-term basis could be analyzed as a function of the posttest performance and the amount and kind of transfer.

The effect of reclassification possibilities within one group of objects should be analyzed for possible task variable interference in the generalization task. A design requiring one group of Ss to classify each of five groups of objects two ways and another group of Ss to classify one set of objects ten ways. This could validate the possibility of a large amount of task variable interference in the generalization task used in the present investigation.

A suggestion arising from this thesis is that the cognitive level of S can be determined not only by his pretest score but also by the amount of training necessary to cause a determined increment in the posttest scores. An experiment could be designed in which E repeats a 15-minute training session until S reaches a specified posttest criterion level. This would give E an indication of the cognitive structure of S prior to training; the more training required to reach criterion, the less functional the cognitive level of S. Although in training S, E may alter the cognitive structure as well as removing the task variable interference, the performance of the S will give a general indication of his level of cognitive development.

SUMMARY

It was expected that Ss who received cognitively related training would improve on a posttest reclassification task, but Ss receiving non-cognitively related training would not improve. This hypothesis was not confirmed by an initial analysis of variance using pre- vs. posttest scores as the dependent variables. But a significantly larger number of Ss showed higher posttest scores under Matrix training than under WISC training. When the data of one improving S in the WISC condition were removed, an analysis of the Pre- vs. Posttest scores resulted in a significant Pre vs. Post x Condition

interaction in the predicted direction.

Subjects who improved under cognitively related training were predicted to have a higher pretest score than those Ss who did not improve under the same training. This hypothesis was confirmed with significantly higher pretest scores for improved vs. non-improved matrix Ss.

It was also expected that Ss successfully completing the pretest would have a significantly higher score on the Generalization task than the WISC or Matrix group, and the Matrix group would have higher scores on the Generalization task than the WISC group. This hypothesis was partially confirmed in that the Completed group had a significantly higher score than either the Matrix or WISC groups on the Generalization task, but the Matrix group did not have a significantly higher score than the WISC group.

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APPENDIX A

Table

TABLE 1

RAW SCORES ON PRETEST, POSTTEST, AND GENERALIZATION

			PRE	POST	GEN.
WISC	MALE	S1	0	0	1
		S2	0	1	1
		S4	3	3	4
		S11	4	4	3
		S12	4	4	3
		S13	1	1	2
		S16	0	0	0
	FEMALE	S3	4	4	3
		S5	4	4	3
		S6	1	1	0
		S7	1	1	2
		S8	1	1	1
		S9	1	1	0
		S10	1	1	0
		S14	1	1	2
		S15	1	4	3
		S17	1	1	0
MATRIX	MALE	S20	1	1	1
		S21	1	1	2
		S22	1	1	2
		S24	1	1	0
		S26	1	1	1
		S27	1	1	4
		S28	1	1	2
		S29	1	3	3
		S32	0	1	1
		S33	4	5	1
		S34	4	5	1
	FEMALE	S18	0	0	0
		S19	3	3	1
		S23	1	1	1
		S25	1	1	0
		S30	4	5	2
		S31	4	5	2
		S35	4	5	4
		S36	1	5	5
		S37	4	5	2
		S38	0	1	2

TABLE 1 (continued)

		PRE	POST	GEN.
COMPLETED	MALE			
	S41	-	-	3
	S42	-	-	1
	S45	-	-	4
	S46	-	-	4
	S48	-	-	2
	S49	-	-	4
	S50	-	-	1
	S52	-	-	5
	S54	-	-	3
	S55	-	-	4
	S56	-	-	2
	S58	-	-	4
	S59	-	-	2
	FEMALE			
	S39	-	-	4
	S40	-	-	2
	S43	-	-	1
	S44	-	-	3
	S47	-	-	6
	S51	-	-	4
	S53	-	-	4
	S57	-	-	1

TABLE 8

NUMBER OF Ss CORRECTLY RESPONDING ON MATRIX TASKS

GROUP (Ss)	MATRIX 5	MATRIX 6	MATRIX 7	TWO OR THREE MATRICES CORRECT	
TRAINING NON-IMPROVEMENT (11)	5	6	3	4	18
TRAINING IMPROVEMENT (10)	8	7	9	9	33

$\chi^2 = 5.62$, df = 3, $p > 0.10$

TABLE 9

MATRIX TRAINING GROUP ANALYZED BY AGE

GROUPS (Ss)	% IMPROVING	% CORRECT ON MATRIX	MEAN RESPONSE ON G.T.	MEAN POSTTEST SCORE
AGE 78-92 (10)	40%	53%	1.30	2.50
AGE 93-114 (11)	54%	66.66	2.18	2.46

APPENDIX B

ANOVA TABLES

Table

TABLE 3

ANALYSIS OF VARIANCE FOR WISC AND MATRIX Ss FOR PRE AND POST, SEX AND CONDITION

SOURCE	df	MS	F
CONDITION (C)	1	2.68	0.68
SEX (A)	1	4.32	1.10
A X C	1	5.51	1.40
Ss/A X C	34	172.44	
PRE-POST (P)	1	4.26	10.92*
P X C	1	0.87	2.23
P X A	1	0.34	0.87
P X A X C	1	0.24	0.61
P X Ss/A X C	34	13.29	

MSe BETWEEN = 3.91
MSe WITHIN = 0.39

* $p < 0.01$

TABLE 4

ANALYSIS OF VARIANCE FOR WISC AND MATRIX Ss[1]
FOR PRE AND POST, SEX AND CONDITION

SOURCE	df	MS	F
CONDITION (C)	1	3.26	0.62
SEX (A)	1	3.93	0.76
A X C	1	6.00	1.16
Ss/A X C	33	171.19	
PRE-POST (P)	1	3.03	10.82**
P X C	1	1.67	5.96*
P X A	1	0.10	0.35
P X A X C	1	0.46	1.64
P X Ss/A X C	33	9.24	

MSe BETWEEN = 5.18
MSe WITHIN = 0.28

* p 0.05
** p 0.01

[1] Data of one S has been removed from the WISC condition. For reasons see results section.

TABLE 5

ANALYSIS OF VARIANCE FOR WISC vs. IMPROVED MATRIX
FOR PRE AND POST SCORES

SOURCE	df	MS	F
CONDITION (C)	1	29.68	6.11*
Ss/C	25	121.32	
PRE-POST (P)	1	6.00	17.64**
P X C	1	4.26	12.52**
P X *Ss*/C	25	8.74	

MSe BETWEEN = 4.85
MSe WITHIN = 0.34

* *p* 0.05
** *p* 0.01

TABLE 6

ANALYSIS OF VARIANCE FOR WISC, MATRIX AND COMPLETED GROUPS ON GENERALIZATION TASK

SOURCE	df	MS	F
CONDITION (C)	2	19.41	3.75*
SEX (A)	1	0.22	0.08
C X A	2	2.25	0.43
Ss/C X A	53	137.04	

MSe = 2.58

* $p < 0.05$

TABLE 7

ANALYSIS OF VARIANCE FOR WISC IMPROVED AND NON-IMPROVED ON GENERALIZATION TASKS

SOURCE	df	MS	F
CONDITION (C')	2	5.64	1.49
Ss/C'	35	66.18	

MSe = 2.32