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ABSTRACT

The present study was undertaken to assess whether training that was known to produce transfer within the Cognition of Figural Relations (CFR) domain of Guilford's Structure-of-Intellect model would also produce transfer to other operations in Guilford's model. Fifty subjects, matched for pretest score on a double classification task, were randomly assigned to either training or control (no training) groups. Within the training group, subjects matched for pretest score were assigned at random to either of two trainers. Training was given both on CFR and NFR (Convergent Production of Figural Relations). Posttests were administered covering CFR, NFR, DFR (Divergent Production of Figural Relations) and ERF (Evaluation of Figural Relations). Training subjects significantly outperformed control subjects in CFR with both taught and untaught logical relations. The two trainers differed in effectiveness. For the better trainer, transfer was obtained within NFR and to EFR, but not to DFR or to Raven's Coloured Progressive Matrices as a measure of CFR. Transfer effects held up three months later. (Author/CK)

RESEARCH BULLETIN

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TRANSFER OF TRAINING IN DOUBLE CLASSIFICATION SKILLS ACROSS OPERATIONS OF GUILFORD'S STRUCTURE-OF-INTELLECT MODEL

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Abstract

The present study was undertaken to assess whether training that was known to produce transfer within the Cognition of Figural Relations (CFR) domain of Guilford's Structure-of-Intellect model would also produce transfer to other operations in Guilford's model. Fifty subjects, matched for pretest score on a double classification task, were randomly assigned to either training (with shape, color, shading and addition the logical relations to be learned) or control (no training) groups. Within the training group, subjects matched for pretest score were assigned at random to either of two trainers. Training was given both on CFR and NFR (Convergent Production of Figural Relations). Posttests were administered covering CFR, NFR, DFR (Divergent Production of Figural Relations) and EFR (Evaluation of Figural Relations).

As in previous studies, training subjects significantly outperformed control subjects in CFR with both taught and untaught logical relations. The two trainers differed in effectiveness. For the better trainer, transfer was obtained within NFR and to EFR, but not to DFR or to Raven's Coloured Progressive Matrices as a measure of CFR. Transfer effects held up three months later.

TRANSFER OF TRAINING IN DOUBLE CLASSIFICATION SKILLS ACROSS OPERATIONS OF GUILFORD'S STRUCTURE-OF-INTELLECT MODEL[1]

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Previous work (Jacobs & Vandeventer, 1971a,b) has shown that first graders could learn double classification skills within an hour's individualized training and retain these skills over several months. The training involved two operations in Guilford's (1967) Structure-of-Intellect model of intelligence: (1) the subject had to fill the empty cell of a 3 x 3 matrix by choosing from among several pieces that piece which would correctly complete a pattern of logical relationships (<u>Cognition of Figural Relations</u>, or <u>CFR</u>); (2) the subject had to arrange nine pieces into a blank 3 x 3 matrix so as to form a pattern (<u>Convergent Production of Figural Relations</u>, or <u>NFR</u>). Transfer was found within the <u>CFR</u> domain to logical relationships not previously taught. Transfer was not, however, found within the <u>NFR</u> domain to two tasks: (1) the subject had to arrange the four missing pieces on a 3 x 3 matrix to correctly complete a pattern involving previously taught relationships, and (2) the subject had to arrange all nine pieces on a blank 3 x 3 matrix to correctly complete a pattern involving relationships <u>not</u> previously taught. The latter task was easier for both trained and control groups than the former, suggesting that a task requiring the arrangement of all nine pieces according to previously taught logical relationships would be easier still. On such a task we might detect the existence of, but not the maximal extent of, transfer within NFR. The present study was therefore undertaken to see if the training procedure, known to produce transfer within the CFR domain, would also produce transfer within NFR and to DFR (Divergent Production of Figural Relations) and EFR (Evaluation of Figural Relations), when simple and appropriate measures of these abilities were utilized.

Guilford has not as yet applied factor analysis to identify tests that measure these hypothesized abilities. Tests were thus developed by the authors expressly for this study through intuitive extensions of tests already identified as measuring particular factors. This is in accord with Carroll's (1968) contention that "In placing factors in the SI (Structure-of-Intellect) model, the investigator must rely entirely upon his intuition as to what is measured by the tests that define a factor [p. 252]."

CFR has been identified by Guilford as measu[illegible] tas[illegible] in which the examinee must "from multiple choices, select a figure to fill a matrix cell, in a 3 x 3 matrix with a different relation in columns and rows [Guilford & Hoepfner, 1966, p. 6]."

Convergent Production has been defined as "Generation of information from given information, where the emphasis is upon achieving unique or conventionally accepted best outcomes [Guilford & Hoepfner, 1966, p. 3]." A test to measure NFR asked the examinee to place nine separate pieces upon an empty 3 x 3 matrix grid in a way that "made a pattern."

Divergent Production is defined as "Generation of information from given information, where the emphasis is upon variety and quality of output from the same source [Guilford & Hoepfner, 1966, p. 3]." A test to measure _DFR_ asked the examinee to select nine of 27 pieces, place them upon an empty 3 x 3 matrix grid to form a pattern, then again to select nine pieces to form another pattern, etc.

Evaluation is defined as "Reaching decisions or making judgments concerning criterion satisfaction (correctness, suitability, adequacy, desirability, etc.) of information [Guilford & Hoepfner, 1966, p. 3]." A test to measure _EFR_ asked to examine whether a 3 x 3 matrix, formerly incomplete, had been correctly completed.

Method

Subjects were the 30 boys and 24 girls comprising the first grade of a New Jersey elementary school.

A pretest covered only _CFR_, while posttests covered _CFR_, _NFR_, _DFR_, and _EFR_.

There were three measures of _CFR_: (1) _Coloured Progressive Matrices_, or CPM (Raven, 1963), (2) a 60-item test that more systematically covered the possible pairings of 11 different logical relations in double classification format, and (3) a 20-item test that covered five different relations. Each item of each test required the subject to select one of several alternatives (of six, in the case of _Coloured Progressive Matrices_, four in the other cases) that would correctly fill an empty cell in the lower right-hand corner of a matrix. The latter two tests are fully described elsewhere (Jacobs & Vandeventer, 1971b). The 20-item test served as a pretest, and the 60-item test and CPM as posttests. For each of the three tests a number-right score was computed.

To measure NFR, the subject was presented with a nine-inch square cardboard marked off to form a 3 x 3 empty matrix, and a set of 2" x 2" cards, each containing an easily nameable shape in a solid color. In each Task A and B there were nine cards that could be used to form a 3 x 3 matrix based upon color and shape relations. In each Task C and D there were an additional three cards that duplicated three of the nine. The cards were as follows:

Task A--colors: red, orange, dark blue; shapes: bird, pear, wagon.

Task B--colors: red, light blue, dark blue; shapes: triangle, square, umbrella.

Task C--colors: dark blue, green, orange; shapes: duck, mitten, tree; plus duplicate duck of each color.

Task D--colors: brown, orange, red; shapes: dog, man, triangle; plus duplicate red of each shape.

For a given task, all the cards were simultaneously displayed in a cardboard holder. The subject was told to place the small cards on the big card, one in each box, to make a pattern.

On NFR Tasks A and B the subject received one point for each relation, color, and shape, with respect to which the cards were systematically varied, either by having the color (shape) remain the same from row to row but different from column to column (or vice versa), or by having the same color (shape) appear only once in each row and column. Thus the arrangement

red wagon	red bird	red pear
orange wagon	orange bird	orange pear
blue wagon	blue bird	blue pear

would receive two points, one for color and one for shape, while the arrangement

red wagon	red bird	red pear
blue wagon	blue pear	blue bird
orange bird	orange pear	orange wagon

would receive

one point for color, and the arrangement

red wagon	blue bird	red pear
blue pear	blue wagon	orange bird
red bird	orange pear	orange wagon

would receive

one point for shape. On Tasks C and D it was also acceptable for the subject to use the duplicate pieces in a systematic way; that is, he would receive one point for color for the arrangement

red dog	red man	red triangle
red dog	red triangle	red man
blue dog	blue triangle	blue man

.

The test to measure DFR was similar to the NFR test, but involved a set of 27 2" x 2" cards, containing all possible combinations of one, two, or three blue, green, or purple arcs, circles, or triangles. The subject was shown all 27 cards simultaneously in a cardboard holder and asked to select those that, when placed one in a box on the big card, made a pattern. After he made his selection and placement, the cards were returned to the holder, and he was asked to "do it again in a different way." This was repeated until four placements of the cards were made.

For most subjects, only one set of cards was used. For the first 16 subjects, a second set of cards with different shapes and colors was also used, as a second divergent production task. Because the divergent production task was time-consuming and scores from the first task correlated for these 16 subjects .87 with score on the second task, the second task was discontinued.

Scoring for the DFR task resembled that for NFR, with these exceptions:

Subjects could receive up to three points on each of the four placements of the pieces, since three relations, shape, color, and number, were involved. Thus the arrangement

two blue arcs	two green circles	two purple triangles
two blue triangles	two green arcs	two purple circles
two blue circles	two green triangles	two purple arcs

would get three points: for shape, color and number. Note that "systematic variation" of a relation could be accomplished by keeping the same value for each element in the matrix (e.g., number, in the example above).

Each arrangement had to be different from each other arrangement of the pieces, where a minimal difference was selecting the same nine of the 27 pieces, but interchanging two columns or rows.

Each item of the EFR test consisted of a complete matrix that the subject had to call "right" or "wrong." The subject was told that another child had pasted in the piece in the lower right-hand corner and was asked if the right or wrong piece had been pasted in. The first two were practice items which did not count in the score. The first practice item was a color (red, blue, green) by shape (dog, duck, wagon) matrix with a purple triangle in the lower right-hand cell. The experimenter pointed to the triangle, said another child had pasted it in, and asked the subject if the right piece had been pasted in. The second practice item was a correctly completed color by shape matrix. On the few occasions when the subject missed a practice item, the experimenter repeated the point that another child had completed the matrix and that the subject had to say whether it was "right" or "wrong."

The 18 actual test items were as follows: #1-8--3 x 3, color by shape; #9-10--3 x 3 shading by shape; #11-12--2 x 2, size by flipover; #13--3 x 3 elements of a set (shape) by shading; #14--3 x 3 shading by shape; #15-16--2 x 2 added element by flipover; #17--3 x 3 size and addition; #18--3 x 3 shape and addition. These logical relations are more fully described by Jacobs and Vandeventer (in press). Half the items were correctly completed; the other half were completed by making the lower right-hand element a repetition of the element to its left. Score was the number correctly judged right or wrong.

Procedure. All subjects were individually administered the pretest by either experimenter ($\underline{E}_1$ or $\underline{E}_2$) chosen at random. The instructions to the subjects were as follows:

> [On first item:] Up here [E points] is a pattern, and here [points] a piece is missing. One of the pieces down here [run finger across four pieces from left to right] is the one that is missing. Look carefully and think about which piece is the missing piece and then point to it. [On ninth item:] Look carefully and then point to the missing piece.

The subjects were then rank-ordered by pretest score. Of the two highest, one was assigned at random to the training group and one to the control group. This procedure was carried out for each subsequent pair. Of the two highest subjects assigned to the training group, one was assigned at random to $\underline{E}_1$ for training, the other to $\underline{E}_3$. This procedure was carried out for each subsequent pair of training subjects. $\underline{E}_3$ had served as a trainer in a previous study (Jacobs & Vandeventer, 1971b). $\underline{E}_1$, who was new to the project, was given approximately six hours of training to prepare for the role of trainer.

Training, which took place approximately one month after pretesting, gave the subject practice in sorting cards on the basis of shape and of color (single classification), and in NFR and CFR with color, shape, shading, and addition relations. No training material exactly duplicated the posttest material in use of stimulus elements. Subjects were trained individually either until they were performing at criterion level or until a one-hour time limit was reached. The procedure is more fully described as "extended training" in another report (Jacobs & Vandeventer, 1971b).

Posttesting took place approximately one week after training. Trained and control subjects were individually tested in a random order. E_1 administered the posttests to those subjects trained by E_3 and their matched controls; E_2 administered the posttests to those subjects trained by E_1 and their matched controls. In this way the experimenter did not know the group identity of the subject being tested. For a given subject the CFR:60-item and CFR:CPM tests were administered in one session, and tests of NFR, DFR and EFR were administered in another session the following day.

Approximately three months after the posttesting, each subject was readministered, for retention testing purposes, the CFR:60-item test, the CPM, the NFR and EFR tests by the same experimenter who had administered the posttests. The DFR test was dropped on the basis of the posttest analyses already carried out. Due to illness the scores of two subjects were not obtainable on part or all of the retention testing.

Results and Discussion

The mean scores on each test are presented for each group in Table 1. Significant differences favoring the experimental group were found with the

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Insert Table 1 about here

CFR:60-item test and the NFR test as posttests. It appears, then, that as in the previous study (Jacobs & Vandeventer, 1971b), transfer of training occurs within the CFR domain, and, in addition, transfer has now been demonstrated to occur within the NFR domain.

But there are two ways in which the results in Table 1 fail to replicate those of the previous study, which found that the significant difference on the CFR:60-item test held up upon retesting and also found a significant difference on CPM, which was administered only upon the retesting occasion.

Further analysis reveals that the conjunction of two separate effects produced the failure of replication. A comparison of CFR:60-item posttest means between the comparable groups of the two studies shows that the trained group of the previous study did better (35.0 vs. 30.3) and the control group of the previous study did worse (15.2 vs. 23.8). These differences maintain their direction during retention testing, with both CFR:60-item test and CFR:CPM.

The differences between the control groups in the two studies, both carried out in the same school at the same grade level on two successive years, presumably reflect a socioeconomic change in the district. Prior to the start of the second study, a new housing development of somewhat higher socioeconomic status opened in the area. According to school records, in the former study only an estimated 7% of the subjects' fathers had occupations in the category "higher executives, proprietors of large concerns, and major professionals [Hollingshead, 1957]," while the corresponding figure for the present study was 24%.

The differences between the trained groups in the two studies presumably reflect differences in the quality of training. In the previous study, no differences were found in the effectiveness of the two trainers used. To check on possible differences in training effectiveness in the present study, which employed one "old" trainer and one "new" one, matched-group t tests were carried out for each posttest and retention test. The initial matching of subjects on pretest score yielded 11 pairs of subjects, in which one member of the pair had been trained by E_1 and the other by E_3. In each case subjects trained by E_3 did better, significantly so for the NFR retention test ($M_d = 2.2$; $t = 3.47$; $p < .01$) and almost significantly for the CFR:60-item posttest ($M_d = 7.5$; $t = 2.21$; $p < .06$).

The principal way the trainers may have differed in their mode of administering training was in their judgments of when the subject had mastered a particular stage of training. A premature judgment would mean that the subject would be insufficiently prepared for the next stage, while a tardy judgment risked boring the subject. E_3 had previously served as a trainer with the same procedure and had several years of elementary school teaching experience. E_1 had neither experience. It is likely, therefore, that E_3 had greater ability to judge a subject's mastery and was thus more effective as a trainer.

If E_3 is the better trainer, then comparisons of only subjects trained by E_3 with control subjects may yield a more favorable picture of the results of training. Those comparisons show, in addition to the already demonstrated superiority of trained subjects on CFR:60-item posttest and the NFR posttest, significantly better performance on the EFR posttest ($M_d = 3.90$; $t = 4.15$; $p < .01$) and the NFR retention test ($M_d = 1.91$; $t = 2.33$; $p < .05$) and nearly significantly better performance on CFR:60-item retention test ($M_d = 10.9$; $t = 2.14$; $p < .07$) and the EFR retention test ($M = 2.27$; $t = 1.94$; $p < .09$).

With the better trainer, therefore, training on CFR and NFR does transfer within NFR and to EFR and is retained, at least for NFR, three months later. One should note that "retention testing" in the experimental psychology of learning usually refers to amount of forgetting of differently treated groups at some interval after posttesting. In the present case of providing an enrichment experience for a still developing set of skills, "retention testing" assesses whether initial increments are maintained during the course of development (Wohlwill, 1970).

Why was transfer obtained within NFR and to EFR but not to DFR? Since the results obtained depend on the particular trainer used, and the amount of transfer within the CFR domain depends upon the logical relations used in training and in testing (Jacobs & Vandeventer, 1971b), we might expect that the conclusion "transfer within NFR and to EFR but not to DFR" would also be affected by specific procedural and testing details. Had we administered a more comprehensive posttest battery, we might have found no transfer within NFR when new logical relations were involved, or found transfer to DFR by using a longer, more reliable test, an alternate scoring scheme, or a different DFR task in which the subject is repeatedly given only nine pieces differing in two stimulus dimensions to arrange in a pattern.

Given the unknown situational parameters that have affected our results, it may nevertheless be instructive to examine the relationships among CFR, NFR, DFR, and EFR. Table 2 presents the intercorrelations of these variables. The correlations are almost all significantly greater than zero, and frequently

Insert Table 2 about here

surprisingly high. Here, too, the results may be situation-specific. Guilford has expressed the view that the intercorrelations of the Structure-of-Intellect abilities are ". . . very much functions of the person population in question and also of the test population, so that any statements of universal factor intercorrelation are probably out of the question." It should be noted again that the tests of NFR, DFR, and EFR developed for this study did not emerge directly from factor analytic work, although they were developed along the lines laid down by Guilford:

> In developing a test for some particular SI ability, it has been one major strategy of the Aptitudes Research Project to take advantage of the expected factor's three parameter properties, seeing to it that each property and no other for the same parameter are satisfied. A second major strategy has been to develop a new test by analogy to a test of a factor that differs in only one parametric property. For example, a test of ESU is developed by analogy to a test of DSU or to one of CSU or NSU, changing only the operation emphasized [1967, pp. 469-470].

Are the relationships among CFR, NFR, DFR, and EFR hierarchical in nature? In this regard Guilford has written:

> As for operations, cognition is basic to all other kinds; hence it appears first. If no cognition, no memory; if no memory, no production, for the things produced come largely from memory storage. If neither cognition nor production, then no evaluation.

From front to back of the model, then, there is increasing dependency of one kind of operation upon others [1967, p. 63].

To check on these dependencies, we considered the first eight items of CFR:60-item test, involving shape and color relations, the first two tasks of NFR, involving shape and color relations in nine-piece format, the first task of DFR, which dealt with shape, color, and number relations, and the first eight items of EFR, involving color and shape relations each to be a "task" that was "passed" if a maximum possible score was obtained (8, 4, 12, and 8 for CFR, NFR. DFR, and EFR respectively) and otherwise was failed. The assumption was made that if no case is found in which a subject can pass A while failing B, it is likely that B is a prerequisite for A.

The pass-fail data for all possible pairings in posttesting of CFR:60-item test, NFR, DFR, and EFR are shown separately for trained and control groups in Table 3. It appears that NFR is a likely prerequisite for CFR:60-item test and for DFR for the trained group in posttesting, but not for the control group, nor for the trained group in retention testing (not shown in table). The two apparent dependencies appear therefore to reflect something

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Insert Table 3 about here

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about the specific training procedure used and not about "natural development" of these abilities. While NFR would seem logically to precede DFR in development, it is not clear why it should precede CFR for the trained group. Perhaps NFR gives the subject the freedom to arrange either the colors or the shapes horizontally or vertically as he wishes and to place any of the shapes (colors) he wishes in any row (column) he wishes, while the CFR task makes him conform to someone else's "arbitrary" placements. A more definitive answer awaits a finer-grain behavioral analysis of the CFR, NFR, and DFR tasks used here, such as Resnick, Siegel, and Kresh (1971) have carried out for two other double classification tasks.

The present study, one in a series of investigations of the "trainability" of intelligence, has utilized Guilford's Structure-of-Intellect model to increase our knowledge of transfer from training in double classification skills. The Structure-of-Intellect model provides a common language for describing both "environmental influences" and "intelligence" in studying environmental influences upon intelligence. It can also serve as a basis for curriculum development (Meeker, 1969). Perhaps the Structure-of-Intellect can serve as a framework for further rapprochement among training, testing, and curriculum development.

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[2]Now at Yeshiva University.

Table 1

Group Means and Differences on Each Test

	n	Mean, Trained Ss	Mean, Control Ss	Mean Difference	t
Pretest					
CFR:20 items	25	7.6 (6.9)**	7.6 (6.9)		
Posttests					
CFR:60 items	25	30.3 (35.0)	23.8 (15.2)	6.5	2.14*
CFR:CPM	25	20.0	20.2	-0.2	0.13
NFR	25	5.9	4.5	1.4	2.42*
DFR	25	7.2	6.6	0.6	0.52
EFR	25	13.5	11.4	2.1	1.90
Retention Tests					
CFR:60 items	24	33.0 (40.5)	28.7 (19.6)	4.3	0.89
CFR:CPM	24	21.5 (23.8)	22.6 (18.8)	-1.1	0.65
NFR	23	5.7	5.4	0.3	0.46
EFR	23	13.4	12.9	0.5	0.45

*$p < .05$, two-tailed test

**Means in parentheses are for corresponding group in previous study (Jacobs & Vandeventer, 1971b).

Table 2

Test Intercorrelations*

		Control Group								
		Posttests					Retention Tests			
		CFR: CPM 1	CFR: 60 Items 2	NFR 3	DFR 4	EFR 5	CFR: CPM 6	CFR: 60 Items 7	NFR 8	EFR 9
	1		.80	.46	.44	.55	.81	.76	.49	.53
	2	.79		.50	.49	.70	.76	.88	.58	.67
	3	.42	.46		.81	.36	.30	.42	.69	.29
	4	.39	.54	.70		.40	.27	.48	.73	.45
Trained Group	5	.47	.61	.12	.26		.48	.69	.46	.74
	6	.79	.78	.33	.43	.48		.77	.40	.59
	7	.74	.91	.33	.48	.59	.82		.64	.78
	8	.52	.59	.45	.72	.40	.44	.53		.43
	9	.55	.69	.19	.13	.66	.50	.74	.35	

*$p < .05$ for $r \geq .413$; $p < .01$ for $r \geq .526$

Table 3

Pass-Fail Fourfold Tables for Posttest Pairings

Trained Group

		NFR Pass	NFR Fail
CFR	Pass	5	0
	Fail	9	11

		NFR Pass	NFR Fail
DFR	Pass	5	0
	Fail	9	11

		NFR Pass	NFR Fail
EFR	Pass	5	4
	Fail	9	7

		DFR Pass	DFR Fail
CFR	Pass	2	3
	Fail	3	17

		EFR Pass	EFR Fail
CFR	Pass	2	3
	Fail	7	13

		EFR Pass	EFR Fail
DFR	Pass	2	3
	Fail	7	13

Control Group

		NFR Pass	NFR Fail
CFR	Pass	5	1
	Fail	0	19

		NFR Pass	NFR Fail
DFR	Pass	3	2
	Fail	2	18

		NFR Pass	NFR Fail
EFR	Pass	3	2
	Fail	2	18

		DFR Pass	DFR Fail
CFR	Pass	3	3
	Fail	2	17

		EFR Pass	EFR Fail
CFR	Pass	4	2
	Fail	1	18

		EFR Pass	EFR Fail
DFR	Pass	2	3
	Fail	3	17