An Analysis of Synchrony between Concrete-operational Tasks in Terms of Structural and Performance Demands

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TOUSSAINT, N. A. *An Analysis of Synchrony between Concrete-operational Tasks in Terms of Structural and Performance Demands*. CHILD DEVELOPMENT, 1974, 45, 922–1001. A set of tasks theoretically presumed to require equivalent logical competence (multiplication of classes, multiplication of relations, seriation, and transitivity) was administered to 32 first graders and 32 second graders. The performance demands were made equivalent by equating across tasks the amount of stimulus information and response requirements. Response measures emphasizing the operative and figurative aspects were compared within each task. Correlations indicated that the operative measures were the most successful in producing a high degree of correspondence in the levels of performance across tasks. Factor analyses confirmed the theoretical distinction between operative and figurative factors. The findings are discussed in relation to the importance of incorporating the figurative-operative distinction in the assessment of logical concepts.

The structuring or *structure d'ensemble* criterion, one of Piaget's defining characteristics of the stage construct, postulates that mutual connections and reciprocal interdependencies exist between the logical operations, and that it is these interrelationships which create the unified system of the logical structures that characterize a given period of development (Piaget 1956; Pinard & Laurendeau 1969). Two important consequences that follow from this postulate are: (*a*) that the acquisition or development of a family of related concepts should be expected to occur at about the same time, and consequently (*b*) that solutions to tasks of related logical structure should be expected to be of equivalent difficulty.

The studies that have assessed this criterion (reviewed by Pinard & Laurendeau 1969) have obtained quite inconsistent results. The heterogeneity of findings has resulted, first, from the lack of adherence to the criteria which according to Piaget's theory (and as interpreted by Pinard & Laurendeau 1969, p. 142) should yield synchrony (i.e., testing at an intraconceptual level, at the end of a stage of development, etc.) and, second, from the fact that the various situations designed to yield synchronous performance have been aimed to be equivalent mainly in terms of their structural or logical demands but not in terms of all the information-processing requirements involved (i.e., memory demands, strategies necessary for the solution of the task, etc.). For example, as analyzed by Klahr (1972) and Klahr and Wallace (1970), logical tasks which structurally require related operations have been found to involve far from homogeneous information-processing demands that in fact render them of unequal difficulty.

The present study investigated the correspondences or synchrony in the development of tasks of analogous logical structure, and

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thus presumably of equivalent logical difficulty, by incorporating the often acknowledged theoretical and methodological necessity (e.g., Flavell & Wohlwill 1969; Pascual-Leone 1968) of also equating the tasks in their information-processing or performance requirements. Specifically, the performance demands between tasks were equated in terms of the total amount of stimulus information that each task involved (e.g., number of dimensions in the stimuli) and in terms of the response requirements. Furthermore, to assess the extent to which logical competence would vary as a function of the response requirements, within each task three types of response measures were compared.

The three response requirements were, first, to complete or fill in the missing elements of a configuration of stimuli; second, to reproduce the just previously completed configuration when it was no longer visible; and third, to reconstruct the same configuration after having to make a reverse transformation, again when the configuration was no longer visible. The completion or fill-in procedure, commonly illustrated in matrix completion tasks, has usually been considered an indicator of operative understanding of multiplicative concepts (e.g., Overton & Brodzinsky 1972). However, according to Inhelder and Piaget (1964), such a procedure can give rise to behaviors based on perceptual rather than operative strategies because it focuses on the perceptual symmetries as well as on partial aspects of an almost completely given stimulus array. If, as defined by Piaget and other authors (e.g., Wohlwill 1962), logical inferences are made in accordance with rules not explicitly given by the perceptual characteristics of the stimuli, then the fill-in procedure would not be expected to measure uniquely and exclusively operative behavior. The reproduction procedure, on the other hand, yields an immediate memory measure which also emphasizes the perceptual and figurative aspects of the stimuli. Nonetheless, such a memory measure requires the assimilation of the total figurative or symbolic component of the stimuli, an activity deemed to be dependent on the operative understanding of the configuration (Piaget & Inhelder 1968). Thus, theoretically the immediate reproduction procedure would be expected to reflect operative behavior to a greater extent than the fill-in measure. Finally, the reverse procedure would be expected to measure most directly an understanding of the rules underlying the tasks because it explicitly focuses on the transformational or operative component of the configuration.

Measuring techniques somewhat similar to those described above have been employed by other authors to compare some of the same logical concepts tested in this study (Bruner, Olver, & Greenfield 1966; Mackay, Fraser, & Ross 1970). However, their findings concerning the differences between logical tasks are equivocal because no methodological controls were used within each task to specify clearly whether the differences obtained resulted from the various procedures or from other yet-to-be-specified sources of variance.

This study, then, evaluated the degree of correspondence or synchrony between tasks of common logical structure when the response requirements across tasks were equated in their information-processing requirements. At the same time, it evaluated whether the various response measures created, within the same task, processing requirements which differentially assessed operative capacity.

Method

Subjects

The Ss were 32 first graders with a mean age of 7.02 (range: 6.5–8.0 years, SD = 5.53 months), Group 1 (G1), and 32 second graders with a mean age of 7.93 (range: 7.4–9.0 years, SD = 4.52 months), Group 2 (G2). Half the Ss in each grade were males, half females. The sample was drawn from a primary school in a lower-middle-class district of Vancouver, British Columbia. The testing was carried out during the months of April and May.

General Procedure

Four tasks were administered: multiplication of classes (MC), multiplication of relations (MR), seriation (SER), and transitivity (TRAN). For the MC, MR, and SER the task requirements were identical; the TRAN task had somewhat different task requirements but was administered to complement information concerning the synchronous development of the logical structures underlying all of the three first tasks. The tasks were administered in two sessions, with a mean interval of 2½ weeks between. The MC and TRAN tasks were given during the first session, and the MR and SER tasks during the second one. In each session, lasting approximately 15–25 minutes, the order of tasks was counterbalanced.

Multiplication of Classes (MC)

Materials.—The stimuli consisted of 45 individual plastic-coated cardboard shapes and a 30 × 23-cm board divided into a 3 × 3-cell matrix. Each individual shape had a different combination of three attributes of the following six dimensions: (1) shape—triangles, squares, rectangles; (2) size—small (2.6 × 2.6 cm), medium (4.5 × 4.5 cm), large (6.4 × 6.4 cm); (3) color—blue, pink, white; (4) background—lines, black dots, plain; (5) superimposed diamonds—zero, one, or two black diamonds on center of shape; (6) thickness—thin (only one layer of 1.5-mm-thick cardboard), medium (four layers), thick (seven layers). Of the total 45 pieces, only nine had the combination of attributes in the six dimensions that could satisfy appropriately all of the vertical and horizontal changes in dimensions simultaneously. In the correct arrangement of the nine positive instances, shown in figure 1, shape, background, and thickness varied across rows, and size, number of diamonds, and color varied across columns.

Procedure.—The S was presented with the empty matrix board and was shown three trays, in each of which were the 15 stimuli that corresponded to the three types of shapes. The S was first asked to point out all the dimensions present in the stimuli by having him describe the similarities and differences between the stimuli in the three trays; then, positions 1, 2, and 4 were filled in by *E* with the appropriate shapes, and *S* was asked to indicate the similarities and differences between stimuli in cells 1 and 2, and in 1 and 4. Positions 8, 6, and 9 were also filled in, and S was asked, again after each of the correct shapes was placed, to indicate similarities and differences between the stimuli in the position just filled in and those of the adjacent cells. Cells 7, 5, and 3 remained empty, and *S* was asked to look at the whole board and try to see if he could find, among the shapes remaining in the trays, those that would fill cells 3, 5, and 7, such that each would fit with the others in the board both vertically and horizontally (axes indicated by gesture). This requirement of having to fill in three cells instead of the usual one was made in order to minimize the effect of perceptual symmetries. After S filled in the cells, he was asked to check the whole board just in case he might want to change any one stimulus. From now on this final question is referred to as Q. After *S* indicated that he was satisfied with his choices, *E* immediately gave feedback by replacing the incorrect shapes with the correct ones while explaining how the replacement had to match with the dimensions of the columns and rows. This response was the fill-in measure (MCFILL).

After the correct matrix was completed, S was told that all the shapes were going to be removed and mixed with the others and that *E* wanted to see if *S* could find them all and

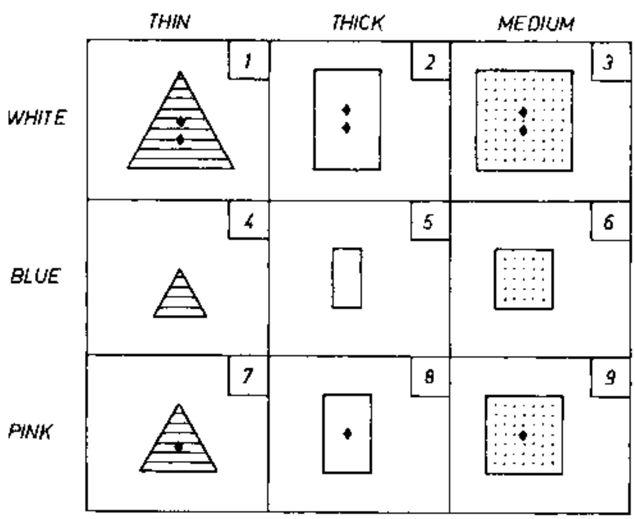

Fig. 1.—Multiplication of classes matrix

put them back in exactly the same places as before. The S was then allowed to look at the completed matrix for as long as he wished; all the shapes were subsequently removed and mixed thoroughly with the remaining ones in their respective trays. These manipulations were performed in full view of the S. As S proceeded to fill the whole matrix, he was allowed to change as many shapes as he wanted, with no time limit. When S completed the matrix, he was asked Q and again given immediate feedback just as after the fill-in procedure. This response was the reproduction measure (MCREPR). Immediately afterward, *E* told *S* that he would have one more chance to find the correct shapes, and that again they were going to be removed. When *S* indicated that he had looked at the filled matrix long enough, all shapes were removed except the one in cell 7. The *S* was then told to put back the same shapes in exactly the same places as before except that this time the board would be turned around—*E* then turned the board 180° so that cell 7 now corresponded to the position of cell 3. After *S* filled the matrix, *E* asked Q and then proceeded to record S's choices. This response was the reverse measure (MCREVE).

Scoring.—Any one dimension was considered to have been solved correctly when the attribute values of that dimension were appropriate for all nine cells. Since the defining criterion of the matrices is the simultaneous cross-classification of elements, the reproduction (MCREPR) score was obtained by multiplying the number of correct dimensions of those which varied across columns (0–3) by the number of correct dimensions of those which varied across rows (0–3). To reduce the range (from 0–9 to 0–3), the square root of the above product was obtained. This score represents the number of cross-classifications which simultaneously incorporated correct dimensions varying along the rows and columns. The reverse (MCREVE) score was obtained following an identical procedure. The fill-in (MCFILL) score was derived as MCREPR and MCREVE, with the exception that each of the three diagonal cells was considered individually and the final MCFILL score was the mean value of the three cells.

Multiplication of Relations (MR)

Materials.—The materials consisted of the same 30 × 23-cm matrix board used in the MC task and 45 plastic-coated cardboard equilateral triangles, each having a different combination of the three attributes of the following six dimensions: (1) color—pink, gray, blue; (2) brightness—dark, medium, light; (3) size—small (2.6 × 2.6 cm), medium (4.5 × 4.5 cm), large (6.4 × 6.4 cm); (4) thickness—thin (one layer of 1.5-mm-thick cardboard), medium (four layers), thick (seven layers); (5) number of lines—one, two, or three horizontal lines at the base of the triangles; (6) orientation—small superimposed yellow triangle pointing to the right, upward, or to the left. Of the total 45 elements, only nine constituted the correct combination of attributes in the six dimensions that could satisfy all the vertical and horizontal changes simultaneously. In the correct arrangement of the nine positive instances, shown in figure 2, orientation, size, and color varied across rows, and number of lines, thickness, and brightness varied across columns.

Procedure.—The procedure was identical in every respect with that of the MC task, and it also comprised the following scores: (*a*) fill-in (MRFILL), (*b*) reproduction (MRREPR), and (*c*) reverse (MRREVE).

Seriation (SER)

Materials.—The stimuli consisted of 36 plastic-coated cardboard "little men." Each stimulus had a different combination of the attributes of the following six dimensions: (1) height—from 6.4 cm to 10.2 cm, with a difference between successive elements of 0.4 cm; (2) width—from 2.1 cm to 6.4 cm; (3) orientation of eyes—eyes were rotated at successive angles of 30° starting with the eyes oriented straight downward (stimulus 1) and ending in the left bottom quadrant after a 270° turn (stimulus 9); (4) location of tie—tie was lowered from the center horizontal line in successive 0.6-cm steps; (5) width of frock—the horizontal lines in the bottom half of the little men varied in width from 0.3 to 2.5 cm; (6) thickness—three degrees of thickness were used, thin (two layers of 1.5-mm-thick cardboard), medium (four layers), thick (seven layers). Only nine little men had the combination of attributes in the six dimensions that could be seriated simultaneously. In the correct series, the first three elements were thin, the middle three were medium, and the last three were thick. There was also a board measuring 54 × 12 cm, numbered 1–9 along the upper and lower edges where the stimuli were to be placed.

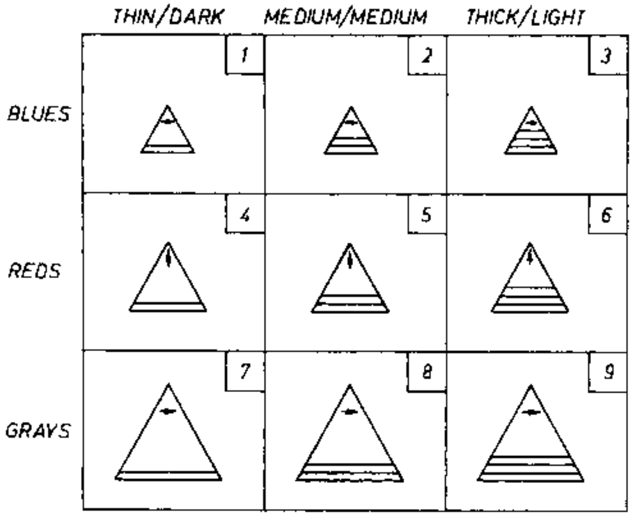

FIG. 2.—Multiplication of relations matrix

Procedure.—The S was first presented with three trays (one with 12 thin little men, another one with 12 medium ones, and the last one with 12 fat ones), and was made aware of the characteristics of the stimuli by being required to describe the differences between two stimuli. The *E* proceeded to make up the series by placing the shortest of the correct stimuli in position 1 of the board, then the next one in position 2, up to position 9, while at the same time indicating after each placement how the six dimensions were successively changing. After the series was completed, S was asked to look at it carefully because the little men were going to be put back in the respective trays and the *E* wanted to see whether S could remember them and put them back in exactly the same way. The S was allowed to look at the series for as long as he wanted; then the correct stimuli were removed and mixed with those in the trays. The S was allowed to make up a series, and as before, he could change his choices as many times as he wanted. When S indicated he had finished, *E* asked Q, and if no changes were made, S's choices were recorded. This response constituted the reproduction measure (SEREPR). No fill-in measures were obtained in this task. The *E* gave immediate feedback by replacing the incorrect stimuli with the correct ones while indicating why the replacements were appropriate. When the whole correct series was completed again, S was told that he would have one more chance to find the nine little men, and to look at them carefully again. When S indicated he had looked enough, the stimuli were removed; but this time the board was turned around, and S was asked to complete the series, this time starting with the little man previously in position 9, which now was placed in position 1. In this way S was forced to reverse all the relationships. After S indicated he had finished completing the series, *E* asked Q, and if no changes were made, S's choices were recorded. This response was the reverse (SEREVE) measure.

Scoring.—The reproduction (SEREPR) score was the total number of dimensions correctly solved over the nine elements of the series. The reverse (SEREVE) score was determined in exactly the same way except that the correct criterion was the reversed series.

Transitivity (TRAN)

Materials.—The stimuli consisted of four "little men" which only differed from each other in height and in the color of their bottom half. The differences in height were small enough that the stimuli had to be directly compared with each other to determine which one was taller. Stimulus 1 (S_1, purple bottom) was 8.3 cm tall; S_2 (white polka-dotted bottom) and S_3 (pink bottom) were the same height, 7.8 cm; and S_4 (blue bottom) was 7.3 cm tall.

Procedure.—The S was first shown the four little men in scrambled order and told that this was going to be a memory game. The *E* put away all stimuli under a board, took out only S_1 and S_2, and asked S to check which one of the two was taller. The S proceeded to compare S_1 with S_2, and *E* emphasized to the *S* to remember what he had just seen. The *E* then proceeded to remove S_1; S_2 was then compared with S_3, and S_3 with S_4, following the above procedure. Thus, *S* compared sequentially the pairs of stimuli S_1-S_2, S_2-S_3, and S_3-S_4. After the last comparison, *E* aligned S_1 and S_4 under a board so that only the bottoms of the stimuli showed and no differences in height were visible, and asked *S* to point out which one of the two he thought was the taller. After he gave his response, *E* removed all stimuli from the *S*'s view and then took out S_3 and S_1 again in the same way as before and repeated the same procedure. Finally, *E* took out S_2 and S_4 and again repeated the same procedure as above. The order of presentation was the same for all Ss.

Scoring.—One point was given for each correct response, thus obtaining a range of possible scores from 0 to 3.

Results

One-way analyses of variance performed on the scores of each group divided on the basis of sex and order of presentation of tasks indicated no significant differences within each group as a function of either variable. Table 1 presents all the mean raw scores of each group on each measure. Hotelling *t* tests for correlated means indicated that there were significant differences between the means of the two groups on all measures except MRREPR, MRREVE, and TRAN. The TRAN measure was rescored in terms of whether the S was correct on all three comparisons, thus obtaining a pass-fail score. This rescoring was deemed necessary because the procedure used facilitated making at least one or two comparisons correct, which led to distributions with most scores concentrated on points 2 and 3. According to this criterion, in G1, 11 of 32 Ss passed, while in G2, 17 of 32 Ss passed, and the difference between the groups was significant, $\chi^2(1) = 5.04$, $p < .05$.

To observe the interrelationship among the measures, a correlational matrix of all the scores was obtained for each group. These matrices, presented in table 2, show that for both groups it is among the reverse measures of the MC, MR, and SER (6, 7, 8) tasks that the highest intercorrelations occurred (range: .72–.86, $p < .001$). The correlations among just the reproduction measures (3, 4, 5), or between the fill-in measures alone (1, 2), are either significantly lower ($p < .01$, Hotelling *t* test of differences between correlated coefficients) than among the reverse measures, or not significant. Thus both groups showed significantly higher consistency in their performances across tasks on the reverse procedure than on either the reproduction or fill-in procedures.

To delineate more clearly whether the underlying structure of the data supported the a priori theoretical distinctions between figurative and operative measures, classical factor analyses with oblique rotations were performed, first, on the combined scores of all 64 Ss and, second, on each group separately. The criterion for factor extraction was an eigenvalue equal to or greater than 1.00 and the rotational parameter δ was set at zero. The pattern matrices for the combined and separate data are presented in table 3. In the combined G1-G2 data two oblique factors ($r = .67$) were obtained. Factor I (accounted for 87.9% of the variance) has high loadings on all the operative measures (reverse measures and TRAN) and only one high loading on a

TABLE 1

Raw Scores on All Logical Measures for Group 1 and Group 2

	G1		G2			
	Mean	SD	Mean	SD	t ($df = 62$)	p
MCFILL	2.01	1.63	2.33	1.82	2.40	.02
MCREPR	1.32	1.51	1.68	1.64	1.75	.08
MCREVE	1.43	1.58	1.94	1.82	2.21	.02
MRFILL	2.02	1.49	2.37	1.53	2.38	.02
MRREPR	1.37	1.58	1.63	1.57	1.25	N.S.
MRREVE	1.72	1.99	1.85	1.78	0.52	N.S.
SEREPR	1.38	1.13	1.64	1.20	2.36	.02
SEREVE	1.31	1.16	1.56	1.17	2.12	.04
TRAN	2.25	0.67	2.31	0.82	0.25	N.S.

TABLE 2

INTERCORRELATIONS BETWEEN SCORES IN THE LOGICAL TASKS FOR G1 AND G2

	MCFILL (1)	MRFILL (2)	MCREPR (3)	MRREPR (4)	SEREPR (5)	MCREVE (6)	MRREVE (7)	SEREVE (8)	TRAN (9)
G1:									
1)	...	.39*	.56**	.51**	.33	.56**	.69***	.50**	.30
2)	...	...	.46**	.44*	.55**	.47**	.57**	.47**	.35
3)	...	...	...	.56**	.20	.56**	.59**	.46**	.21
4)	...	...	...	...	.30	.59**	.70***	.48**	.29
5)	...	...	...	...	...	.50**	.66***	.68***	.37
6)	...	...	...	...	...	...	.86***	.77***	.40*
7)	...	...	...	...	...	...	...	.78***	.39*
8)	...	...	...	...	...	...	...	...	.40*
G2:									
1)	...	.28	.39*	.32	.23	.28	.21	.26	.26
2)	...	...	.30	.34	.09	.43*	.42*	.47**	.43*
3)	...	...	...	.55**	.27	.56**	.49**	.29	.29
4)	...	...	...	...	.20	.28	.25	.20	.03
5)	...	...	...	...	...	.55**	.60**	.56**	.07
6)	...	...	...	...	...	...	.84***	.72***	.56**
7)	...	...	...	...	...	...	...	.76***	.46**
8)	...	...	...	...	...	...	...	...	.48**

* $p < .05$.
** $p < .01$.
*** $p < .001$.

TABLE 3

FACTOR PATTERNS (CLASSICAL FACTOR ANALYSES WITH OBLIQUE ROTATIONS) AND LOADINGS FOR EACH OF THE NINE MEASURES

	Factor		
Group and Task	1	2	3
G1 and G2:			
MCFILL	.163	.527	...
MCREPR	−.038	.807	...
MCREVE	.790	.149	...
MRFILL	.342	.330	...
MRREPR	−.022	.723	...
MRREVE	.692	.191	...
SEREPR	.700	−.061	...
SEREVE	.966	−.100	...
TRAN	.604	.029	...
G1:			
MCFILL	.678	.070	...
MCREPR	.827	−.134	...
MCREVE	.597	.353	...
MRFILL	.312	.402	...
MRREPR	.738	.013	...
MRREVE	.650	.434	...
SEREPR	−.167	.981	...
SEREVE	.322	.617	...
TRAN	.156	.361	...
G2:			
MCFILL	.018	.443	−.105
MCREPR	.103	.673	−.059
MCREVE	.626	.158	−.356
MRFILL	.009	.302	−.471
MRREPR	−.035	.768	.134
MRREVE	.749	.059	−.268
SEREPR	.857	.043	.277
SEREVE	.663	−.020	−.347
TRAN	.070	−.018	−.761

figurative measure, SEREPR. Factor 2, on the other hand, has high loadings only on the figurative measures. The pattern matrix for the G2 data alone is quite similar even though three, instead of two factors, were obtained, F1/F2 $r = .42$; F1/F3 $r = -.35$; F2/F3 $r = -.34$. Factor 1 (72% of variance) and Factor 2 (15% of variance) load on essentially the same measures as Factors 1 and 2 of the combined data; Factor 3 (12% of variance) is mainly defined by the high negative loading of the TRAN measure and residuals. For the G1 data also two oblique factors ($r = .57$) were obtained. Factor 1 (87% of variance) is defined mainly by the MC and MR scores; it can be considered as the figurative factor, despite relatively high loadings on the reverse measure, because it loads highest on the reproduction measures. Factor 2 (12.9% of variance) loads highest on the seriation measures and to a lesser extent on TRAN and the MC and MR reverse measures. The distinction between figurative and operative measures is thus supported by the data except for the seriation task, where both reverse and reproduction measures load on the operative factor. However, for the younger group it is the factor defined on the figurative measures which accounts for most of the variance, while for the older group it is the factor defined on the operative measures which accounts for most of the variance.

From the factor analysis of the combined data, factor scores were obtained for each S. In the operative factor the mean factor scores were 47.41, SD = 9.62, for G1, and 52.59, SD = 10.01, for G2; the corresponding means in the figurative factor were 47.40, SD = 10.17, for G1, and 52.61, SD = 9.43, for G2. Two-tailed t tests performed between the scores of each group on each factor yielded significant differences between the groups on both factors: operative factor, $t(62) = 2.11$, $p < .03$; figurative factor, $t(62) = 2.12$, $p < .03$. However, within each group there were no significant differences between the figurative and operative factor scores. These between-group differences in factor scores more succinctly show the significant differences between the groups already evidenced between the mean raw scores (table 1).

Discussion

One hypothesis of this study was that a synchrony in the development of concepts of equivalent logical structure should be evidenced when the performance requirements are also equivalent. This hypothesis is supported mainly when the tasks are compared in terms of the reverse measures, where the highest intertask correlations were obtained. It would appear, then, that to measure synchony it is not sufficient that the performance requirements be equivalent. More precisely, it would appear necessary that the tasks be made common as far as explicitly demanding an understanding of the transformational or operative rules underlying the tasks.

These findings, then, lend support to Piaget's reformulated synchrony hypothesis but do not give the necessary validity to the *structure d'ensemble* construct. First, only a few of the possible groupings of the concepts tested were examined; and second (pointed out by R. Case, 1973, personal communication), the experimental design does not show that the correlations among other operative tasks where the logical structures are *not* supposed to be common are significantly lower than those obtained here. The latter criticism points out the difficult problem of defining what indeed constitutes an appropriate criterion of synchrony. Nonetheless, the present results are in agreement with recent ones (Dagenais 1973) in which synchrony was obtained over a wider range of tasks when certain methodological and theoretical criteria were met. Furthermore, the high correspondences across tasks are also significant because of the methodological controls used, which were lacking in previous studies (e.g., Mackay et al. 1970). For example, since all subjects were administered all the tasks, these findings constitute within-subjects results. Also, the possibility of obtaining correct responses by chance alone was minimal because, contrary to Bruner et al. (1966) and Mackay et al. (1970), there were many more choice elements to complete the tasks than just the correct ones. Finally, the feedback procedure, by which the subjects were shown the correct configuration and explained the underlying rule, created built-in learning loops that maximized the possibility that the subjects understood the task requirements and thus adapted their available mental structures to the specifics of the tasks.

The data also give support to the distinction between figurative and operative measures. The close correspondence between figurative and operative factor scores within each group indicates, however, that these two factors are interrelated, a conclusion which is in agreement with that of Youniss and Dennison (1972). Thus Piaget's hypothesis that the ability to reproduce the figurative aspect of a structured configuration reflects operative understanding (Piaget & Inhelder 1968) is supported.

Despite the close relationship that may exist between these two factors, however, it appears very important to take into account the differential role that each may have in any given situation on any given developmental level. The figurative measures, being more dependent on the specific characteristics of the tasks, seem more likely to render ambiguous measures of logical competence. The fill-in measure, for instance, has been commonly considered an operative measure. Yet, in the present study, it loaded mainly on the figurative factor and yielded the most inconsistent scores, reflected in the low correlations with each other across tasks and with the other measures. This finding, which lends support to Inhelder and Piaget's (1964) assertion that this measure can give rise to performances based on other than operative strategies, raises the question of the validity of using exclusively this type of procedure (e.g., Overton & Brodzinsky 1972) to assess operative attainment of multiplicative concepts.

In conclusion, it appears that "true" developmental synchronisms or asynchronisms will only be successfully assessed to the extent that the information-processing requirements made by the specific situations are explicitly evaluated. Further analysis of the role of figurative factors on logical inference should prove very useful in clarifying the course of development of logical competence.

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