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ABSTRACT

Kindergarten and third grade children originally assessed in 1973 were retested one year later on a series of conservation and transitive inference tasks (length and weight content areas). An additional sample of matched cohort/grade subjects was assessed in the second year only to permit evaluation of repeat measurement biases for the longitudinal sample. Results indicated a lack of presentation order, slelctive survival, repeated measurement, sex, and content area significant main effects or interactions. Analyses of the longitudinal sample subjects' conservation task performances over the annual interval indicated significant grade-level distinctions, year one versus year two differences, and type of conservation distinctions. Identity conservation scores were consistently superior to equivalence conservation scores and this superiority was most notable for the younger subjects. Transitive inference tasks were significantly less difficult than equivalence conservation tasks. Most importantly, evidence for a developmental mastery sequence (transitivity to conservation) was demonstrated. Pass/fail comparisons indicated a lack of regression effects and greater growth for the conservation abilities as contrasted with transitivity task mastery. Identity/equivalence conservation task distinctions were most apparent for the without verbal justification response criterion. Implications for the general concept of the Piagetian concrete operations stage were discussed. (Author/BW)

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a longitudinal analysis of logical reasoning relationships: conservation and transitive inference

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WISCONSIN RESEARCH
AND DEVELOPMENT
CENTER FOR
COGNITIVE LEARNING

Technical Report No. 380

A LONGITUDINAL ANALYSIS OF LOGICAL REASONING RELATIONSHIPS: CONSERVATION AND TRANSITIVE INFERENCE

by

Frank H. Hooper and Thomas A. Toniolo

Report from the Project on
Children's Learning and Development

Frank H. Hooper
Principal Investigator

Wisconsin Research and Development
Center for Cognitive Learning
The University of Wisconsin
Madison, Wisconsin

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ABSTRACT

One hundred and two children originally assessed in 1973 were retested one year later on a series of conservation and transitive inference tasks (length and weight content areas). An additional sample of matched cohort/grade subjects (first and fourth grade levels) were assessed in the second year only to permit evaluation of repeat measurement biases for the longitudinal sample. Results indicated a lack of presentation order, selective survival, repeated measurement, sex, and content area significant main effects or interactions. Analyses of the longitudinal sample subjects' conservation task performances over the annual interval indicated significant grade-level distinctions, year 1 versus year 2 differences, and type of conservation distinctions. Identity conservation scores were consistently superior to equivalence conservation scores and this superiority was most notable for the younger subjects. Transitive inference tasks were significantly less difficult than equivalence conservation tasks. Most importantly, evidence for a developmental mastery sequence (transitivity → conservation) was demonstrated. Pass/fail comparisons indicated a lack of regression effects and greater growth for the conservation abilities as contrasted with transitivity task mastery. Identity/equivalence conservation task distinctions were most apparent for the without verbal justification response criterion. Implications for the general concept of the Piagetian concrete operations stage were discussed.

I

INTRODUCTION

The present investigation is a longitudinal followup analysis of children's performances on a number of Piagetian concrete operations tasks dealing with conservation and transitive inference. The conservation tasks in both the length and weight content domains focused upon quantitative identity and equivalence concept domains. As originally described by Elkind (1967) and further elaborated by a number of investigators (cf. Brainerd & Hooper, 1975), the quantitative identity conservation format involves a single stimulus which is altered via an irrelevant transformation and the observing subject is questioned as to the relative status of some criterial dimension (e.g., length, weight, number, etc.) before and after the transformation (B→B´). The conventional equivalence conservation format, in contrast, involves a dual stimulus array. Following the establishment of an equality (or inequality) relationship between the two stimuli with regard to the dimension or attribute at issue (A=B), one of the stimuli is perceptually altered (B→B´) and the subject is questioned regarding the resultant relationship of A to B´. Elkind (1967) termed this latter task format to be assessing the conservation of a quantitative relationship between two objects in the face of irrelavant transformations of one of the objects.

Elkind (1967) hypothesized that, since identity conservation understanding is a logically necessary but not sufficient condition for mastering the equivalence conservation task requirements, it should also evidence a developmental priority. This is in distinct contrast to Piaget's (1968) contentions that while an understanding of qualitative identity (e.g., "It's the same clay.") precedes conservation aquisition, quantitative identity and conventional (equivalence format) conservation are theoretically and developmentally nondistinguishable. Thus, it is understandable that Piaget claims the legitimacy of assessing identity conservation concepts in the conventional paired-stimulus task format. The research literature which has dealt with the putative developmental priority of identity conservation *vis-à-vis* equivalence conservation is decidedly mixed. Studies which have found confirmation of Elkind's original contentions included Elkind and Schoenfeld (1972),

Hooper (1969a, 1969b), McManis (1969b), Papalia and Hooper (1971), Rybash, Roodin, and Sullivan (1975), and Schwartz and Scholnick (1970). Nonconfirmatory findings have been reported by Koshinsky and Hall (1973), Moynahan and Glick (1972), Murray (1970), Northman and Gruen (1970), and Teets (1968). These studies have been comprehensively reviewed previously (cf. Brainerd & Hooper, 1975; Toniolo & Hooper, 1975).

In their analysis of the procedural details of these conflicting studies Brainerd and Hooper (1975) identified three major factors which probably underlie the descrepant findings. Relative task sensitivity for the identity and equivalence tasks employed was not found to distinguish among the confirmatory and nonconfirmatory studies. In contrast, the response criteria utilized and the age of the subject samples assessed were both found to be distinguishing factors. Comparing the effects of employing a judgments only versus a judgments plus explanations response criterion, it was shown that the former scoring procedure was more likely to reveal that identity and equivalence conservation emerge in a fixed order (see also Rybash, Roodin, & Sullivan, 1975). In similar fashion, the majority of the supporting studies were found to include younger children (e.g., preschool and kindergarten age) in the subject samples assessed while the studies which failed to find the identity → equivalence sequence tended to assess older subject samples (e.g., early elementary school age).

The research dealing with the developmental relationship of conservation and transitive inference tasks also presents an ambiguous picture. It would appear that Piaget considers the mastery of conservation of quantitative invariants and an understanding of transitive inference to be logical and developmental concommitants (Piaget 1972; Piaget & Inhelder 1962; Piaget & Szeminska, 1952; see also Brainerd, 1973; Flavell, 1963; and Pinard & Laurendeau, 1969). This, of course, follows from the Piagetian position which views all the various concrete operations achievements characteristic of the middle-childhood years as governed by the same interdependent logical *groupements* (cf. Piaget, 1972). Support for this developmental synchronism between conservation and transitivity task mastery has been reported by Smedslund (1959). In contrast, conservation acquisition has been cited as an earlier emerging ability than transitive inference understanding by a number of investigato (Garcez, 1969; Kooistra, 1965; McManis, 1969a; Smedslund, 1961, 1963, 1964). Finally, transitive inference tasks have been found to be of significantly lesser difficulty than their conservation task counterparts by Brainerd (1973) and Lovell & Ogilvie (1961) and this pattern has been corroborated in certain recent concept training studies (Brainerd, 1974; Peterson, Hooper, Wanska, & DeFrain, 1976). The psychometric problems attendant upon an accurate assessment of conservation and transitive inference tasks equated for content area are discussed by Brainerd (1973).

As mentioned above the present study is a direct followup to a previously reported research endeavor (Toniolo & Hooper 1975). This research is part of a larger scale normative assessment project which employed cross-sectional and longitudinal measurement designs over a four-year interval (cf. Hooper & Klausmeier, 1973). The initial subject sample included 180 kindergarten, third, and sixth grade children (30 males and 30 females at each age-grade level) who were individually administered a representative series of Piagetian concrete operations tasks assessing classificatory, relational, conservation, and number concepts. (See Hooper, Brainerd, & Sipple, 1975 for a complete description of the task series.) In the initial assessment year only, an additional sample of preschool children received the conservation and transitive inference tasks discussed in this report.

The primary results of the initial year's assessments were summarized as follows:

> An investigation into the distinction between identity conservation and equivalence conservation, theorized by Elkind (1967), was examined in two content areas, length and weight. In addition, transitivity of length and weight was examined in relationship to conservation.
>
> The sample consisted of 180 subjects, 60 preschool, kindergarten, and third grade students. Within each grade subsample, half the children were male and half were female. Subjects were assigned to one of six different counter-balanced orders of presentation for the conservation and transitivity task battery. The design was a 3/2/2/2 mixed-model analysis of variance. The factors were age (preschool/kindergarten/third grade), task (identity/equivalence), criterion (judgment only/judgment plus explanation), and content area (length/weight).
>
> The main effects of age, task, and criterion were large and highly significant. Equivalence conservation was observed to be of greater difficulty than identity conservation. More trials were passed under the judgment only criterion than with a judgment plus explanation criterion. Significant interactions of Age x Task, Task x Criterion, and Age x Criterion were also observed. Equivalence tasks were found to be more difficult than identity tasks for preschoolers and kindergarteners but not for third graders. Performance differences between the identity and equivalence tasks were greater with a judgment only criterion than with a judgment plus explanation criterion, and these differences between the two criteria were more pronounced with preschoolers and kirdergartners than with third graders. The preschool

> and kindergarten subsamples did not differ. Comparisons of the relative difficulty of the identity versus equivalence conservation cases, utilizing a dichotomous pass/fail scoring criterion, were considerably less persuasive, i.e., only the kindergarten and total sample weight cases indicated a significant lesser difficulty for identity-conservation. A significant performance improvement at every grade level for the transitivity tasks was observed, with the largest differences between the preschool and kindergarten subsamples. The transitivity tasks were significantly easier than all conservation measures at the preschool and kindergarten level, but at the third-grade level, only the transitivity of weight/conservation of weight comparison was significant. (Toniolo & Hooper, 1975, p. IX)

One year later 102 of these kindergarten and third grade subjects were readministered the same task array (they were, of course, first and fourth graders at the time of the second assessment). In addition, a separate sample (N = 48) of testing control subjects was drawn from the original cohort/school population and tested in the second year only. This permitted an evaluation of potential testing carry-over influences for the longitudinal sample continuing subjects (cf. Baltes, 1968, Wohlwill, 1973).

On the basis of the initial Toniolo and Hooper (1975) results it was anticipated that main effects for grade-level, assessment year, conservation task type (identity task performances should exceed equivalence conservation task performances), response criterion (judgment without explanation scores should exceed scores based on judgments plus explanations), and transitivity/conservation distinctions (transitivity should be the easier task) would all be significant. Sex differences, content area distinctions (length versus weight domains), selective survival effects, repeated testing biases, and regression effects were not expected to be significant factors.

II

METHOD

Subjects

The subject sample for the present investigation consisted of 150 children drawn from the Beloit, Wisconsin, public school district. The core longitudinal sample consisted of 102 subjects tested in 1973 and 1974, while the control sample consisted of 48 subjects tested in 1974 only, all selected from the kindergarten/first, third/fourth grade levels. Distribution of the subject population by age and sex is described in Table 1.

Design

Within each grade level ten subjects were randomly assigned to each of six counterbalanced orders of presentation (see Table 2) for the transitivity and conservation task conditions for length and weight. A warm-up preceded all task orders, thereby familiarizing all subjects with the critical terms. Within the six counterbalanced orders of presentation, the questioning within the conservation tasks was always in the order involving the critical terms *Same*, *More*, and *Less*. In addition, conservation of length always preceded conservation of weight in both the identity and equivalence task formats. Within each conservation task, for both prediction and deformation, every S was required to justify his or her objective response to one of the three questions implying the same, more, or less. At each grade level, one-third of the Ss were asked for justifications on questions implying the *Same*, one-third on questions implying *More*, and one-third on questions implying *Less*. For all the conservation tasks, eight justifications were given by every S.

Materials

The complete task administration descriptions are presented in detail in Toniolo & Hooper (1975, pp. 53-69). The materials used in the basic task format were as follows:

(1) Warm-up: a picture of two perceptibly unequal

TABLE 1

DISTRIBUTION BY GRADE, MEAN AGE, AND SEX OF THE SUBJECT SAMPLES

Longitudinal Sample

Grade	Subjects	Males	Females	Mean Age	Range
1	48	26	22	6-10	6-3 to 7-4
4	54	26	28	9-11	9-3 to 10-8

Testing Control Sample

Grade	Subjects	Males	Females	Mean Age	Range
1	24	12	12	6-10	6-4 to 7-4
4	24	12	12	9-10	9-4 to 10-6

TABLE 2

ORDERS OF PRESENTATION FOR THE IDENTITY, EQUIVALENCE, AND TRANSITIVITY TASKS

(1)	A. Identity B. Equivalence C. Transitivity	(2)	A. Identity C. Transitivity B. Equivalence
(3)	B. Equivalence C. Transitivity A. Identity	(4)	E. Equivalence A. Identity C. Transitivity
(5)	C. Transitivity A. Identity B. Equivalence	(6)	C. Transitivity B. Equivalence A. Identity

parallel lines (10-cm and 20-cm), and two perceptibly unequally weighted, cylindrical wooden blocks.

(2) Transitivity of Length: one 27.0-cm blue stick and one 28.0-cm blue stick mounted on a 32" x 20" illustration board, 26 inches apart, and one 28.0-cm white stick.

(3) Transitivity of Weight: one red and one grey clay ball of equal weight (5-1/2 oz.), and one grey clay ball of a lighter weight (2 oz.), but equal diameter as the two weighted balls.

(4) Conservation of Length-Identity Format: one 28.0-cm string.

(5) Conservation of Length-Equivalence Format: two 28.0-cm strings.

(6) Conservation of Weight-Identity Format: one green clay ball, 2 oz. in weight.

(7) Conservation of Weight-Equivalence Format: two brown clay balls of equal weight (2 oz.).

Procedure

The task battery was administered individually, preceded by a warm-up. In addition to familiarizing each subject with the critical terms implying *Same*, *More*, and *Less*, the experimenter was encouraged to promote a relaxed, free, verbal interacting atmosphere between himself or herself and the subject. During this initial experience, the E placed the picture of two perceptibly unequal parallel lines in front of the S, such that the longest line was nearer the S. The following questions were then asked: (a) "Are these two lines the same length?"; (b) "Which line is longer?"; and (c) "Which line is shorter?" The E then removed the picture from the table and gave the S a cylindrical block to hold in each hand and asked: (a) "Are these two blocks the same weight?"; (b) "Which block weighs more?"; and (c) "Which block weighs less?" If the S did not seem to understand the relational terms as indicated by the objective response, the E repeated the warm-up or that portion of which the S seemed uncertain. In the event that an S had failed to understand the relational terms, it would have been necessary to drop that particular S from the sample and select another at random. The task battery was administered individually to each S in a room outside the child's classroom. Total administration time was approximately 20 minutes.

Actual procedures for the transitivity and conservation tasks were as follows:

to indicate which stick was longer in question (b), and shorter in question (c).

(2) Transitivity of Weight (adapted from Brainerd, 1973):
The E placed the three clay balls in the middle of the table, 8-10 inches from the S. The E then asked the S to hold out his or her hands, palm up, after which one grey and one red clay ball of equal weight were handed to the S. The E then asked, "Do these two clay balls weigh the same?" The grey clay ball was then removed from the S's hand and placed on the table 8-10 inches in front of the hand in which it was held. Then the red clay ball was removed and placed in the hand opposite the one in which it originally appeared. Next, the lighter grey clay ball was placed in the remaining empty hand while the S was asked, "Does one of the clay balls weigh more?" If the S replied affirmatively to the question, the child was also asked, "Which one?" The grey clay ball was removed and placed on the table 8-10 inches in front of the hand in which it was held. Finally, the E removed the red clay ball from the table and asked the following: (a) "Do these two clay balls weigh the same?"; (b) "Does one of the clay balls weigh more?"; and (c) "Does one of the clay balls weigh less?" If the child responded affirmatively to questions (b) and (c), the E also asked the S to indicate which clay ball weighed more in question (b), and less in question (c).

(3) Conservation of Length-Identity Format (adapted from Brainerd, 1973; and Hooper, 1969b):
Placing the 28.0-cm piece of string in the middle of the table 8-10 inches from the S, so the length ran horizontally in a straight line from the S's left to right, the E asked the following. (a) "If I were to make this string into a circle, would the string still have the same length?"; (b) "If I were to make this string into a circle, would the string be longer?"; and (c) "If I

(B) INITIAL AND SECOND-YEAR PERFORMANCE COMPARISONS FOR THE LONGITUDINAL SAMPLE

The first and second year conservation task means for

were to make this string into a circle, would the string be shorter?" The E then formed the string into a circle (toward the S) and asked the following: (a) "Is this string the same length as before?"; (b) "Is this string longer than before?"; and (c) Is this string shorter than before?"

(4) Conservation of Length-Equivalence Format (adapted from Brainerd, 1973):

The E placed the two 28.0-cm pieces of string side-by-side in the middle of the table 8-10 inches from the S, so the length ran horizontally from the S's left to right, and so the strings were observed to be of equal length. The S was required to verbalize this latter fact. Leaving the strings exactly as they were, the E asked the following questions while pointing to the string nearest the S: (a) "If I were to make this string into a circle, would the two strings still have the same length?"; and (c) "If I were to make this string into a circle, would one of the strings be shorter?" Taking the string nearest the S and forming it into a circle, the E asked the following: (a) "Are these two strings the same length as before?"; (b) "Is one of the strings longer than before?"; and (c) "Is one of the strings shorter than before?"

(5) Conservation of Weight-Identity Format (adapted from Brainerd, 1973; and Hooper, 1969b):

Placing the green clay ball in the middle of the table 8-10 inches from the S, the E asked the following: (a) "If I were to roll this clay ball into a hot dog, would the piece of clay still have the same weight?"; (b) "If I were to roll this clay ball into a hot dog, would the piece of clay weigh more?"; and (c) "If I were to roll this piece of clay into a hot dog, would the piece of clay weigh less?" The E then rolled the piece of clay into a hot dog, and asked the following: (a) "Does this piece of clay weigh the same as before?"; (b) "Does this piece of clay weigh more than before?"; and (c) "Does this piece of clay weigh less than before?"

(6) Conservation of Weight-Equivalence Format (adapted from Brainerd, 1973):

The E handed a brown clay ball to the S to hold in each hand so the S could verify the equality of weight between the two stimuli. The S was required to verbalize this latter fact. Taking the clay balls from the S and placing them on the table side-by-side 8-10 inches from the S, the E asked the following questions while pointing to one of the stimuli: (a) "If I were to flatten this clay ball into a pancake, would the two pieces of clay still have the same weight?"; (b) "If I were to flatten this clay ball into a pancake, would one of the pieces of clay weigh more?"; and (c) "If I were to flatten this

clay ball into a pancake, would one of the pieces of clay weigh less?" The E then flattened the clay ball into a pancake and asked the following: (a) "Do these two pieces of clay weigh the same as before?"; (b) "Does one of the pieces of clay weigh more than before?"; and (c) "Does one of the pieces of clay weigh less than before?"

Scoring

The various conservation tasks were evaluated according to two response criteria, number of correct judgements alone, and number of correct judgements with an adequate supporting explanation. The latter category included one or more of the following explanation types adapted from Hooper (1969b):

(a)	Inversion	Child verbalizes that if the piece of clay or string were to be returned to its original state, prior to transformation, it would be the same as the other stimulus.
(b)	Reciprocity	Child verbalizes that the standard stimulus can be made to resemble the transformed stimulus.
(c)	Compensatory Relations	Child verbalizes that a decrease in one dimension of the transformed stimulus is compensated by an increase in the other dimension or vice versa so that it remains equal to the standard stimulus.
(d)	Addition/Subtraction	Since nothing has been added to or subtracted from the transformed stimulus, it remains equal to the standard stimulus.
(e)	Statement of Operations Performed	Child verbalizes that the shape of the stimulus has been changed but that the transformed stimulus still has the same amount of clay.

(f)	Reference to the Previous Amount or State of Equality	Child refers to the previous relationship between the stimuli.

The possible score range for each of the transitivity tasks was 0 - 5 and 0 - 6 for each of the conservation tasks. The majority of the results analyses to follow employed interval data based upon these score ranges, i.e., mean number of correct trials (responses). In view of the interrelated nature of correct response patterns within any specific task format, for the dichotomous pass/fail analyses a stringent passing criterion of 5 correct (transitivity cases) and 6 correct (conservation cases) was employed.

III

RESULTS

INITIAL CONSIDERATIONS

The internal consistency of the present conservation and transitive inference tasks was evaluated by computing coefficient alpha values (Hoyt reliability coefficients) for the original year one scores (N=120) of the longitudinal sample. These values and the associated standard errors of measurement are presented in Table 3. It is evident that the present task arrays demonstrate a satisfactory level of internal consistency.

Order of presentation effects were also evaluated for the initial year's dichotomous pass/fail data. None of these comparisons of the six presentation orders (see Table 2) for any of the measures approached statistical significance.

Another issue concerned possible distinctions between the prediction and actual deformation task format questions for the identity and equivalence cases.

The identity and equivalence conservation tasks for length and weight content were divided into two sets of pass/fail dichotomous data, based upon both the prediction and the deformation questions, and the performance levels of the various subsamples under these conditions were compared. Thus, for each grade level, a total of eight four-fold tables (2 tasks x 2 content areas x 2 criteria) of observed frequencies were generated under the prediction/deformation conditions. A McNemar test for the significance of changes failed to indicate any differences between prediction and deformation. As a result, scores were combined across these conditions in all subsequent analyses.

A final area of concern involved the effects of longitudinal sample attrition over the two-year assessment interval. Continued participation effects were evaluated by comparing the initial year's scores of the surviving sample (N=102) and the counterpart scores of the "dropout" subjects (N=18; 4 males and 8 females at the kindergarten level, and 4 males and 2 females at the third grade level). All of these comparisons were consistently nonsignificant thus indicating essential continuity and unbiasedness for the second year longitudinal subject sample.

TABLE 3

HOYT RELIABILITIES (COEFFICIENT ALPHA) FOR THE VARIOUS CONSERVATION AND TRANSITIVITY SUBSCALES COMBINING KINDERGARTEN AND THIRD GRADE SUBJECTS (N = 120) FOR THE INITIAL ASSESSMENT YEAR*

Subscale	Hoyt	Standard Error of Measurement
All (24) Conservation of Length and Weight Items (Supporting Explanation Required)	.95	1.75
All (24) Conservation of Length and Weight Items (Supporting Explanation Not Required)	.94	1.72
All (12) Conservation of Length Items (Supporting Explanation Required)	.94	1.06
All (12) Conservation of Length Items (Supporting Explanation Not Required)	.94	1.03
All (12) Conservation of Weight Items (Supporting Explanation Required)	.93	1.13
All (12) Conservation of Weight Items (Supporting Explanation Not Required)	.93	1.09
All (12) Identity Conservation Items (Supporting Explanation Required)	.87	1.24
All (12) Identity Conservation Items (Supporting Explanation Not Required)	.85	1.17
All (12) Equivalence Conservation Items (Supporting Explanation Required)	.93	1.12
All (12) Equivalence Conservation Items (Supporting Explanation Not Required)	.93	1.14
All (12) Conservation Prediction Items (Supporting Explanation Required)	.88	1.26
All (12) Conservation Prediction Items (Supporting Explanation Not Required)	.87	1.23
All (12) Conservation Judgment Items (Supporting Explanation Required)	.91	1.17
All (12) Conservation Judgment Items (Supporting Explanation Not Required)	.91	1.15
All (5) Transitivity of Length Items	.94	.39
All (5) Transitivity of Weight Items	.91	.33
All (10) Transitivity of Length and Weight Items Combined	.87	.81

*From Hooper, Brainerd, and Sipple (1975, pp. 29-30)

PRIMARY RESULTS

(A) COMPARISONS BETWEEN THE LONGITUDINAL AND TESTING CONTROL SAMPLES

The conservation task means for the longitudinal sample subjects in the second assessment year are presented in Table 4. The counterpart values for the testing control subjects are presented in Table 5.

Factorial variance analysis (see Table 6) indicated significant main effects for the grade-level factor (fourth grade subject's scores were superior to those of their first grade counterparts), conservation task type (identity conservation score levels were higher than equivalence conservation scores), and conservation task response criterion (scores for objective responses with an explanation requirement were lower than the objective response alone cases). Significant interactions were observed for three cases of interest to the present investigation. While there was an absence of assessment condition main effects (longitudinal sample subjects contrasted with testing control subjects), the grade-level x assessment condition interaction was marginally significant ($p < .05$). Inspection of the within-grade assessment condition means comparisons indicated a notable longitudinal group superiority at the first grade level and a contrasting marginal testing control group superiority at the fourth grade level. The significant conservation task x response criterion interaction effect is in accord with the earlier initial year's results reported by Toniolo and Hooper (1975, pp. 30 and 34). In both instances the identity/equivalence distinction was most notable for the without explanation response criterion cases. Finally, a significant grade-level x response criterion interaction was observed. As anticipated (cf. Toniolo and Hooper, 1975, Table 10, page 34), response criterion distinctions were much more notable at the first grade as contrasted with the fourth grade level.

Table 7 presents the transitive inference task means and standard deviations for the two respective assessment conditions.

Factorial variance analyses indicated a significant main effect for the grade-level factor for both the length and weight task cases (see Tables 8 and 9).

A significant grade-level x sex interaction was observed for the weight transitivity task. Male subjects (mean = 4.89) were superior to females (mean = 4.23) at the first grade level while the converse was true for the fourth grade subsamples, i.e., means of 4.81 and 4.93, respectively. No other main effects or interactions approached significance.

We may thus conclude that for both the conservation and transitive inference tasks the effects of repeated testing upon the longitudinal sample subject's performances were negligible. Sex differences were notably absent. The anticipated effects of grade-level were found for all task formats and the conservation task type and response criterion distinctions were evident for both assessment condition samples.

TABLE 4

CONSERVATION TASK MEANS FOR THE LONGITUDINAL SAMPLE SUBJECTS FOR THE SECOND YEAR'S ASSESSMENT

GRADE LEVELS	CONSERVATION TASKS							
	Length Conservation				Weight Conservation			
	Identity Cases		Equivalence Cases		Identity Cases		Equivalence Cases	
	With Exp.	W/O Exp.	With Exp.	W/O Exp.	With Exp.	W/O Exp.	With Exp.	W/O Exp.
First Grade								
Males (N = 26)	4.12	4.42	4.15	4.27	4.00	4.46	3.35	3.62
Females (N = 22)	4.18	4.50	3.68	3.77	3.68	4.36	3.63	4.00
First Grade Total	4.15	4.46	3.94	4.04	3.85	4.42	3.48	3.79
Fourth Grade								
Males (N = 26)	5.35	5.58	5.42	5.42	5.65	5.77	5.58	5.62
Females (N = 28)	4.75	5.04	4.46	4.54	4.93	5.11	4.57	4.61
Fourth Grade Total	5.04	5.30	4.93	4.96	5.28	5.43	5.06	5.09
Total Sample								
Males (N = 52)	4.74	5.00	4.80	4.85	4.87	5.12	4.56	4.62
Females (N = 50)	4.48	4.80	4.08	4.20	4.31	4.78	4.08	4.34
Overall Sample	4.62	4.90	4.46	4.53	4.61	4.95	4.31	4.48

TABLE 5

CONSERVATION TASK MEANS FOR THE TESTING CONTROL SAMPLE SUBJECTS
FOR THE SECOND YEAR'S ASSESSMENT

GRADE LEVELS	CONSERVATION TASKS							
	Length Conservation				Weight Conservation			
	Identity Cases		Equivalence Cases		Identity Cases		Equivalence Cases	
	With Exp.	W/O Exp.	With Exp.	W/O Exp.	With Exp.	W/O Exp.	With Exp.	W/O Exp.
First Grade								
Males (N = 12)	2.83	3.67	1.92	2.67	2.75	3.33	2.75	3.08
Females (N = 12)	3.00	3.58	2.00	2.33	3.33	4.17	2.83	3.08
First Grade Total	2.97	3.63	1.96	2.50	3.04	3.75	2.79	3.08
Fourth Grade								
Males (N = 12)	5.92	6.00	5.08	5.17	4.67	4.92	4.58	4.67
Females (N = 12)	5.67	5.67	5.33	5.50	5.25	5.33	4.50	4.50
Fourth Grade Total	5.79	5.83	5.21	5.33	4.96	5.13	4.54	4.58
Total Sample								
Males (N = 24)	4.38	4.83	3.50		3.71	4.13	3.67	3.88
Females (N = 24)	4.33	4.63	3.67	3.92	4.29	4.75	3.67	3.79
Overall Sample	4.35	4.73	3.58	3.92	4.00	4.44	3.67	3.83

TABLE 6

FACTORIAL ANALYSIS OF VARIANCE SUMMARY
(ASSESSMENT CONDITION x GRADE-LEVEL x SEX
x CONSERVATION TASK TYPE x CONTENT AREA x RESPONSE CRITERION)

Source	df	MS	F Value
Assessment Condition (A)	1	540.97	3.55
Grade-Level (B)	1	5218.06	34.24**
Sex (C)	1	206.62	1.36
A x B	1	643.42	4.22*
A x C	1	184.80	1.21
B x C	1	153.85	1.01
A x B x C	1	47.62	.31
Error Between	142	152.41	
Conservation Task (D)	1	106.68	16.35**
Content Area (E)	1	4.00	.29
Response Criterion (F)	1	40.04	69.23**
D x E	1	.03	.02
D x F	1	1.26	23.05**
E x F	1	.03	.48
D x E x F	1	.00	.23
A x D	1	12.91	1.98
A x E	1	1.47	.11
A x F	1	.80	1.39
B x D	1	5.45	.84
B x E	1	.88	.06
B x F	1	13.89	24.01**

TABLE 6
(cont.)

Source	df	MS	F Value
C x D	1	5.75	.88
C x E	1	4.39	.32
C x F	1	.00	.00
A x B x D	1	.35	.05
A x B x E	1	83.62	5.99*
A x B x F	1	1.50	2.59
A x C x D	1	.01	.00
A x C x E	1	1.07	.08
A x C x F	1	.36	.62
B x C x D	1	.33	.05
B x C x E	1	4.94	.35
B x C x F	1	.03	.05
A x B x C x D	1	3.58	.55
A x B x C x E	1	.42	.03
A x B x C x F	1	.00	.00
Error Within:			
Conservation Task (D)	142	6.53	
Content Area (E)	142	13.95	
Response Criterion (F)	142	.58	
D x E	142	1.40	
D x F	142	.06	
E x F	142	.07	
D x E x F	142	.01	

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

TABLE 7

MEANS AND STANDARD DEVIATIONS OF THE TRANSITIVE INFERENCE TASKS FOR THE LONGITUDINAL AND TESTING CONTROL SAMPLE SUBJECTS FOR THE SECOND YEAR'S ASSESSMENT

Condition and Grade Level	Length Case		Weight Case	
	Mean	Stand. Dev.	Mean	Stand. Dev.
Longitudinal Sample				
First Grade				
Males (N = 26)	3.77	2.12	4.89	.59
Females (N = 22)	3.68	2.10	4.23	1.77
Total	3.73	2.09	4.58	1.30
Fourth Grade				
Males (N = 26)	4.92	.39	4.81	.98
Females (N = 28)	4.79	.63	4.93	.38
Total	4.85	.53	4.87	.73
Total Sample				
Males (N = 52)	4.35	1.62	4.85	.80
Females (N = 50)	4.30	1.55	4.62	1.24
Total	4.32	1.58	4.74	1.04
Testing Control Sample				
First Grade				
Males (N = 12)	3.17	2.41	4.75	.62
Females (N = 12)	3.50	2.07	4.25	1.60
Total	3.33	2.20	4.50	1.22
Fourth Grade				
Males (N = 12)	4.83	.58	4.83	.39
Females (N = 12)	4.83	.58	5.00	.00
Total	4.83	.56	4.92	.28
Total Sample				
Males (N = 24)	4.00	1.91	4.79	.51
Females (N = 24)	4.17	1.63	4.63	1.17
Total	4.08	1.76	4.71	.90

TABLE 8

FACTORIAL ANALYSIS OF VARIANCE SUMMARY FOR THE LENGTH TRANSITIVE INFERENCE TASK (ASSESSMENT CONDITION x GRADE-LEVEL x SEX)

Source	df	MS	F Value
Assessment Condition (A)	1	1.39	.58
Grade-Level (B)	1	56.25	23.64**
Sex (C)	1	.02	.01
A x B	1	1.12	.47
A x C	1	.63	.27
B x C	1	.30	.13
A x B x C	1	.16	.07
Within (error)	142	2.38	

**$p < .01$

TABLE 9

FACTORIAL ANALYSIS OF VARIANCE SUMMARY FOR THE WEIGHT TRANSITIVE INFERENCE TASK (ASSESSMENT CONDITION x GRADE-LEVEL x SEX)

Source	df	MS	F Value
Assessment Condition (A)	1	.00	.00
Grade-Level (B)	1	4.32	4.50*
Sex (C)	1	1.54	1.60
A x B	1	.09	.09
A x C	1	.08	.09
B x C	1	4.25	4.42*
A x B x C	1	.03	.03
Within (error)	142	.96	

*$p < .05$

(B) INITIAL AND SECOND YEAR PERFORMANCE COMPARISONS FOR THE LONGITUDINAL SAMPLE

The first and second year conservation task means for the continuing longitudinal sample subjects are presented in Table 10. The derived factorial analysis of variance summary is presented in Table 11. It should be noted that the less sensitive (in terms of putative identity/equivalence conservation task distinctions) judgments plus explanations response criterion was not employed in this analysis.

For the between-subject variables, we may note a significant main effect for the grade-level factor (older subjects consistently out perform their younger counterparts), an absence of consistent sex main effects; and a significant grade-level/sex interaction (female subsample means exceed the male subsample values for six of the eight kindergarten/first grade cases while a converse pattern of relative superiority is true of all the third grade/fourth grade cases, see Table 10).

For the within-subject variables a number of significant main effects and interactions were observed. As anticipated, time of assessment was significantly related to performance with the second year's means consistently exceeding the initial year's assessment values. The significant grade-level/assessment year interaction reflects the fact that the average increments for the kindergarten to first grade transition were consistently greater than those shown for the third to fourth grade interval. The conservation task distinction was significant (in all the cases shown in Table 10 the identity task means exceed the equivalence task values). In addition, the significant grade-level/conservation task interaction reflects the more notable task distinctions at the younger age range. This difference in the relative superiority of identity task performances is more notable for the initial assessment year and larger mean differences are evident for the kindergarten/first grade subsample than for the older children (i.e., significant assessment year x conservation task and grade-level x assessment year x conservation task higher order interactions in Table 11). The role of the content area variable (length versus weight concepts) was negligible in all of these comparisons.

Comparisons for the transitive inference task performances (means and standard deviations) between the initial and second year assessments are presented in Table 12 (length case) and Table 14 (weight case). The associated variance analysis summaries are presented in Tables 13 and 15.

The only significant main effect or interaction in either content area was a grade-level distinction for transitivity of length. There was no evidence for an increase in scores over the one year interval for either transitive inference case.

TABLE 10

CONSERVATION TASK MEANS
FOR THE YEAR 1 AND YEAR 2 ASSESSMENTS
FOR THE LONGITUDINAL SAMPLE
(WITHOUT EXPLANATION RESPONSE CRITERION)

Grade Levels	ASSESSMENT YEAR							
	YEAR 1				YEAR 2			
	Identity Cases		Equivalence Cases		Identity Cases		Equivalence Cases	
	Length	Weight	Length	Weight	Length	Weight	Length	Weight
Kindergarten/ First Grade								
Males (N = 26)	3.08	3.39	1.85	1.92	4.42	4.46	4.27	3.62
Females (N = 22)	3.82	3.82	2.55	2.55	4.50	4.36	3.77	4.00
Total	3.42	3.58	2.17	2.21	4.46	4.42	4.04	3.79
Third/Fourth Grade								
Males (N = 26)	5.27	5.42	5.15	5.19	5.58	5.77	5.42	5.62
Females (N = 28)	4.75	4.39	3.89	3.86	5.04	5.11	4.54	4.61
Total	5.00	4.89	4.50	4.50	5.30	5.43	4.96	5.09
Total Sample								
Males (N = 52)	4.17	4.40	3.50	3.56	5.00	5.12	4.85	4.62
Females (N = 50)	4.34	4.14	3.30	3.28	4.80	4.78	4.20	4.34
Total	4.26	4.28	3.40	3.42	4.90	4.95	4.53	4.48

TABLE 11

SUMMARY OF FACTORIAL ANALYSIS OF VARIANCE
FOR THE LONGITUDINAL SAMPLE FOR THE CONSERVATION TASKS
(SEX x GRADE-LEVEL x YEAR OF ASSESSMENT
x CONSERVATION TASK x CONTENT AREA)

Source	df	MS	F Value
Sex (A)	1	105.20	.98
Grade-Level (B)	1	3494.57	32.58**
Sex x Grade	1	583.94	5.44*
Ss x Sex x Grade (Error)	98	107.26	
Assessment Year (C)	1	1256.51	28.77**
Sex x Year	1	19.84	.45
Grade x Year	1	293.33	6.72**
Sex x Grade x Year	1	85.48	1.96
Ss x Year x Sex x Grade (Error)	98	43.68	
Conservation Task (D)	1	662.75	45.89**
Sex x Task	1	14.99	1.04
Grade x Task	1	118.69	8.22**
Sex x Grade x Task	1	20.38	1.41
Ss x Task x Sex x Grade (Error)	98	14.44	
Content Area (E)	1	.16	.00
Sex x Content	1	1.90	.05
Grade x Content	1	1.57	.04
Sex x Grade x Content	1	8.34	.22
Ss x Content x Sex x Grade (Error)	98	37.63	

*p <.05
**p <.01

TABLE 11
(cont.)

Source	df	MS	F Value
Year x Task	1	75.92	6.70**
A x Year x Task	1	.00	.00
B x Year x Task	1	47.23	4.17*
A x B x Year x Task	1	2.22	.20
Ss x Year x Task x A x B (Error)	98	11.33	
Year x Content	1	.16	.00
A x Year x Content	1	14.10	.52
B x Year x Content	1	17.38	.64
A x B x Year x Content	1	3.53	.13
Ss x Year x Content x A x B (Error)	98	27.07	
Task x Content	1	.98	.09
A x Task x Content	1	18.82	1.64
B x Task x Content	1	3.93	.34
Ss x Task x Content x A x B (Error)	98	11.47	
Year x Task x Content	1	.98	.09
A x Year x Task x Content	1	.60	.06
B x Year x Task x Content	1	.04	.00
A x B x Year x Task x Content	1	10.07	.96
Ss x Year x Task x Content x A x B (Error)	98	10.53	

*p <.05
**p <.01

TABLE 12

MEANS AND STANDARD DEVIATIONS FOR THE YEAR 1 AND YEAR 2 ASSESSMENTS FOR THE LONGITUDINAL SAMPLE FOR TRANSITIVITY OF LENGTH (STANDARD DEVIATIONS IN PARENTHESES)

Grade Level	Assessment Year	
	Year 1	Year 2
Kindergarten-1st Grade	Males (N = 26) 3.73 (1.91)	Males (N = 26) 3.77 (2.12)
	Females (N = 22) 3.55 (2.09)	Females (N = 22) 3.68 (2.10)
	Total 3.65 (1.97)	Total 3.73 (2.09)
3rd-4th Grade	Males (N = 26) 4.19 (1.83)	Males (N = 26) 4.92 (0.39)
	Females (N = 28) 4.46 (1.37)	Females (N = 28) 4.79 (0.63)
	Total 4.33 (1.60)	Total 4.85 (0.53)
Total Sample	Males (N = 52) 3.96 (1.87)	Males (N = 52) 4.35 (1.62)
	Females (N = 50) 4.06 (1.77)	Females (N = 50) 4.30 (1.56)
	Total 4.01 (1.81)	Total 4.32 (1.58)

TABLE 13

SUMMARY OF FACTORIAL ANALYSIS OF VARIANCE FOR THE LONGITUDINAL SAMPLE FOR TRANSITIVITY OF LENGTH

Source	df	MS	F Value
Sex	1	.08	.01
Grade	1	83.28	14.02**
Sex/Grade	1	1.05	.18
Ss/Sex x Grade (Error)	98	5.94	
Year	1	2.51	2.00
Sex x Year	1	.19	.15
Grade x Year	1	1.26	1.00
Sex x Grade x Year	1	.41	.32
Ss x Year/ Sex x Grade (Error)	98	1.26	

**$p < .01$

TABLE 14

MEANS AND STANDARD DEVIATIONS FOR THE YEAR 1 AND YEAR 2 ASSESSMENTS FOR THE LONGITUDINAL SAMPLE FOR TRANSITIVITY OF WEIGHT (STANDARD DEVIATIONS IN PARENTHESES)

Grade Level	Assessment Year			
	Year 1		Year 2	
Kindergarten-1st Grade	Males (N = 26)	4.42 (1.03)	Males (N = 26)	4.89 (0.59)
	Females (N = 22)	4.50 (1.26)	Females (N = 22)	4.23 (1.77)
	Total	4.46 (1.13)	Total	4.58 (1.30)
3rd-4th Grade	Males (N = 26)	4.62 (1.36)	Males (N = 26)	4.81 (0.98)
	Females (N = 28)	4.93 (0.38)	Females (N = 28)	4.93 (0.38)
	Total	4.78 (0.98)	Total	4.87 (0.73)
Total Sample	Males (N = 52)	4.52 (1.20)	Males (N = 52)	4.85 (0.80)
	Females (N = 50)	4.74 (0.90)	Females (N = 50)	4.62 (1.24)
	Total	4.63 (1.06)	Total	4.74 (1.04)

TABLE 15

SUMMARY OF FACTORIAL ANALYSIS OF VARIANCE FOR THE LONGITUDINAL SAMPLE FOR TRANSITIVITY OF WEIGHT

Source	df	MS	F Value
Sex	1	.04	.02
Grade	1	9.39	3.72
Sex x Grade	1	6.51	2.58
Ss/Sex x Grade (Error)	98	2.53	
Year	1	.30	.66
Sex x Year	1	1.27	2.81
Grade x Year	1	.00	.00
Sex x Grade x Year	1	.46	1.03
Ss x Year/ Sex x Grade (Error)	98	.45	

(C) PASS/FAIL PERFORMANCE COMPARISONS FOR THE LONGITUDINAL SAMPLE:

The dichotomous performance patterns (all task trials must have been successfully completed for a passing designation) for the initial and second year's assessments are presented in Tables 16 to 19.

In the case of the various conservation task formats (see Tables 16 and 17) considerable improvement is shown across the annual assessment interval and this is more notable for the younger subjects (i.e., 33.6% newly passing subjects in Year 2 for the combined task condition). Regression effects (% of subjects failing in Year 2 who passed the respective conservation tasks in Year 1) do not appear to be a major consideration (i.e., 3.6% of the younger subjects and 9.0% of the older subjects for the combined task conditions).

Performances on the transitive inference tasks, in relative contrast, indicate a lower percentage of improving subjects at both grade-levels and a higher percentage of *regressing* subjects for the kindergarten/first grade comparison. It is obvious that the great majority of the older third/fourth grade subjects are mastering the transitive inference tasks. Indeed, only 20% and 5% of these children failed the length and weight transitivity tasks, respectively in the initial year's assessments. The comparison values for the younger kindergarten subjects were 40% and 25%. Thus the present subjects show a continuing growth in conservation concept mastery while ceiling effects are evident for the transitive inference concept tasks.

(D) COMPARISON OF THE CONSERVATION AND TRANSITIVE INFERENCE TASK RELATIVE DIFFICULTIES:

This question was investigated from two perspectives, i.e., analysis of interval data and an analysis of dichotomous pass/fail results for the longitudinal sample subjects. The former case involved two mixed model analysis of variance comparisons. The between subject factors in each instance were sex and grade-level. The within-subject variables in one analysis were assessment year and transitivity of length versus conservation of length (equivalence without explanation case) and assessment year and transitivity of weight versus conservation of weight (equivalence without explanation case). These particular conservation task formats were selected as most representative of conventional paired stimulus tasks without possible response criterion confounding and hence represent a conservative test of the hypothesized transitivity/conservation relationships.

For the length comparison case, as anticipated, the main effects of grade level ($F = 33.72$, df 1, 98, $p < .001$) and assessment year ($F = 18.01$, df 1, 98, $p < .001$) were significant.

TABLE 16

PERFORMANCE STATUS OF LONGITUDINAL GROUP SUBJECTS ON CONSERVATION TASKS FROM YEAR 1 (KINDERGARTEN) TO YEAR 2 (FIRST GRADE)

Improved	Regressed	Unchanged	
TASK CASES			
For All Identity Conservation Tasks			
60 (31.3%)	10 (5.2%)	122 (63.5%)	Total = 192
For All Equivalence Conservation Tasks			
69 (35.9%)	4 (2.1%)	119 (62.0%)	Total = 192
CONTENT CASES			
For All Length Conservation Tasks			
66 (34.4%)	5 (2.6%)	121 (63.0%)	Total = 192
For All Weight Conservation Tasks			
63 (32.8%)	9 (4.7%)	120 (62.5%)	Total = 192
CRITERION CASES			
For All Conservation Tasks - With Explanation			
65 (33.9%)	7 (3.6%)	120 (62.5%)	Total = 192
For All Conservation Tasks - Without Explanation			
64 (33.3%)	7 (3.7%)	121 (63.0%)	Total = 192
FOR ALL CONSERVATION TASKS			
129 (33.6%)	14 (3.6%)	241 (62.8%)	Total = 384

TABLE 17

PERFORMANCE STATUS OF LONGITUDINAL GROUP SUBJECTS ON CONSERVATION TASKS FROM YEAR 1 (THIRD GRADE) TO YEAR 2 (FOURTH GRADE)

Improved	Regressed	Unchanged	
TASK CASES			
For All Identity Conservation Tasks			
46 (21.3%)	18 (8.3%)	152 (70.4%)	Total = 216
For All Equivalence Conservation Tasks			
48 (22.2%)	21 (9.7%)	147 (68.1%)	Total = 216
CONTENT CASES			
For All Length Conservation Tasks			
40 (18.5%)	24 (11.1%)	152 (70.4%)	Total = 216
For All Weight Conservation Tasks			
54 (25.0%)	15 (6.9%)	147 (68.1%)	Total = 216
CRITERION CASES			
For All Conservation Tasks - With Explanation			
50 (23.2%)	21 (9.7%)	145 (67.1%)	Total = 216
For All Conservation Tasks - Without Explanation			
44 (20.4%)	18 (8.3%)	154 (71.3%)	Total = 216
FOR ALL CONSERVATION TASKS			
94 (21.8%)	39 (9.0%)	299 69.2%)	Total = 432

TABLE 18

PERFORMANCE STATUS OF LONGITUDINAL GROUP SUBJECTS ON TRANSITIVITY TASKS FROM YEAR 1 (KINDERGARTEN) TO YEAR 2 (FIRST GRADE)

Improved	Regressed	Unchanged	
LENGTH TRANSITIVITY			
12 (25.0%)	9 (18.8%)	27 (56.3%)	Total = 48
WEIGHT TRANSITIVITY			
10 (20.8%)	4 (8.3%)	34 (70.8%)	Total = 48
FOR ALL TRANSITIVITY TASKS			
22 (22.9%)	13 (13.5%)	61 (63.5%)	Total = 96

TABLE 19

PERFORMANCE STATUS OF LONGITUDINAL GROUP SUBJECTS ON TRANSITIVITY TASKS FROM YEAR 1 (THIRD GRADE) TO YEAR 2 (FOURTH GRADE)

Improved	Regressed	Unchanged	
LENGTH TRANSITIVITY			
8 (14.8%)	2 (3.7%)	44 (81.5%)	Total = 54
WEIGHT TRANSITIVITY			
2 (3.7%)	1 (1.9%)	51 (94.4%)	Total = 54
FOR ALL TRANSITIVITY TASKS			
10 (9.3%)	3 (2.8%)	95 (88.0%)	Total = 108

However, the main effects of the task factor failed to reach an acceptable significance level. In the case of the weight concept inter-task comparisons, similar significant grade-level and assessment year main effects were observed, i.e., F values of 25.26 and 16.31, (df 1, 98, p < .001), respectively. The main effect of the task factor was also significant (F = 14.68, df 1, 98, p < .001) reflecting the overall transitivity task means of 4.63 (initial year) and 4.74 (second year) contrasted with conservation means of 3.42 and 4.48, respectively. As may be expected from these average values, a significant assessment year x task distinction interaction was found (F = 8.40, df 1, 98, p < .01). Finally, the higher transitivity as contrasted with conservation performances were more notable for the younger subsample of kindergarten/first grade subjects (grade-level x task interaction F value = 15.68, df 1, 98, p < .001).

These relative task difficulty comparisons are, however, potentially confounded by the fact that, an unequal number of items or trials are presented in the transitivity (score range = 0-5) versus the conservation cases (score range = 0-6). To adjust for this discrepancy, variance analyses identical to those reported above were conducted utilizing the proportion of correct responses by each subject as the input variable for the transitive inference and conservation measures. These results are presented in Table 20 and the associated variance analyses for the length and weight concept cases are summarized in Table 21.

As expected, the main effects of grade-level and assessment year were significant for both content areas. More importantly, the effect of task type was also significant reflecting a consistently higher proportion of correct transitivity responses contrasted with equivalence conservation. For the length comparison cases this distinction is most notable for the kindergarten/first grade children in the initial assessment year, i.e., difference in mean proportion correct between transitivity and conservation = .37. The comparison value for the second year's assessments is .08. For the older third/fourth grade subjects the difference values are .12 and .14 for the initial and second year's assessments, respectively. There distinctions underlie the significant grade x year x task higher order interaction.

Two significant interactions are of interest in the weight comparison cases. The grade-level x task interaction reflects the differential relative disparity in mean proportions at the kindergarten/first grade level (.52 and .29) versus .21 and .12 at the third/fourth grade level. In similar fashion the initial assessment year's mean proportion differences (.52 and .21) are greater than those values shown for the second year's assessments for younger (.29) and older (.12) children.

TABLE 20

MEAN PROPORTION OF CORRECT RESPONSES FOR THE TRANSITIVE INFERENCE AND CONSERVATION OF EQUIVALENCE TASKS (LENGTH AND WEIGHT CASES) FOR THE LONGITUDINAL SAMPLE

	ASSESSMENT YEAR							
	YEAR 1				YEAR 2			
Grade Levels	Length Cases		Weight Cases		Length Cases		Weight Cases	
	Transitivity	Conservation	Transitivity	Conservation	Transitivity	Conservation	Transitivity	Conservation
Kindergarten/ First Grade								
Males (N = 26)	.75	.31	.89	.32	.75	.71	.98	.60
Females (N = 22)	.71	.42	.90	.42	.73	.62	.84	.66
Total	.73	.36	.89	.37	.75	.67	.92	.63
Third/Fourth Grade								
Males (N = 26)	.83	.85	.92	.86	.98	.90	.96	.93
Females (N = 28)	.89	.65	.96	.64	.95	.76	.99	.77
Total	.87	.75	.96	.75	.97	.83	.97	.85
Total Sample								
Males	.79	.58	.90	.59	.87	.81	.97	.77
Females	.81	.55	.95	.55	.86	.70	.92	.72
Total	.80	.57	.93	.57	.87	.76	.95	.75

TABLE 21

SUMMARY OF FACTORIAL ANALYSES OF VARIANCE FOR THE LONGITUDINAL SAMPLE TRANSITIVITY AND CONSERVATION (EQUIVALENCE WITHOUT EXPLANATION CASE) TASKS (SEX x GRADE-LEVEL x ASSESSMENT YEAR x TASK TYPE)

	Length Cases			Weight Cases		
Source	df	MS	F Value	df	MS	F Value
Sex	1	.44	.70	1	.22	.41
Grade-Level	1	21.23	34.19**	1	13.43	24.76**
Sex x Grade	1	.61	.98	1	.80	1.47
Ss/ x Sex x Grade (Error)	98	.62		98	.54	
Assessment Year	1	6.41	16.71**	1	4.00	15.90**
Sex x Year	1	.27	.71	1	.20	.80
Grade x Year	1	.52	1.34	1	.71	2.80
Sex x Grade x Year 1	1	.16	.42	1	.26	1.03
Ss/ x Year x Sex x Grade (Error)	1	.38		1	.25	
Task Type	1	12.12	19.20**	1	31.48	72.61**
Sex x Task	1	.59	.93	1	.21	.49
Grade x Task	1	.92	1.45	1	5.95	13.72**
Sex x Grade x Task	1	1.42	2.24	1	3.66	8.46**
Ss/ x Task x Sex x Grade (Error)	98	.63		98	.43	
Year x Task	1	1.60	3.65	1	2.45	7.32**
Sex x Year x Task	1	.05	.12	1	.21	.62
Grade x Year x Task	1	2.61	5.95*	1	.69	2.05
Sex x Grade x Year x Task	1	.83	1.90	1	.00	.00
Ss/ x Year x Task x Sex x Grade	98	.44		98	.33	

*p < .05
**p < .01

Insofar as the pass/fail performance patterns are concerned, Tables 22 and 23 present the second year performance patterns for a special subsample of the initial year's assessment cases. All of the children in these comparisons in the initial assessment, passed the respective transitive inference tasks while failing a counterpart conservation task. Their performances on the same tasks are shown in Tables 22 and 23. For the kindergarten/first grade subsample there is some evidence for either, regression or initial measurement error on the length transitivity tasks (cases I to IV in Table 22). Thirty to thirty-eight percent of these subjects fail the transitivity tasks in the second year's assessment. Still there is considerable evidence that the respective conservation task formats (equated for content area) are significantly more difficult than the transitive inference counterparts. In cases V to VIII in Table 22 the diagonal cell comparisons significantly favor this transitivity/conservation relationship (McNemar Test for the significance of changes, $p < .05$). Moreover, 62% to 92% of the second year cases (depending upon the conservation task in question) show the subjects to be passing transitive inference while failing conservation or passing both concept tasks. This latter category (32% to 52.2% of the present cases) suggests that solution of the transitive inference task may be a <u>developmental</u> precursor of conservation concept mastery.

In this regard, more distinct patterns are evident in the third grade/fourth grade second year results reported in Table 23 although the overall sample frequencies are necessarily lower. In the 8 cases presented there are only 2 instances of transitive inference failures (91.7% to 100% of the subjects are observed in the predicted cells of the 2 x 2 matrices). More importantly, 58.3% to 69% of the second year cases appear in the pass both tasks category thus lending additional support to the developmental sequence position described above.

TABLE 22

SECOND YEAR PERFORMANCE PATTERNS FOR THE LONGITUDINAL SAMPLE SUBJECTS PASSING TRANSITIVITY AND FAILING CONSERVATION AT THE TIME OF INITIAL ASSESSMENT (KINDERGARTEN/FIRST GRADE GROUP)

I. Length Transitivity and Conservation of Length-Identity Without Explanation Case (N = 21)

Conservation	Transitivity +	Transitivity -
+	8	1
-	5	7

II. Length Transitivity and Conservation of Length-Equivalence Without Explanation Case (N = 23)

Conservation	Transitivity +	Transitivity -
+	12	1
-	4	6

III. Length Transitivity and Conservation of Length-Identity With Explanation Case (N = 24)

Conservation	Transitivity +	Transitivity -
+	11	0
-	5	8

IV. Length Transitivity and Conservation of Length-Equivalence With Explanation Case (N = 24)

Conservation	Transitivity +	Transitivity -
+	12	1
-	4	7

TABLE 22
(cont.)

V. Weight Transitivity and Conservation of Weight-Identity Without Explanation Case (N = 24)

Conservation	Transitivity +	Transitivity -
+	12	1
-	10	1

VI. Weight Transitivity and Conservation of Weight-Equivalence Without Explanation Case (N = 32)

Conservation	Transitivity +	Transitivity -
+	13	2
-	15	2

VII. Weight Transitivity and Conservation of Weight-Identity With Explanation Case (N = 31)

Conservation	Transitivity +	Transitivity -
+	10	1
-	18	2

VIII. Weight Transitivity and Conservation of Weight-Equivalence With Explanation Case (N = 32)

Conservation	Transitivity +	Transitivity -
+	13	2
-	15	2

TABLE 23

SECOND YEAR PERFORMANCE PATTERNS FOR THE LONGITUDINAL SAMPLE SUBJECTS PASSING TRANSITIVITY AND FAILING CONSERVATION AT THE TIME OF INITIAL ASSESSMENT (THIRD AND FOURTH GRADE GROUP)

I. Length Transitivity and Conservation of Length-Identity Without Explanation Case (N = 12)

Conservation	Transitivity +	Transitivity −
+	7	0
−	5	0

II. Length Transitivity and Conservation of Length-Equivalence Without Explanation Case (N = 12)

Conservation	Transitivity +	Transitivity −
+	7	1
−	4	0

III. Length Transitivity and Conservation of Length-Identity With Explanation Case (N = 15)

Conservation	Transitivity +	Transitivity −
+	9	0
−	6	0

IV. Length Transitivity and Conservation of Length-Equivalence With Explanation Case (N = 13)

Conservation	Transitivity +	Transitivity −
+	8	0
−	5	0

TABLE 23
(cont.)

V. Weight Transitivity and Conservation of Weight-Identity Without Explanation Case (N = 16)

Conservation	Transitivity +	Transitivity -
+	11	0
-	5	0

VI. Weight Transitivity and Conservation of Weight-Equivalence Without Explanation Case (N = 19)

Conservation	Transitivity +	Transitivity -
+	13	1
-	5	0

VII. Weight Transitivity and Conservation of Weight-Identity With Explanation Case (N = 23)

Conservation	Transitivity +	Transitivity -
+	14	0
-	9	0

VIII. Weight Transitivity and Conservation of Weight-Equivalence With Explanation Case (N = 19)

Conservation	Transitivity +	Transitivity -
+	13	1
-	5	0

IV

DISCUSSION

The major findings of the present investigation may be briefly summarized. There was little evidence for repeated measurements confounding for the longitudinal sample subjects' performances. Thus no differences were found between the continuing subjecting subjects' and *drop-out* subjects' initial year performances, and distinctions between the longitudinal and testing control samples' second year scores were minimal. Significant sex differences and distinctions between the content areas of length and weight were notably absent. As anticipated, the repeated measurement analysis of the longitudinal sample subjects' performances revealed significant grade-level, assessment year, and conservation task distinctions. In general, the predicted superiority of identity task performances was most notable for younger subjects whether viewed in terms of grade differences or initial versus second year assessment distinctions. Increases in conservation performances from year 1 to year 2 were most notable for the younger subjects. In contrast to these results the transitive inference task analyses indicated a lack of significant score increments from initial to second year assessments and a significant grade-level effect only for the length transitivity case. Pass/fail performance comparisons substantiate these generalizations indicating a lack of regression effects and greater growth over the one year interval for conservation abilities as contrasted with transitivity task mastery.

These conservation task distinctions support the original predictions of Elkind (1967) and are in contrast to the views of Piaget (1968). Moreover, the interactive influences of response criterion utilized and subject sample age-ranges assessed upon the identity/equivalence distinctions as suggested by Brainerd and Hooper (1975) are confirmed.

While contrary to the cases of greater transitivity task difficulty reported by Kooistra (1965), McManis (1969a), and Smedslund (1961, 1963, 1964), the present distinctions between transitive inference and conventional conservation task performances are in agreement with the recent research of Brainerd (1973, 1974) and compliment the results reported for the present subjects' initial assessment analyses (Toniolo & Hooper, 1975).

In contrast to the concurrence predictions of orthodox Piagetian theory (cf. Pinard & Laurendeau, 1969, pp. 136-145), transitivity tasks appear to be of significantly lesser difficulty when compared to their conservation task counterparts. Most importantly there is evidence in the present findings that mastery of transitive inference relationships developmentally precedes conservation concept acquisition, i.e., the relatively greater intertask performance discrepancies for the initial years' assessments (see Table 21) and the pass/fail patterns for the second year's assessments (see Tables 22 and 23).

In each instance, the identity/equivalence and transitivity/conservation concept acquisition patterns indicate within-stage sequences rather than concurrences. While these results are clearly at variance with the traditional interpretations of the Piagetian stage construct, they support certain recent interpretations of within-stage behavioral phenomena (cf. Flavell, 1971, 1972; and Wohlwill, 1973). In terms of Flavell's (1972) discussion, the present inter-task relationships probably represent examples of inclusion sequences. The logical requirements of the equivalence conservation task format clearly include, yet go beyond or subsume, those of the identity conservation task. The subject must recognize the essential nonrelevance of the B → B′ transformation and apply this knowledge to the logical relationship pattern (i.e., A = B, B = B′, ∴ A = B′). As has been emphasized previously (e.g., Brainerd & Hooper, 1975; Hooper, 1969b) there is simply no manner in which identity conservation could follow the acquisition of equivalence conservation (given the present operational definitions) except through the occurence of measurement errors, i.e., relative task item sensitivities. By the same argument, identity/equivalence item concurrences would be shown by subjects relatively advanced in age or developmental status.

The transitive inference → conservation of equivalence developmental sequence is probably more complex than those patterns found within the conservation concept domain. In this case the logical and memoric task requirements appear to be quite similar, i.e., the three step deduction process common to both transitivity and conservation tasks. It should be recalled that the response criterion employed in the present intertask comparisons was a conservative choice for testing the putative transitivity → conservation sequence, i.e., objective judgments without supporting explanations. Thus, the differences between the task requirements would not appear to lie in greater verbal understanding (in terms of instructional set and criterial terms employed) or verbal productivity (in terms of rationalizing or justifying previously stated judgments). Rather, the critical difference between the two concept tasks lies in the role the transformational stimulus (B → B′) plays in the conservation task (cf. Beilin, 1969). The physical knowledge which is demonstrated by the subject who recognizes relevant (e.g., adding or subtracting) transformations as distinct from nonrelevant alterations

(e.g., spatial rearrangement) is, of course, the key to conservation task correct solutions. Apparently this physical knowledge acquisition is a later emerging conceptual understanding than the ability to deal with three item transitive relationships. This conclusion is born out by the fact that transitive inference performances also exceed identity conservation performances. (See Toniolo & Hooper, 1975, pp. 41-44, and Tables 22 and 23 of the present report.)

The more interesting general question concerns the relevancy of the present developmental sequences to the nature of the Piagetian concrete operations stage. It is clear that the transition from pre-operational to concrete-operational thought is not best represented as a punctate episode or an abrupt reorganization of logically interrelated concept domains. As Flavell (1971), Wohlwill (1973), and others have emphasized, the emergence of qualitatively distinct behaviors characteristic of stage progressions is apt to be a rather gradual and, at times, notably non-uniform process. This state of affairs would appear to be particularly likely at the earliest phases of a given stage such as that shown by the younger subjects in the present investigation. The sequences reported herein speak most directly against only one of the salient stage criteria of orthodox Piagetian theory, that of synchronous emergence. It is quite possible to modify this theoretical assumption in the light of discordant empirical evidence and still retain the stage construct as a useful descriptive and heuristic tool for developmental analysis (cf. Wohlwill, 1973, especially pp. 236-239). In commenting on Flavell's (1970) suggestion that, in order to avoid the vissicitudes of asynchronous emergence, the optimal approach to observing concrete operations functioning and associated structures in depth would be to study the performances of bright adolescents or adults, Wohlwill has stated:

> This view, for all its seeming surface plausibility, is clearly at variance with that of the present chapter. In fact, it would leave the stage concept paradoxically devoid of any developmental significance, since it would be merely a descriptive characterization of an ideal end-state, lacking in any implications for the process by which it comes into being during the course of the child's development. It may be countered in several ways. First, even if one were to grant that the structural cohesiveness of a stage does not become manifest except in its terminal form, and is achieved only when all development with respect to its component elements has ceased, it would still be true that each such stage is generally followed by further development toward higher-level stages. Flavell's suggestion, intriguing though it appears in principle, is thus not practicable: The late adolescent or adult, well into the elaboration of formal operations, does not afford us an

> adequate picture of concrete operations even in their mature form, any more than the six-year-old would with regard to the final stage of sensorimotor development. The same point is of course true *a fortiori* for more delimited stages, such as those of the sensorimotor intelligence period, which may have no more than a purely transitional status, but may yet lay claim to a structural entity and serve a unifying function.
>
> More positively, stages do remain way stations, for the most part, rather than end points on the course of development, and give rise to specifically developmental phenomena during the period between the child's acquisition of one set of skills, concepts or operations, and the next set, such as observed during periods of transition and consolidation (cf. the studies by Uzgiris and Nassefat described previously). These phenomena are difficult to account for, and to investigate effectively, without postulating stages as a regulatory, harmonizing mechanism in the child's development. (Wohlwill, 1973, pp. 237-238.)

In point of fact the demonstration of inter-concept sequences via longitudinal analysis in no way guarantees that the typical child only acquires concept B by means of initially mastering concept A (the same argument holds true, of course, for claiming common developmental processes as underlying concepts which are structurally or logically interdependent and demonstrate high degrees of interitem concurrence, cf. Flavell, 1970). True functional interdependence would only be unequivocably shown by an experimental research design in which the induction of one concept was found to transfer to the logically and developmentally related concept counterpart (Wohlwill, 1973). In this regard, minimal evidence for interconcept transfer following transitivity and conservation of length instruction has been reported by Brainerd (1974) and Peterson, Hooper, Wanska, & DeFrain (1976).

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