DOCUMENT RESUME

ED 229 158 PS 013 516

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TITLE Training Effects on the Development and Generalization of Piagetian Logical Operations and Counting Strategies.
PUB DATE Apr 83
NOTE 9p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (Detroit, MI, April 21-24, 1983).
PUB TYPE Speeches/Conference Papers (150) -- Dissertations/Theses - Practicum Papers (043)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Development; Comparative Analysis; *Computation; *Generalization; *Logical Thinking; *Number Concepts; *Preschool Children; Preschool Education; Pretests Posttests; Quantitative Tests; Training
IDENTIFIERS Piagetian Theory

ABSTRACT

The effects of two training sequences on the development of young children's logical operations and number concepts, including rational counting strategies, were investigated. Forty-five preschool children, aged 3.11 to 4.10, were randomly assigned to two treatment groups and one control group. Subjects in the treatment groups received training either in classification and seriation skills (logical foundations) or in rational counting strategies and other number skills (skills integration). The control group children received instruction devoid of logical/mathematical content. Major pretest and posttest findings indicated that while both experimental groups significantly outperformed the control group on number concepts and logical operations tests, the number skills integration group significantly outperformed the logical foundations group on the number concepts test. (MP)

Training Effects on the Development and Generalization of Piagetian Logical Operations and Counting Strategies

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Presented at the 1983 biennial meeting
of the Society for Research in Child Development
Detroit, Michigan
April 1983

Training Effects on the Development and Generalization
of Piagetian Logical Operations and Counting Strategies

This study investigated the effects of two training sequences on the development of logical operations and number concepts, including rational counting strategies, in children aged 3;11 to 4;11.

Each sequence was based on either of two broad perspectives (Reese & Overton, 1970): (a) the logical foundations model of Piagetian theorists, and (b) a skills integration model. Piagetian-based models define number as a synthesis of class inclusion and assymetrical relations (Elkind, 1964; Piaget, 1952). In this view numerical operations, including those of counting, lack meaning until operational competence is achieved. Skills integration models (Klahr & Wallace, 1976; Schaeffer, Eggleston, & Scott, 1974) along with recently developed models of counting (Carpenter & Moser, 1982; Davydov, 1982; Fuson & Hall, 1982; Fuson, Richards, & Briars, 1982; Ginsburg, 1982; Resnick, 1982) hypothesize that number development results from the integration of number skills such as counting, subitizing, and comparing.

Evidence concerning the existence and significance of a rational counting schema for the young child (Gelman & Gallistel, 1978; Steffe, von Glaserfeld, Richards, & Cobb, 1982) further complicates the question: What abilities and experiences facilitate the development of number concepts and logical operations? Whereas normative or correlational evidence has been reported (e.g., Gonchar, 1975), it affords a weak test of the premise. By comparison, training/transfer experiments hold more promise.

Method

A pretest-posttest design with two treatment groups and one control group was used. Forty-five preschool children, aged 3;11 to 4;10, from a day care center and a university preschool were randomly assigned to one of

three groups. Each was pretested on number concepts and logical operations, subsequently trained for eight weeks, and posttested. Tests were designed to: (a) include tasks derived from a variety of number development theories so as to measure the acquisition of counting and other numerical strategies and concepts (e.g., conservation); (b) provide appraisals of children's developmental levels for each domain; (c) allow comparison to previous studies; and (d) possess adequate validity and reliability. Estimates of reliability (coefficient alpha) for the tests ranged from .93 to .97.

Each of the two major theoretical approaches formed the basis of one experimental treatment. This was the development, coordination, and integration of either (a) classification and seriation abilities (logical foundations, Piagetian) or (b) rational counting strategies and other number skills (skills integration). The control group children received instruction devoid of logical/mathematical content. Data were analyzed utilizing analysis of covariance with the pretest as the covariate. Statistical significance was predetermined at $p < .05$.

Results

Briefly, the findings were: (a) that both experimental groups significantly outperformed the control group on the number concepts and logical operations tests; (b) that the number skills integration group significantly outperformed the logical foundations group on the number concepts test; (c) there was no significant difference between the experimental groups on the logical operations test; and (d) there were consistent and significant, although moderate, correlations between the logical foundations subtests and the number concepts subtests (see Tables 1, 2, and 3).

Discussion

Children in the number skills integration group performed significantly

higher on the number concepts test than the children in the control group and the logical foundations treatment group. This supports the contention that training in rational counting strategies and other number skills increases performance on number concepts tasks. On the test of logical operations, the mean score of the number skills integration group was significantly higher than that of the control group; however, there was no difference between the experimental groups. Thus, the number skills treatment evidenced transfer to logical operation tasks.

The logical operations group performed higher than the control group on each test. Thus, there is evidence that training in classification and seriation increases performed on tests of these operations and transfers slightly to number concepts. This results contradict the notion that children invariably lack the cognitive underpinnings necessary for such learning.

The transfer demonstrated for each treatment is psychologically and educationally significant. Along with the significant correlations among all the subtests, it provides support for the hypothesized functional interdependence among classes, series, and number. However, exact sequences and concurrences may need to be reconsidered and the operational model amended. Children may use counting strategies as representational tools to construct logical operations, including classification, seriation, and number conservation (cf. Acredolo, 1982).

There are also important implications for education; for if taught in a meaningful and challenging fashion, a skills integration curriculum can significantly improve both arithmetical and operational competence.

Table 1

Means and Standard Deviations for the Tests by Treatment

Treatment[A]		Pretest	Posttest Raw	Posttest Adjusted
Number Concepts Test				
Number Skills Treatment	Mean	19.13	46.80	46.55
	SD	5.97	7.46	2.02
Logical Foundations Treatment	Mean	17.67	28.73	29.45
	SD	5.63	2.61	2.03
Control	Mean	19.47	21.67	21.20
	SD	5.46	3.25	2.02
Logical Foundations Test				
Number Skills Treatment	Mean	19.87	39.80	41.47
	SD	5.75	3.83	0.78
Logical Foundations Treatment	Mean	23.53	43.47	43.26
	SD	1.21	1.21	0.70
Control	Mean	26.00	28.67	27.20
	SD	5.39	2.04	0.76

[A] $N = 15$ for each group

Table 2

Pairwise Comparisons of Treatments for Adjusted Means

Comparison[A]	Estimate of Contrasts	DF	.95 Confidence Limits Lower	Upper
Number Concepts Test				
T1 - T3	25.35*	1	18.02	32.69
T1 - T2	17.10*	1	9.71	24.48
T2 - T3	8.26*	1	0.84	15.68
Logical Foundations Test				
T1 - T3	14.27*	1	11.23	17.32
T1 - T2	-1.79	1	-4.52	0.94
T2 - T3	16.06*	1	13.44	18.69

[A]T1 = Number Skills Treatment

T2 = Logical Foundations Treatment

T3 = Control

*Difference is statistically significant at the .05 level.

Table 3

Correlation Matrix for Tests and Subtests
of the Number Concepts Instrument with the Logical Foundations Instrument

Logic. Found. Subtests	Rat. Count.	Choose More	After Before Between	Count. on Back	Equal-izing	Iden. Cons.	Equiv. Cons.	Verb. Prob.	Conc. Prob.	TOTAL NUMBER
Free Class.	.21	.31*	.20	.10	.31	.03	.25	.25	.39*	.37**
Plan.	-.07	.08	.11	.10	.03	.19	.27	.06	.14	.07
Some/ All	.52***	.40**	.29*	.33*	.35*	.10	.32*	.25	.29*	.52***
Class. Inclu.	.22	.48***	.20	.28*	.12	.23	.25	.28	.41**	.40**
Class. Matrix	.19	.16	.10	.35*	.33*	.23	.17	.20	.30*	.27*
SUBTL. CLASS.	.47***	.50***	.26	.30*	.37*	.20	.37*	.36*	.48**	.56***
Copy Order	.19	.46***	.32*	.46***	.21	.35*	.18	.52***	.42**	.46***
Discr. Seria.	.44**	.48***	.26	.29*	.07	-.03	.39*	.21	.35*	.34*
Free Seria.	.45**	.46***	.19	.15	.55***	.11	.28	.35*	.26	.41**
Inser.	.27*	.62***	.37*	.55***	.54***	.31*	.38*	.45**	.47**	.55***
Seria. Corr.	.48***	.46***	.11	.26	.21	-.01	.18	.28	.28	.45**
Seria. Matrix	.29	.25	.08	.14	.45*	.29	.40*	.38*	.24	.32*
SUBTL. SERIA.	.67***	.68***	.27*	.47***	.54***	.18	.35*	.50***	.48**	.69***
TOTAL LOGIC. F.	.63***	.65***	.29*	.45**	.56***	.22	.42**	.52***	.52***	.68***

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