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Simultaneous and Successive stimulus presentation were compared in a concept-learning task using blank trials. Subjects were kindergarten children; fourth-grade children; ninth-grade children; college students; returning students thirty-five to forty-six years of age; and females sixty-five years and older. With the Simultaneous problems Levine's method was used; the Successive problems were derived from these.

The study replicated Wells' results of the potent efficiency of the Simultaneous stimulus presentation. This efficiency, which was maximized with younger and older Ss, was attributed to the Simultaneous condition's serving as an aid in perceiving the logical intersection of positive and negative instances, and retention of processed information. Eimas' contention that the inadequacy of young subjects (fourth graders) may not be due to developmental readiness but to information not reaching higher processing was substantiated. Hypothesis-testing behavior was found in Ss of all developmental levels with the poor performance of kindergarten and older Ss mediated by different processes: logic for kindergarteners, and the loss of processed information for older Ss. The equivalent performance of ninth-grade,

college, and returning students was qualified by differences in retention, recoding, and coding.

CONCEPT IDENTIFICATION AT VARIOUS DEVELOPMENTAL LEVELS AS A FUNCTION OF SIMULTANEOUS AND SUCCESSIVE STIMULUS PRESENTATION

by

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APPROVAL PAGE

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INTRODUCTION

One would expect improvement in concept-learning tasks with developmental level, and empirical evidence validates such expectation. Bourne (1971) reports such studies of sequential concepts (Friedman, 1965), oddity concepts (Strong, 1966), identifying class concepts (Pishkin, Wolfgang and Rasmussen, 1967), acquiring discrimination set (Harter, 1966), and verbal logic problems involving class concepts (Saltz and Segal, 1967). Performance of older individuals, seniles over sixty-five, deteriorates (Strong, 1966). This deterioration would be consonant with decline in general intelligence (Jones and Conrad, 1933).

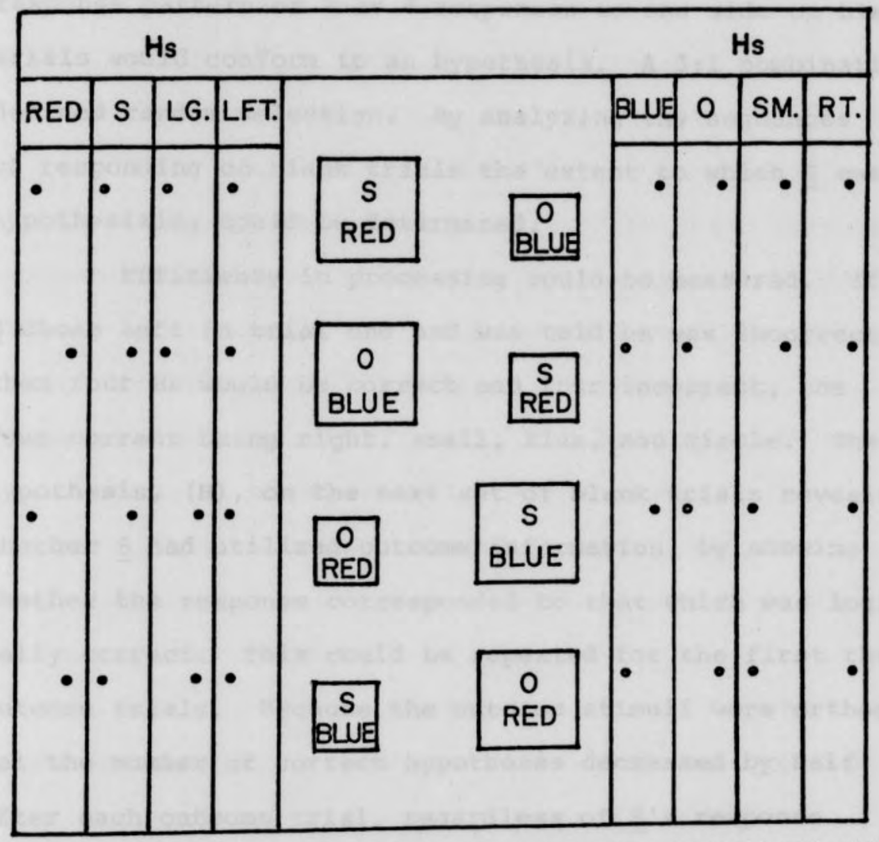
Developmental changes are apparent in concept learning tasks, yet, as Bourne elaborates, chronological age serves only as a temporal marker, and far more important and interesting are the component processes which contribute to the difference.

Are these component differences attributable to developmental stages as described by Piaget, such that children cannot consider all possibilities until they reach the stage of formal operations? Friedman's results support this conclusion. His results reveal that behavior of children below fourth grade can be described by traditional models of learning, while children above this level test hypotheses. Rieber (1967) suggests that hypothesis testing does not appear before fourth grade.

Ingalls and Dickerson (1969) used college, tenth, eighth, and fifth-grade students, and found that some subjects at all ages test hypotheses, although it is eighth grade before they consistently do so.

Eimas (1969) used a simultaneous, blank-trials procedure and tested children from grades two, four, six, and eight, and college students. He administered eight sixteen-trial hypothesis-testing problems. He analyzed component processes by Levine's method. In a discrimination-learning task S would select some attributes of a multistimulus array and predict it as correct and respond accordingly. Practice problems made known the set of hypotheses from which S sampled. Levine found that Ss maintain an hypothesis across blank trials. In the procedure four sets of blank trials were bounded by outcome trials. With four-dimensional, bivariate stimuli there were eight possible arrays. Each level of every dimension was paired exactly twice with every other. One set of four arrays was used for outcome trials, (OT), 1, 6, 11, 16 and a second set for blank trials, (BT), 2, 3, 4, 5; 7, 8, 9, 10; 12, 13, 14, 15.

Figure 1 depicts Eimas' Problem.



EIGHT PATTERNS OF CHOICES CORRESPONDING TO EACH OF EIGHT HYPOTHESES WHEN FOUR SIMULTANEOUS PAIRS ARE PRESENTED.

Figure I. EIMAS' PROBLEM

Any pattern of responding which matched one of the eight patterns could be construed as testing a hypothesis. Any response pattern of 2 or 4 responses to one side on blank trials would conform to an hypothesis. A 3:1 combination defined random selection. By analyzing the sequences of responding on blank trials the extent to which S was hypothesizing could be determined.

Efficiency in processing could be measured. If S chose left in trial one and was told he was incorrect, then four Hs would be correct and four incorrect, the four correct being right, small, blue, and circle. The hypothesis, (H), on the next set of blank trials revealed whether S had utilized outcome information, by showing whether the response corresponded to that which was logically correct. This could be repeated for the first three outcome trials. Because the outcome stimuli were orthogonal the number of correct hypotheses decreased by half after each outcome trial, regardless of S's response pattern or the sequence of reinforcement. After one outcome there were 4 logically correct, after two outcomes 2, and after 3 only 1 logically correct H.

Component processes could be detected. Coding was reflected by blank trial Hs consistent with immediately preceding positive-outcome trials. Recoding could be measured by blank trial responses consistent with negative-outcome trials. An H consistent with previous outcome information was designated local consistency. Retention of stored information could be measured by determing if an H was consistent with outcome information several steps away. Consistency with outcome feedback one step away was designated LC-1; two steps away, LC-2.

Eimas found (a) Ss from all grade levels hypothesis test, (b) the extent to which hypothesis testing was manifested increased with developmental level, (c) the ability to predict outcome trials was significantly related to developmental level, (d) focusing or information-processing ability was different for differing age levels for blank trial sequences after the second and third outcome trials. Analysis showed age differences in component processes of coding, recoding, and retention of stored information.

Eimas (1970) postulated that the ability to test hypotheses might not be a stage-like progression beyond the intellectual capacities of younger children and offered an alternative explanation based on Levine's analysis of focusing, that there might be in younger children a deficiency in a component process necessary for hypothesis testing. Levine's explanation assumes that when S is presented a total stimulus array he codes the stimulus of his choice by means of some perceptual or covert verbal response. If he is told "correct" then this set of cues becomes the set of functional hypotheses that determines his later choices. With negative outcomes S recodes the stimulus. He must store the information of the alternative stimulus and use this as the functional set of hypotheses. At least two processes must be operative: (1) The S must retain the coded or recoded information, (2) he must be capable of the logical process of intersection; he must be able to code as the functional set of Hs the overlap of the present and previous sets of logically correct Hs.

A deficiency in either process will result in reduced focusing. In his previous study Eimas had found ability to code, recode, and retain information to be positively related to developmental level. He suggested that poor performance of children was a result of deficiency in degree of one or more processes. In a second experiment with a group of second graders he used (1) standard procedures, (2) a reduced set of potentially correct Hs, (3) a memory aid, and (4) memory plus coding aids. In a parallel experiment four groups of college students were given a similar series of blank trials problems with 16 potentially correct Hs. The second condition of the second graders was not used. Results showed all groups reliably used H sequences. Improvements in focusing closely matched increased performance in component processes. Eimas' results indicated that what has been assumed to be a deficit in intellectual functioning may well be a deficiency in relevant information reaching higher processing. Young children have a deficit in memory rather than an inability to use logical rules and intersection. Eimas found focusing behavior in three groups of first graders as well.

Such data are consistent with Gagne's model (1968) of intellectual development based on a notion of cumulative learning, new learning depending on combining of previously acquired and recalled entities.

Wells (1967) found facilitation of concept learning by using a "simultaneous contrast" procedure. In the contrast condition one positive and one negative instance were shown on each trial. In a Successive condition a single positive or negative instance was shown on each trial. The Simultaneous condition was the most efficient by a measure of instances prior to criterion as well as trials to criterion.

According to Eimas, the Simultaneous presentation of a positive and a negative instance would allow the S to perceive more readily the logical intersection of the positive and negative instance. Eimas (1970) manipulated memory, coding, and recoding aids, and established their part in improving performance deficits previously attributed to developmental readiness.

Purpose

The purpose of the present study was to manipulate simultaneous versus successive stimulus presentation at several developmental levels. In the Simultaneous condition one positive and one negative instance were shown on each trial. In the Successive condition a single positive or negative instance was shown on each trial. Simultaneous presentation was expected not only to serve as a memory aid, but also as an aid for perception of the logical intersection of all Ss.

There are a number of measures which may be used to measure the effectiveness of these variables.

A gross efficiency measure can be given by the proportion of problems solved. There are several identifiable component processes which contribute to efficient concept learning (Levine, 1969; Wells, 1972). The present study used Wells' analysis of component processes. (a) Responding by hypotheses. The extent to which S's responses are organized according to some appropriate H may be specified, as there are two classes of blank trials: eight patterns which correspond to specified Hs and the eight patterns not conforming (3:1 patterns). If Ss were responding randomly on blank trials, 50% of the patterns should be 3:1. Verification of the H-testing model can be given by the extent to which Ss' responses correspond to simple Hs. Another measure of the validity of the H-testing assumption is the extent to which outcome trial responses can be predicted by the previous blank trial set. (b) Immediate reaction to feedback. It is often assumed that S retains his H when told he is correct, but selects a different H after an error. The occurrence of this reaction can be discerned by looking at the instances of interpretable responses where blank trial set and previous outcome trial were consistent. If S were told "correct," he should keep the H and the next blank trial set and outcome trial should be the same, a win/stay strategy. When told "wrong" the appropriate H of the next blank trial set and outcome trial would be a different one, a lose/shift strategy. (c) Information processing. To permit a comparison with other studies it is desirable to calculate the number of Hs, N(H), left in S's pool when he resamples after an error on a given outcome trial. After three outcome trials only one H is consistent with all prior information. Another measure, the local consistency process, is indicative of the extent to which S processes information about alternative Hs, so that the H selected will be consistent with the last informative trial. Coding is the process measured by the proportion of Hs that are consistent with an immediately preceding positive outcome trial. Recoding is measured by the proportion of Hs consistent with an immediately preceding negative-outcome trial. (d) Memory. Having processed information, S must retain some portion to guide future H selection. Retention of previously stored information may be evaluated by the proportion of Hs that are consistent with all prior information one and two steps from feedback, designated LC_1 and LC_2 respectively. Another memory measure is the proportion of loss of information from LC to LC_2.

Developmental differences could be detected in terms of the above measures. Not only would a difference between simultaneous and successive presentation be evident throughout all levels, but those differences should be maximized at younger and older levels.

Hypothesis testing as described by Levine should be demonstrated at all levels including kindergarten.

Friedman (1965) and Klugh, Colgan, and Ryba (1964) have found an inverse relationship with developmental level and improvement in fourth graders. Friedman attributed this to a tendency toward rigidity and an inability to modify. This tendency should be found in perseveration as measured by lose/stay patterns. By providing the logical intersection, simultaneous presentation should diminish the perseveration. Eimas (1970) found fourth graders aided by a memory aid, a memory aid plus a recoding aid, and a memory, recoding and attentional aid. Covering the negative instance (comparable to successive stimulus presentation) in order to draw attention to the positive stimulus reduced efficiency below that of a memory and recoding aid. Eimas surmised that this might be due to a loss of information provided by the negative cues.

Ninth graders should be proficient at H testing, and college students even better. The highly motivated returning student should do well, but some memory deficit might be manifest. Wechsler (1958) asserts memory to be the test most significantly affected by age, and a memory deficit would accrue for over sixty-five year olds.

METHOD

Subjects

The Ss were:

Twenty female kindergarten students from First Presbyterian Church Kindergarten and Tot Spot Kindergarten in Danville, Virginia, both catering to an upper middle class socio-economic group. The range in age was from 5 years to 6 years and 6 months, with a median age of 5 years and 11 months.

Twenty fourth-grade girls ranging in age from 9 years to 11 years and 2 months, with a median age of 9 years and 10 months. These students were designated as college-bound by Lorge-Thorndike scores in the upper quartile of their class. They attended Forest Hills Elementary School and Woodberry Hills Elementary School in Danville, Virginia.

Twenty ninth-grade girls, ages 13 years and 9 months to 15 years and 5 months, with a median of 14 years and 7 months, enrolled in college-bound curriculum of the John M. Langston Junior High School of Danville, Virginia.

Twenty female introductory-psychology students at Stratford College, in Danville, Virginia, ranging in age from 19 years to 22 years, with a median of 20 years and 1 month.

Twenty female students enrolled in continuing education programs or full curricula at Stratford College, Danville Community College, and Averett College, in Danville, Virginia, with a range from 35 years to 45 years, and a median of 39 years.

Twenty females over 65 years of age with a range of 65 years to 78 years, with a median of 70 years. Each had received college training, and 5 were actively engaged in teaching or occupational pursuits.

Ss were all naive in concept learning. Sex of Ss was held constant, as Pishkin, Wolfgang, and Rasmussen (1967) have found interactions between sex and number and types of instances. Wells (1967) did not find sex interaction in simultaneous contrast facilitation of concept learning.

Materials and Concepts

The stimuli were geometrical figures with four binary dimensions: shape--square or circle; size--large or small; internal pattern--dot or stripe; and color--red or blue in the first problems and red or green in the second problems.

The first simultaneous problem was a 16-trial problem in which an outcome trial (the S given feedback) was presented on the first, sixth and eleventh trial. Levine (1966) describes how stimuli for these trials can be arranged with certain specifications. In a four dimensional, simultaneous-discrimination problem there are eight different stimulus pairs which may be presented. These may be grouped into two different sets, each composed of four pairs, with dimensions being perfectly counterbalanced (on the left two blue, two red; two circles, two squares; two dots; two stripes; two small, two large; the same restrictions for the right stimulus). Figure 2 pictures such a set (Set A), in which each level of every dimension appears exactly twice with every other dimension. Such a counterbalanced set may be described as internally orthogonal. The set for blank trials (no feedback) may be produced by simply interchanging the position of the stimuli in each pair. For the top pair the small red striped square would be placed on the left and the large blue dotted circle on the right. This new set (Set B) will also be internally orthogonal. The Set A was used for outcome trials. The interchanged set, Set B, was used for all blank trials (trial 2, 3, 4, 5; 7, 8, 9, 10; 12, 13, 14, 15).

The trial to trial order was different for each of the sets. Table 1 delineates Problem 1 Simultaneous.

Such an internally orthogonal arrangement yields 8 different patterns of responses indicating an hypothesis, one pattern for each of the eight different hypotheses. For example, on the outcome trial set 1, 6, 11, 16 responses left, right, left, right indicate the hypothesis blue; left, left, left the hypothesis dot, etc. . . . The same is true for a set of blank trials. If S were responding randomly there would be 3:1 patterns, i.e., left, left, left, right.

For the first successive problem the left hand stimulus of each card of Set A was used for outcome trials 1, 6, 11 and 16 and for blank trials 6-10. The right hand stimulus was used for blank trials 2-5 and 12-15. Table 1 delineates Problem 2 Simultaneous.

The second simultaneous problem was constructed by using the outcome trials of problem 1, randomly arranged, as blank trials. Thus this problem too was internally orthogonal, yielding eight patterns, conforming to hypotheses and eight patterns that did not. Table 1 shows Problem 3 Successive.

The second successive problem, problem 4, used the left hand stimulus of problem 2's trial 1, 6, 11, 16 for outcome trials. The left hand stimulus was used for blank trials 6-10. The right hand stimulus was used for blank trials 2-5 and 12-15. Table 1 depicts Problem 4 Successive.

The stimuli were printed on 3 x 5 index cards, which were then sprayed with acrylic plastic.

Figure 2 shows Set A Simultaneous Problems.

TABLE 1

Problem 1 Simultaneous

	Blue	Circle	Dot	Large	Small	Stripe	Square	Red
Outcome								
1.	lf.	lf.	lf.	lf.	rt.	rt.	rt.	rt.
6.	rt.	lf.	lf.	rt.	lf.	rt.	rt.	lf.
11.	lf.	rt.	lf.	rt.	lf.	rt.	lf.	rt.
16.	rt.	rt.	lf.	lf.	rt.	rt.	lf.	lf.
Blank								
2.	rt.	lf.	rt.	lf.	rt.	lf.	rt.	lf.
3.	lf.	lf.	rt.	rt.	lf.	lf.	rt.	rt.
4.	lf.	rt.	rt.	lf.	rt.	lf.	lf.	rt.
5.	rt.	rt.	rt.	rt.	lf.	lf.	lf.	lf.
7.	rt.	rt.	rt.	rt.	lf.	lf.	lf.	lf.
8.	lf.	rt.	rt.	lf.	rt.	lf.	lf.	rt.
9.	rt.	lf.	rt.	lf.	rt.	lf.	rt.	lf.
10.	lf.	lf.	rt.	lf.	lf.	lf.	rt.	rt.
12.	lf.	rt.	rt.	lf.	rt.	lf.	lf.	rt.
13.	rt.	rt.	rt.	rt.	lf.	lf.	lf.	lf.
14.	rt.	lf.	rt.	lf.	rt.	lf.	rt.	lf.
15.	lf.	lf.	rt.	rt.	lf.	lf.	rt.	rt.

Problem 2 Simultaneous

Outcome

	Green	Circle	Dot	Large	Small	Stripe	Square	Red
1.	rt.	lf.	rt.	lf.	rt.	lf.	rt.	lf.
6.	rt.	rt.	rt.	rt.	lf.	lf.	lf.	lf.
11.	lf.	rt.	rt.	lf.	rt.	lf.	lf.	rt.
16.	lf.	lf.	rt.	rt.	lf.	lf.	rt.	rt.

Blank

2.	rt.	lf.	lf.	rt.	lf.	rt.	rt.	lf.
3.	lf.	rt.	lf.	rt.	lf.	rt.	lf.	rt.
4.	rt.	rt.	lf.	lf.	rt.	rt.	lf.	lf.
5.	lf.	lf.	lf.	lf.	rt.	rt.	rt.	rt.
7.	rt.	rt.	lf.	lf.	rt.	rt.	lf.	lf.
8.	lf.	rt.	lf.	rt.	lf.	rt.	lf.	rt.
9.	lf.	lf.	lf.	lf.	rt.	rt.	rt.	rt.
10.	rt.	lf.	lf.	rt.	lf.	rt.	rt.	lf.
12.	rt.	rt.	lf.	lf.	rt.	rt.	lf.	lf.
13.	lf.	lf.	lf.	lf.	rt.	rt.	rt.	rt.
14.	lf.	rt.	lf.	rt.	lf.	rt.	lf.	rt.
15.	rt.	lf.	lf.	rt.	lf.	rt.	rt.	lf.

Problem 3 Successive

Outcome

	Blue	Circle	Dot	Large	Red	Square	Stripe	Small
1.	A	A	A	A	A	B	B	B
6.	B	A	A	B	A	B	B	A
11.	A	B	A	B	B	A	B	A
16.	B	B	A	A	A	A	B	B

Blank

	Blue	Circle	Dot	Large	Red	Square	Stripe	Small
2.	B	A	B	A	A	B	A	B
3.	A	A	B	B	B	B	A	A
4.	A	B	B	A	B	A	A	B
5.	B	B	B	B	A	A	A	A
7.	A	A	A	A	B	B	B	B
8.	B	A	A	A	B	B	B	A
9.	A	A	A	B	B	A	B	A
10.	B	B	A	A	A	A	B	B
12.	A	B	B	A	B	A	A	B
13.	B	B	B	B	A	A	A	A
14.	B	A	B	A	A	B	A	B
15.	A	A	B	B	B	B	A	A

Problem 4 Successive

	Blue	Circle	Dot	Large	Red	Square	Stripe	Small
Outcome								
1.	B	A	B	A	A	B	A	B
6.	B	B	B	B	A	A	A	A
11.	A	B	B	A	B	A	A	B
16.	A	A	B	B	B	B	A	A
Blank								
2.	A	B	A	B	B	A	B	A
3.	A	A	A	A	B	B	B	B
4.	B	A	A	B	A	B	B	A
5.	B	B	A	A	A	A	B	B
7.	A	A	B	B	B	B	A	A
8.	B	A	B	A	A	B	A	B
9.	A	B	B	A	B	A	A	B
10.	B	B	B	B	A	A	A	A
12.	B	B	A	A	A	A	B	B
13.	A	A	A	A	B	B	B	B
14.	A	B	A	B	B	A	B	A
15.	B	A	A	B	A	B	B	A

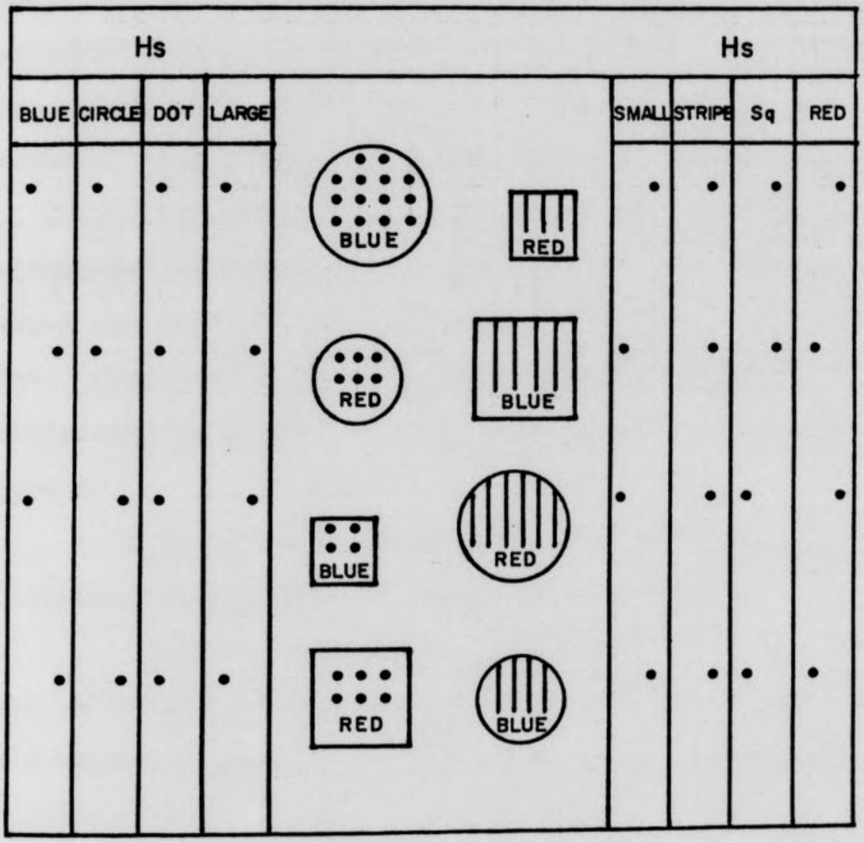


Figure 2. SET A SIMULTANEOUS PROBLEMS O.T.S.

Procedure

Ss were run individually. In order to meet the assumption that the set of hypotheses from which S samples was known exhaustively to E, a practice session preceded the experiment's two successive and two simultaneous problems. The practice problems are delineated in Table 2. With practice problems the first four problems were successive, with feedback on each trial of the first, second and third. Blank trials were initiated on problem four. Problems 5 and 6 were simultaneous problems constructed by adding the contrast stimulus to problems 3 and 4.

S was seated across from E and received the following instructions for successive problems.

"In this experiment ("game" for children) you will be presented with several easy problems. Each problem is a series of pictures. Each picture has four characteristics, shape (either square or round), two sizes (either small or large), inside pattern (either stripe or dot), and color (either red or blue, or sometimes red or green). Each picture is an A or a B, one each time. I want you to guess whether the picture you see is an A or B. I will tell you whether it was an A or B. There is just one characteristic ("thing" for children) that makes it an A. For example you may find all squares are A's. If you can find what characteristic (thing) makes it an A you can be right all the time. In a minute I'll start the problem (game). Make your guess on the very first trial. Remember you are looking for just one characteristic (thing), either color, size, shape, or inside pattern."

The first practice problem consisted of eight trials in which red was an A. The S received the deck face up. He responded to the top card, the appropriate outcome was given, and S then turned the card face down, out of the way. Ss who said "red" received the next practice problem. An S who chose any other than the eight simple hypotheses was told, "The problem is not that complicated. One of the shapes, circle or square, or one of the colors, red or blue, or one of the patterns, dot or stripe, or one of the sizes, large or small, makes it an A." The non-solving S then did that problem again.

If S did not solve it the second time he was simply told "A is red."

On the second practice problem, large was an A. With the third problem A was circle. The same procedures were followed.

On practice problem four, blank trials were introduced. S received the following instructions:

"On the last problem I said 'right' or 'wrong' after each card. For the next problem I will not always tell you whether you are right or wrong. After some cards I won't say anything. Don't let that bother you. Try to be right all the time."

E repeated, "One of these--red or blue, circle or square, large or small, stripe or dot--makes it an A."

E then presented the fifth and sixth practice problems with these instructions: "In some problems you will be asked to put your finger on one of two pictures which you think is an A. Put your finger on the one that is an A." These instructions were repeated with each trial.

Experimental problems described previously were administered, either the two Simultaneous or the two Successive together.

The order of simultaneous or successive problems was counterbalanced by randomly assigning half the subjects of a developmental level to one order, the other half to the other, using a table of random numbers.

The E said "right" or "wrong" on trials 1, 6, and 11 according to a prearranged schedule and regardless of S's response. The eight possible right/wrong sequences were randomly assigned to two sets, and Ss were assigned to feedback sets using a table of random numbers.

TABLE 2

Practice Problems

Number	Constant	Irrelevant	Relevant	Stimuli	Order
1. Succ.	Size: large	Pattern: S vs D Shape: C vs S	Color: R = A B = B	LBSS LBSD LBCS LRSD LRSS LRCS LRCD	Same
2. Succ.	Pattern: stripe	Shape: C vs S Color: R vs B	Size: L = A S = B	A. LBSS B. LBCS C. SBSS D. SBCS E. SRCS F. SRSS G. LRCS H. LRSS	C,H,G,A,E,D,B,F
3. Succ.	-	Size: L vs S Color: R vs G		A. LRSS I. LRSD B. LRCD J. LRCS C. LGSD K. LGSS D. LGCS L. LGCS E. SRSD M. SRSS F. SRCS N. SRCD G. SGSS O. SGSD H. SGCD P. SGCS	J,N,H,A, Q,L,M,G, B,K,C,F, I,P,D,E,

TABLE 2--Continued

4. Succ.	-	Size: L vs S Color: R vs B Shape: C vs S	Pattern: D vs S	left stimulus of OT 1,6,11,16, & BT 2,3,4, 5,12,13,14,15; right stimulus of BT 7,8,9,10 of problem 6		B,G,E,F, H,D,H,G, F,E,C,H, E,G,F,A,
5. Sim.	was produced by adding contract stimulus to problem 3.					
6. Sim.		same as 4		Left	Right	
				B. LRCS	SBSD	B,G,E,F,
				D. SRSS	LRCD	H,D,H,G,
			OT	C. LBSS	SRCD	F,E,C,H,
				A. SBCS	LRSD	E,G,F,A,
				E. LBCD	SRSS	
			BT	F. SRCD	LBSS	
		produced by interchanging OT position; randomize		G. SBSD	LRCS	
				H. LRSD	SBCS	

The sets of feedback are shown in Table 3.

Trial sixteen was treated separately. S was told nothing after this trial.

TABLE 3

Right-Wrong Feedback

rt.	rt.	wr.	rt.	wr.	wr.	rt.	wr.
wr.	wr.	rt.	rt.	wr.	rt.	rt.	wr.
rt.	wr.	wr.	wr.	wr.	rt.	rt.	rt.

Each counterbalanced cell consisted of 20 Ss in a 2 (replications) by 2 (conditions) by 6 (developmental levels) design.

Following the experimental session each S was given a package of M and M candy.

RESULTS

Statistical tests of the difference between proportions

$$z = \frac{p_1 - p_2}{\sigma_{p_1 - p_2}}$$

were used to compute results based on four problems (two simultaneous, two successive) for twenty Ss per developmental level, giving a total of 480 problems, 1,440 blank trial sets and 1,920 outcome trials.

Gross Efficiency

A gross analysis of efficiency can be given by the number of problems solved. The criterion of problem solution was the last BT set consistent with the correct hypothesis. For problems solved, the Simultaneous condition was more efficient, $z = 3.36$, $p<.001$. Proportions of problems solved in the Simultaneous and Successive conditions at various developmental levels are presented in Tables 4A and 4B.

The Simultaneous condition was superior for each developmental level except kindergarten, where Ss solved an equal number of problems.

In the Successive condition, fourth graders tended to solve fewer problems than kindergarteners (a fourth grade dip), and significantly fewer than ninth graders, $z = 2.19$, $p<.05$. Given the Simultaneous condition, fourth graders were not only more adept than kindergarteners; they were in a class with ninth graders and college students.

Older Ss were not different from returning students in the Simultaneous condition; given the Successive presentation, fewer problems were solved, $z = 1.85$, $p<.05$.

TABLE 4A

Proportion of Problems Solved in the Simultaneous and Successive Conditions at Developmental Levels

	Proportion		z	
Group	Simultaneous	Successive		Total
K	.25	.25		.25
4	.425	.15	2.49**	.2875
9	.50	.275	2.02	.3875
C	.45	.325	1.12	.3875
R	.50	.375	1.12	.4375
O	.325	.175	1.43	.24

The proportions of problems solved at developmental levels are given in Table 4A.

TABLE 4B

Comparison of Groups

Simultaneous	z
K & 4	1.81*
R & O	1.57
Successive	**z**
R & O	1.85*
4 & C	2.19**
4 & 9	1.56
Total	**z**
4 & 9	1.46
R & O	2.38**
K & O with C,9,R	1.96**

*p<.05
**p<.01

The potency of the Simultaneous condition was revealed by finer grain analysis of component processes.

Responding by Hypotheses

The tendency of Ss' responses to be organized by a consistent H was significantly different from 50% (the expected score had S been randomly generating responses rather than responding systematically in terms of Hs) for each developmental group in both conditions. The impact of condition was great, $z = 3.85$, $p<.01$. The proportions of H sets corresponding to simple Hs in the Simultaneous and the Successive condition at developmental levels are presented in Table 5.

TABLE 5

Proportion of H Sets Consistent with a Simple H in the Simultaneous and the Successive Conditions at Developmental Levels

	Proportion		z	
Group	Simultaneous	Successive		Total
K	.7125	.6563	2.30*	.6844
4	.7831	.775		.7781
9	.8313	.8375		.8344
C	.8250	.775	2.5**	.80
R	.825	.7875	1.87*	.7992
O	.825	.7375	4.38**	.7831

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

Developmental trends in responding by simple Hs are given in Table 5, in the Total column.

The tendency for Ss' responses to be organized by Hs as ascertained by the extent to which OTs can be predicted from BT data was again different from chance for each group in both conditions. Proportions of OTs consistent with preceding BT set in the Simultaneous and the Successive condition at developmental levels are shown in Table 6A.

TABLE 6A

Proportions of OTs Consistent with BT Set in the Simultaneous and the Successive Conditions at Developmental Levels

	Proportion		z	
Group	Simultaneous	Successive		Total
K	.6083	.55	.92	.5792
4	.7917	.7667		.7792
9	.8083	.8167		.8125
C	.8583	.8250		.8417
R	.8083	.7583		.7833
O	.7833	.725		
T	.7764	.7403	1.61	

TABLE 6B

Comparison of Groups

Simultaneous	z
Successive	z
Total	z
K & 4	4.47**
4 & 9	.89
R & O	3.01**

*p<.05
**p<.01

Proportions of OTs consistent with BT sets a developmental levels are shown in Table 6, in the Total column.

Immediate Reaction to Feedback

Win/stay. The proportion of precriterion BT sets on which the previous H was repeated following a correct outcome was greater in the Simultaneous condition, z = 2.23, p<.05. This result was obtained for all groups except college students, where the Successive condition was slightly more efficient, and kindergarteners and ninth graders, where the results were equivalent. Proportions of win/stay in the Simultaneous and the Successive condition at developmental levels are presented in Table 7A.

TABLE 7A

Proportions of Win/stay Responses in the Simultaneous and the Successive Conditions at Developmental Levels

	Proportion		z	
Group	Simultaneous	Successive		Total
K	.5735	.5849		.5785
4	.8485	.6333	3.36**	.746
9	.8824	.8929		.8871
C	.7941	.8302		.8099
R	.8254	.7667		.7967
O	.8971	.7358	2.95**	.8130

Given the Successive condition, fourth graders were significantly inferior to ninth graders; with the Simultaneous condition they were equivalent to ninth graders. There was a significant effect of condition for older Ss.

Developmental differences in win/stay are shown in Table 7, in the Total column.

TABLE 7B

Comparison of Groups

Simultaneous	z
Successive	z
4 & 9	3.12**
Total	z
K & 4	2.38**
4 & 9	3.52**
9 & C	1.87*
9 & R	2.26*

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

The probability of S retaining an H which was confirmed was found to increase with developmental level, although Ss of all groups responded appropriately above chance level. There was no decrement from returning to older Ss.

Lose/shift. The tendency to reject a disconfirmed H for another was supported by the data; the appropriate response was facilitated by condition, $z = 2.39$, $p<.01$.

Lose/shift proportions in the Simultaneous and the Successive conditions at developmental levels are presented in Table 8A.

TABLE 8A

Proportion of Lose/shift Responses in the Simultaneous and the Successive Conditions at Developmental Levels

	Proportion		z	
Group	Simultaneous	Successive		Total
K	.3542	.5	1.57	.4352
4	.62	.3548	2.95	.4786
9	.6751	.6557		.6637
C	.7059	.6508		.6745
R	.7193	.6333	1.04	.6752
O	.75	.5385	2.62**	.6325

Fourth graders, below kindergarteners, ninth graders, college, and returning Ss in the Successive condition, were again in the class with ninth graders and others when presented the Simultaneous stimuli. Developmental trends in lose/shift are presented in Table 8, in the Total column. There was no decrease in lose/shift from returning to older Ss.

TABLE 8B

Comparison of Groups

Simultaneous	z
K & 4	2.80**
Successive	**z**
K & 4	1.6
4 & 9	3.47**
R & O	1.46
Total	**z**
K & 4	2.38**
4 & 9	3.52**
9 & C	1.87*
9 & R	2.26*

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

Figure 3 depicts Logic in the Simultaneous and the Successive Conditions at Developmental Levels.

Information Processing

The behavior of all Ss can be described in accordance with the preceding measures as H testing. How

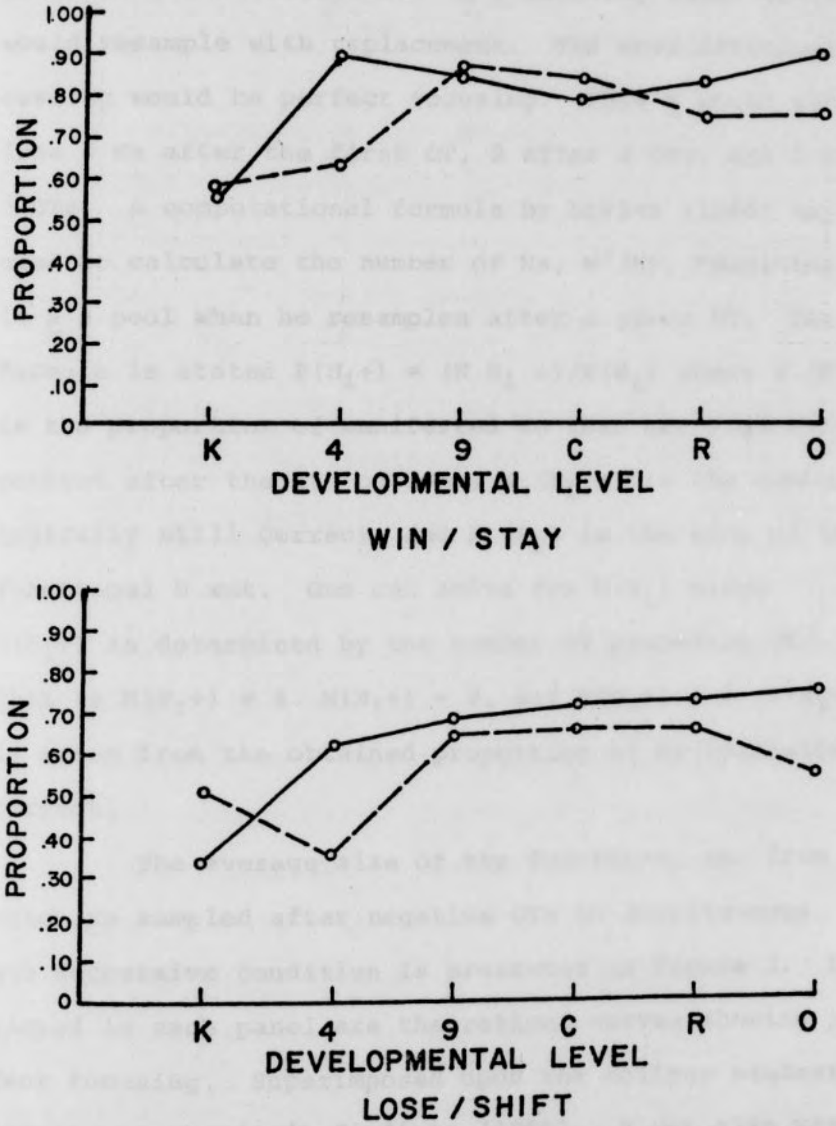


Figure 3. LOGIC IN THE SIMULTANEOUS AND THE SUCCESSIVE CONDITIONS DEVELOPMENTAL LEVELS

well does the S process the information? How well does he eliminate incorrect Hs? A S behaving least efficiently would resample with replacement. The most efficient processing would be perfect focusing. This S would sample from 4 Hs after the first OT, 2 after 2 OTs, and 1 after 3 OTs. A computational formula by Levine (1966) may be used to calculate the number of Hs, N (H), remaining in S's pool when he resamples after a given OT. The formula is stated $P(H_i+) = (N\ H_i\ +)/N(H_i)$ where $P\ (H_i\ +)$ is the proportion of manifested Hs that are logically correct after the ith outcome, $N\ (H_i\ +)$ is the number logically still correct, and $N\ (H_i)$ is the size of the functional H set. One can solve for $N(H_i)$ since $N(H_i+)$ is determined by the number of preceding OTs. That is $N(H_1+) = 4$, $N(H_2+) = 2$, and $N(H_3+) = 1$. $P(H_i+)$ is taken from the obtained proportion of Hs logically correct.

The average size of the functional set from which Ss sampled after negative OTs in Simultaneous and Successive condition is presented in Figure 3. Depicted in each panel are theoretical curves showing perfect focusing. Superimposed upon the college students' results are Levine's findings (1966). H set size was reduced by condition for all except kindergarten Ss.

Figure 4 depicts H Set Size Simultaneous and Successive at Developmental Levels.

Coding

Efficiency in information processing may be ascertained by examining whether a H after a correct OT is consistent with information conveyed by the previous positive OT. This coding process was designated "+ logical consistency." Proportions of + logical consistency (coding) in the Simultaneous and the Successive condition for developmental levels are presented in Table 9. Condition was potent, $Z = 2.25$, $p<.01$.

Recoding

The H following an error trial may be judged as consistent or inconsistent with information conveyed by the previous OT. This recoding process was designated "- logical consistency." Proportions of - logical consistency (recoding) in the Simultaneous and the Successive condition at each developmental level are shown in Table 10. A significant effect of condition was again observed, $Z = 1.85$, $p<.05$.

Memory

Retention of previously stored information may be measured by Hs that were consistent with the outcome information one or two steps away. Consistency with respect

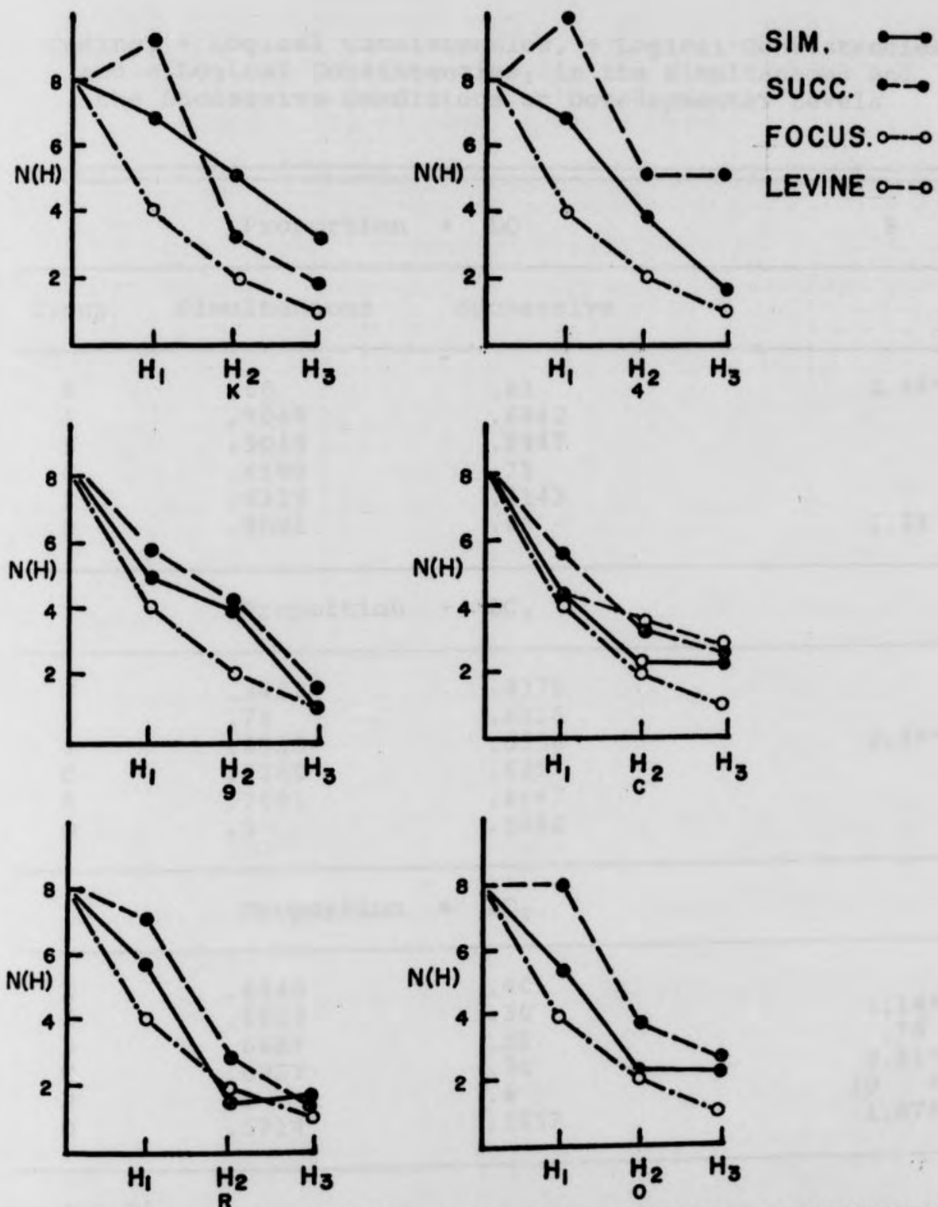


Figure 4. H SET SIZE SIMULTANEOUS AND SUCCESSIVE AT DEVELOPMENTAL LEVELS

TABLE 9

Coding, + Logical Consistencies, + Logical Consistencies$_1$ and + Logical Consistencies$_2$ in the Simultaneous and the Successive Conditions at Developmental Levels

	Proportion + LC		z
Group	Simultaneous	Successive	
K	.60	.61	2.38**
4	.9048	.6842	
9	.9048	.8947	
C	.6190	.75	
R	.6319	.7143	
O	.9091	.80	1.23
	Proportion + LC$_1$		
K	.3462	.4375	
4	.76	.6316	
9	.8333	.5556	2.39**
C	.7380	.625	
R	.7083	.6667	
O	.5	.5882	
	Proportion + LC$_2$		
K	.4545	.40	
4	.6667	.30	2.14*
9	.6667	.55	.79
C	.6957	.30	2.81**
R	.8	.4	10 **
O	.5714	.2857	1.87*

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

TABLE 10

Proportions of - Logical Consistencies (Recoding), - Logical Consistencies$_1$, - Logical Consistencies$_2$ in the Simultaneous and the Successive Conditions at Developmental Levels

Group	Simultaneous	Successive	z
Proportion of - Logical Consistencies			
K	.4762	.4167	
4	.5	.5238	
9	.7895	.70	
C	.85	.6190	2.08*
R	.6667	.5789	
O	.7	.52	1.23
Sim.			
Proportions of - Logical Consistencies$_1$			
K	.3077	.2917	
4	.5	.5238	
9	.7895	.70	
C	.7333	.3750	2.46*
R	.6667	.44	1.46
O	.60	.30	1.82*
Proportions of - Logical Consistencies$_2$			
K	.1667	.20	
4	.3333	.15	1.19
9	.3333	.10	1.51
C	.3857	.30	1.51
R	.2105	.40	1.44
O	.11	.10	

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

to positive outcome information one and two steps remote was designated "+ LC_1" and "+ LC_2," respectively. Retention of positive information two steps remote from feedback was enhanced by condition, $Z = 4.42$, $p<.001$.

Decrement in performance with "- LC_1" and "- LC_2" (information consistent with negative feedback and consistent with all previous information) was less in the Simultaneous condition.

Retention effects may be evaluated by finding the difference proportion of Hs zero and two steps remote from feedback. These difference proportions at developmental levels are shown in Figure 4. Once processed, OT information was well retained by returning S̲s, lost at high rates by ninth grade and older S̲s.

Figure 4 shows Proportion of Loss at Developmental Levels LC to LC_2.

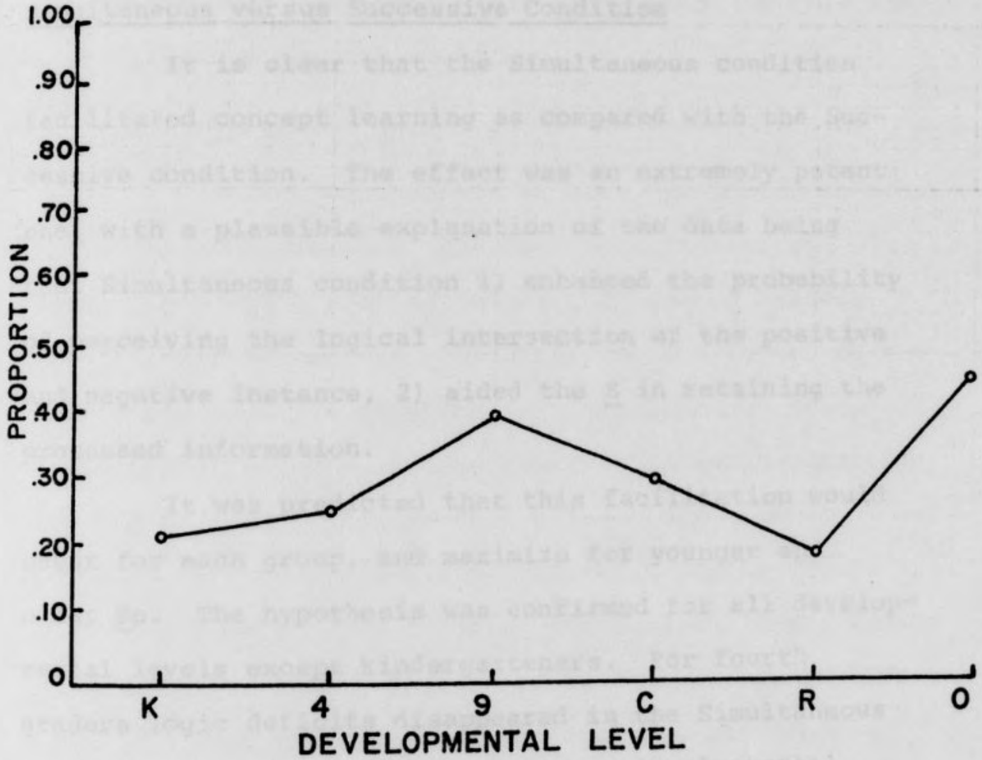


Figure 5. PROPORTION OF LOSS AT DEVELOPMENTAL LEVELS LC TO LC_2

DISCUSSION AND CONCLUSIONS

Simultaneous versus Successive Condition

It is clear that the Simultaneous condition facilitated concept learning as compared with the Successive condition. The effect was an extremely potent one, with a plausible explanation of the data being that Simultaneous condition 1) enhanced the probability of perceiving the logical intersection of the positive and negative instance, 2) aided the S in retaining the processed information.

It was predicted that this facilitation would occur for each group, and maximize for younger and older Ss. The hypothesis was confirmed for all developmental levels except kindergarteners. For fourth graders logic deficits disappeared in the Simultaneous condition. Figure 3 depicts logic at developmental levels.

Rieber (1967) found in elementary school children that, although the Simultaneous presentation allowed children to make direct comparisons, it also decreased the likelihood that the stimuli would be perceived individually, with a net effect of easier learning with the Successive presentation. When the uniqueness of cues was enhanced by having them present at the time the response was made, Simultaneous presentation led to faster learning.

With a self-paced procedure it is possible that kindergarteners, and many other Ss, turned the card before utilizing the information.

Developmental Differences

Problems were solved at each developmental group including kindergarten. The fact that Ingalls and Dickerson found H testing behavior in second graders (1969) while Rieber did not (1965) was attributed to the use of six practice problems (all simultaneous procedure). Eimas (1970) found H testing behavior in second graders and one group of first graders using eight practice problems (all simultaneous procedure). Levine (1966) used four simultaneous practice problems to insure that S was sampling from a finite set of Hs known exhaustively to E. Thus the present study's use of six practice problems to acquaint S with two different procedures seemed reasonable.

There was a reliable increase in performance from kindergarten to fourth-grade to ninth-grade Ss in problem solving. Ninth graders, college, and returning students did not differ, while older Ss solved the same proportion of problems as kindergarteners, but for different reasons.

For kindergarteners the deficiency was mediated by failure of information processing, for older Ss by the loss of processed information.

Eimas' contention (1970) that deficit in younger Ss' performance may be attributed to information's not reaching higher processing rather than failure to perceive the logical intersection was substantiated by the results from the fourth-grade Ss in the Simultaneous condition. "The fourth-grade dip" was suggested in the Successive condition. High proportions of win/stay and BTs consistent with OTs, low proportions of lose/shift in the Successive condition could be construed as perservation in fourth graders and older Ss.

Equivalent performance of ninth grade, college, and returning students was qualified by different component processes. Ninth-grade performance was characterized by intensity of performance with immediate feedback, with some memory loss as demands of processing became more remote from feedback, suggesting that the performance of the ninth-grade children remained quite high despite loss because they had so much to lose. It is interesting to speculate on their improvement five years hence, given the college student's facility with recoding and memory. Superior retention of processed information, and less effect of condition made substantial contribution to the returning student's efficiency.

These results indicate that the readily available college student is a representative part of the over-all picture when one looks at concept learning at some varying developmental levels. Even with this cross-sectional picture, one needs to replicate the results by a longitudinal study of the same subjects. One must await this experiment.

SUMMARY

An experiment was conducted with 120 Ss, twenty at each of six developmental levels: kindergarten, fourth grade, ninth grade, college students, returning students thirty-five years to forty-six years of age, and older Ss sixty-five years old or older. It sought to determine the efficiency of the Simultaneous versus the Successive stimulus presentation with blank trials in concept learning.

It was hypothesized that the Simultaneous presentation would enable Ss of all developmental levels to perceive the logical intersection of positive and negative instances, and retain the processed information more readily, and that this facilitation should maximize for younger and older Ss. The hypothesis was confirmed, although facilitation was not as great for kindergarteners.

H testing behavior was observed in kindergarteners.

An over-all logic deficit in fourth graders was greatly diminished by the Simultaneous presentation. These results were consistent with Eimas' (1969, 1970) supposition that the inefficiency of younger Ss may not be attributable to "intellectual deficit," absence of

rules and ability to apply them, but to the role of memory in processing.

Developmental differences were manifested in a general curve, appearing across conditions, of increase from kindergarten to fourth grade to ninth grade, where a plateau of performance of ninth grade, college, and returning students occurred, with a significant decrease for older Ss.

Component processes that contributed to equal performance were analyzed, and found quite distinctive for various developmental levels.

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