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AUTHOR	Bourne, Lyle E., Jr.
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ABSTRACT

Conceptual problems were administered in two formats, rule learning and attribute identification, to 192 college students. The stimulus patterns were gemoetric designs. Results showed that bidimensional concepts about the patterns were retained nearly perfectly up through periods of one week, without intevening practice. The one exception was concepts based on the rule "if x, then y" learned in the attribute identification paradigm; the difficulty appeared to be traceable to the asymmetry of the conditional rule and to the greater susceptibility of relevant stimulus attributes than conceptual rules themselves to forgetting. (Author/DT)

LONG-TERM RETENTION OF SIMPLE CONCEPTS

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COGNITIVE LEARNING

Technical Report No. 240

LONG-TERM RETENTION OF SIMPLE CONCEPTS

by

Lyle E. Bourne, Jr.

Report from the Conditions of Learning and Instruction Component of Program 1

Vernon L. Allen, Frank H. Farley,
Herbert J. Klausmeier and Joel R. Levin
Principal Investigators

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

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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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Abstract

One function of concepts is to simplify what a person knows and remembers about his circumstances. Any concept may be formed on the basis of a wide and numerous variety of instances. A learner presumably need not remember these instances, however; as long as he has the concept, he can work his way back to those particulars.

Surprisingly, there is little empirical evidence about the long-term retention of concepts. This study shows that bidimensional concepts about neutral pictorial material are retained nearly perfectly up through periods of one week, without intervening rehearsal or practice. The one exception is concepts based on a conditional rule, "if $\underline{x}$, then $\underline{y}$," learned in an attribute identification paradigm. The difficulty of this concept appears to be traceable to the asymmetry of the conditional rule and the greater susceptibility of relevant stimulus attributes than conceptual rules themselves to forgetting.

I
Introduction

There has been considerable recent research on the importance of logical rules as determiners of the difficulty of conceptual tasks (e.g., Bourne, 1970; Laughlin, 1969). In rule learning or rule identification problems, i.e., where the relevant attributes of the concept are given to S but the rule combining them is unknown, a regular order of rule difficulty has been observed. Affirmations and conjunctives are the easiest, followed in order by disjunctives, conditionals, and biconditionals. That order of difficulty has been attributed to the relative familiarity of different rules and to the interference effects of preexisting habits when the rule is something other than a conjunctive or an affirmation (Bourne & O'Banion, 1971, Sawyer & Johnson, 1970). In attribute identification problems, where the rule is given and the attributes are unknowns, rule differences also affect problem difficulty, though the precise order appears to depend on certain experimental conditions. When the selection paradigm is used, the typical order is conjunctive, biconditional, disjunctive, and conditional, from easiest to hardest (e.g., Laughlin, 1969; Taplin, 1971). In the reception paradigm with three-leveled stimulus dimensions, the order is identical to that observed in rule learning: conjunctive, disjunctive, conditional, and biconditional, from easiest to hardest (Bourne, 1970).

Like most available data, these observations have been taken in problems which require the learning of some unknown concept. While the importance of short-term memory within the initial concept formation process is well documented (e.g., Dominowski, 1965), data are lacking on the long-term memory of concepts. Even if one includes the retention of concepts embedded in prose materials, the evidence, as Gagné (1969) has noted, is at best fragmentary and inconsistent. Retention of substance, of ideas, or of concepts, in contrast to the retention of rote-learned verbal material, is still relatively unexplored. The present study, then, is fundamentally exploratory. It examines the retention of class concepts pertaining to pictorial material and based on a variety of rule forms over intervals up to one week.

Both intuitively and on the basis of Gagné's results (Gagné, 1969; Gagné & Eassler, 1963), one would expect individual concepts, once learned, to be well retained. While the initial formative process might be difficult because of the necessity to master a complex unfamiliar rule and/or to evaluate the relevance of a large number of stimulus attributes, the solution itself takes a simple form which ought to be highly resistant to forgetting. It represents a principle for organizing and responding to a large number of stimuli, but only some small subset of stimulus attributes--e.g., one or two--needs to be remembered. The principle that is formed is logically general enough to apply to any stimulus. Thus, retention of particular stimuli used in training is not required.

There are some potentially interesting empirical questions about the retention of concepts. First, as was noted above, concepts are not equally difficult to learn. Some, according to Neisser and Weene (1962), are structurally more complex than others. One might ask whether structural complexity makes a difference in how well concepts are retained. For example, are biconditional concepts more difficult to retain than structurally-simple conjunctive concepts?

Secondly, suppose we think of the rule and the attributes of a concept as two distinct kinds of subordinate knowledge (Gagné, 1969). We know from previous research that attribute identification problems based on a particular rule are typically more difficult than rule learning problems based on the same rule. Does the difficulty of the original problem format, and the type of knowledge it requires S to learn, relate significantly to retention?

Finally, assuming that concrete concepts are subject to forgetting, how does that process proceed in time and what are the underlying factors?

It should be noted that the procedures to be used in this study differ in a number of ways from those of experiments on the retention of prose and other substantive concepts. Most importantly, in the present case Ss will learn only one concept, not several. The reason is that concepts of the type to which this research is meant to apply are relatively difficult and time consuming to master. Further we wish to avoid interference effects from other simultaneously-learned concepts (e.g., Gagné & Wiegand, 1968). Secondly, degree of original learning, a possible contaminating variable in some earlier experiments, will be controlled by using the same criterion for all concepts in all conditions. Finally, all major aspects of the learning situation, including the concepts themselves and S's responses during learning and the retention tests, are nonverbal. While these conditions have been relatively standard in experimental work on concept formation, they are essentially untried in the study of concept retention.

In summary, the purpose of this study is to examine the retention of individual, non-verbal concepts based on a variety of rules up through a one-week innterval. While the study is essentially empirical, we do expect (a) that retention, in general, will be excellent, (b) that initial rule difficulty will relate directly to amount of forgetting, and (c) that possible differential forgetting of the subordinate knowledge components, the rule and the attributes of the concept, will emerge.

II
Method

Subjects and Experimental Design

The Ss were 192 college students who received $3 for their participation in the experiment. They were assigned at random, but in equal numbers, to 48 conditions. They participated individually, and none had been in a concept learning experiment before.

Conceptual problems were based on four different rules, the conjunctive (and), the disjunctive (and/or), the conditional (if, then), and the biconditional (if and only if). Each rule generates a unique assignment of stimulus patterns to response categories. These differences are illustrated in Bourne (1970). Problems were administered in two task formats, rule learning and attribute identification. Instructions for a rule learning problem provide S with the names and a written reminder of the two relevant attributes of the unknown concept. The S's task, then, is primarily to discover the correct relationship between two given attributes. Instructions for an attribute identification problem provide S with a description and several examples of the rule to be used. In this case, then, the rule is given and S's task is to discover the two relevant attributes. To provide some generality and to cut down on possible collusion among Ss, two different sets of relevant attributes, one chosen from the dimensions of color and form and the other chosen from the dimensions of size and number, were used for different Ss. Finally, conditions were arranged so as to test Ss for their retention after 1 hour, 1 day, or 1 week. Thus, the design was a 4 (rule), by 3 (retention interval), by 2 (task format), by 2 (pair of relevant attributes) factorial, yielding 48 conditions. There were four Ss in each condition, two females and two males.

Task and Procedure

In the learning phase, S's task was to learn how to assign stimulus patterns to two response categories, marked "plus" and "minus" on a response panel. At the beginning of the experiment, each S received oral instructions describing the nature of the concepts, the stimulus population, the general procedure of the experiment, the use of the pushbutton response panel, and the meaning of feedback. Practice with naming the stimuli and using the response panel was given. Prior to the first trial of the experimental problem, either the two relevant attributes or the rule to be used (depending upon whether S was assigned to an attribute identification or a rule learning problem) was named, described, and illustrated until both S and E agreed on an understanding. At the beginning of the experimental problem, a stimulus was back-projected to a translucent screen in front of S. The S pressed one of the two response buttons, "plus" or "minus," to indicate his guess of a category for that stimulus. The slide immediately disappeared and at the same time a light appeared for a duration of 2 sec. over the correct response button. Following a 5-sec. intertrial interval, the next slide appeared and the procedure was repeated. The learning phase was terminated when S had completed 16 correct response trials in a row.

Between the learning phase and the test of retention, Ss practiced for 1 hr. on a pursuit rotor task. While this task was meant only as a diversion, it was described to S as an integral part of the experiment, just as important as the concept learning problem previously learned. After instructions about the pursuit rotor, Ss were given 25 30-sec. practice trials with a 1 min. rest between trials. The pursuit rotor task was always practiced during the 1 hr. period just before the test for concept retention. Thus, one-third of the Ss practiced immediately after the concept learning phase, one-third practiced 23 hours later, and one-third practiced 167 hours later.

Immediately after pursuit rotor practice, S was seated once again before the viewing screen used in the concept learning problem. Several tests of retention were administered to S in the following order. First, he was required to give a verbal description of the concept he had previously learned, with no instructions, stimuli, or other kinds of information provided by E as prompts. A correct verbal report had to include both the relevant attributes and a rule stated in such a way that all stimuli could be properly categorized. After S's statement had been recorded, a series of 16 stimuli were presented successively on the screen and S was asked to classify them into the "plus" or "minus" categories without feedback. The task was self-paced with a 5-sec. interval between S's response and the appearance of the next stimulus. The stimuli were chosen so as to include four with both relevant attributes, four with the first but not the second, four with the second but not the first, and four with neither relevant attribute. Finally, after these 16 stimuli had been presented without feedback, S was required to relearn the original problem. Conditions were identical to those used in the original learning phase, including feedback for each response. The S was taken to the criterion of 16 correct responses in a row.

Materials

The stimulus patterns were geometric designs projected on a viewing screen. Patterns varied in four dimensions, each with three levels: color (red, yellow, blue), size (large, medium, small), number (1, 2, 3 identical figures), and form (square, triangle, hexagon). The relevant attributes were either red and square or one and large, with all other attributes irrelevant to the solution.

Presentation of stimulus patterns, the control of feedback signals, the timing of various experimental events, and the recording of responses and feedback were accomplished automatically with an apparatus described by Bourne and Haygood (1959). The pursuit rotor and associated apparatus are described in Lordahl and Archer (1958).

III
Results

The raw scores for five measures, errors and trials to solution of the original problem, errors on the 16-item retention test, and errors and trials to solution after the retention interval, were approximately normally distributed and the heterogeneity of variance was within reasonable tolerance limits. Means of these measures, plus the percentage of Ss who correctly verbalized the concept just prior to retention tests, are presented in Table 1 for the various main conditions of the experiment.

Measures of Original Problem Solving

While it is obviously a dummy variable, length of retention interval was used to classify trials and errors to original problem solution. There were three significant sources of variance for both measures: Task, $F(1,144) = 35.16$, $p < .01$; Rule, $F(3,144) = 29.01$, $p < .01$; and the interaction of Rule and Task, $F(3,144) = 6.25$, $p < .01$--all Fs for error scores only. These results are entirely consistent with previous experiments. Attribute identification, i.e., gaining knowledge of the relevant attributes of a concept, presents a more difficult problem than rule learning, i.e. gaining knowledge of the rule component (Haygood & Bourne, 1965). Rules increase in difficulty in the order conjunctive, disjunctive, conditional, and biconditional, with significant difference (by Newman-Kuels analysis) between each pair of rules except conjunctive and disjunctive, $p < .05$. An examination of the means for the interaction between Rule and Task shows that it is not attributable to differing rule orders in rule learning and attribute identification. Rather it reflects the fact that differences between successive pairs of rules are considerably greater for attribute identification than for rule learning. Thus, as in earlier experiments using the reception paradigm (e.g., Bourne & Haygood, 1959), the order of rule difficulty is the same, conjunctive through biconditional, in both task formats.

It may be noted that no statistically significant effects were attributable to length of retention intervals. Mean errors for 1 hour, 1 day, and 1 week intervals were 16.4, 15.5, and 16.9, respectively. This outcome attests to the adequacy of sampling procedures and the lack of any bias in retention test measures which might be attributable to initial differences among groups in problem-solving ability.

Measures of Retention

Retention of concepts is indexed by four measures, C through F, in Table 1. These measures tend to be redundant; what can be said about one of them can, in general, be said about all. The least sensitive measure is the percentage of Ss giving a correct verbalization, which was generally high across conditions. That fact plus some inexplicable irregularities in the percentages lead us to emphasize errors (and trials) to relearning as the primary index.

There were three primary sources of variance. First of all, errors to relearning increased with length of the retention interval, $F(2,144) = 8.76$, $p < .01$. Rules differed significantly, $F(3,144) = 8.09$, $p < .01$, but the order was not the same as that observed in original learning. Conjunctive was easiest, followed in order by biconditional, disjunctive, and conditional. A reliable Rule by Time interaction, $F(6,144) = 4.48$, $p < .01$, helps to clarify this change. There is little difference in rule difficulty over a one hour, or even a one day, retention interval. After one week, however, the conditional requires over five times as many trials and errors for solution as any of the other rules. The remaining rules are, at this point, roughly equivalent

TABLE 1

Retention Interval

Rule	Task*	Measure**	1 hour	1 day	1 week
Conjunctive	AI	A	8.50	8.25	8.88
		B	21.50	24.75	29.76
		C	88	88	75
		D	.38	.00	1.63
		E	.00	.13	.50
		F	.00	.13	1.50
	RL	A	1.63	.88	1.88
		B	7.75	4.75	6.63
		C	100	100	88
		D	.50	.00	.88
		E	.00	.13	.88
		F	.00	.13	1.63
Disjunctive	AI	A	10.63	11.63	15.75
		B	32.38	37.13	44.13
		C	100	75	100
		D	.13	1.00	1.00
		E	.13	1.63	.75
		F	.88	3.88	5.38
	RL	A	8.50	7.75	6.00
		B	27.50	24.50	25.50
		C	63	75	88
		D	.63	.63	.25
		E	.00	.75	1.00
		F	.00	2.40	5.88
Conditional	AI	A	20.00	26.88	26.13
		B	72.00	78.50	77.75
		C	63	38	25
		D	.88	2.50	3.75
		E	.75	1.88	7.88
		F	4.75	8.50	29.76
	RL	A	16.13	11.75	17.38
		B	58.88	41.50	56.38
		C	88	50	38
		D	1.00	1.13	1.25
		E	.13	.88	2.63
		F	.50	6.88	10.88

(Continued)

TABLE 1 (Continued)

Rule	Task	Measure*	1 hour	1 day	1 week
Biconditional	AI	A	48.00	42.88	41.38
		B	106.25	106.00	94.38
		C	100	88	88
		D	.00	.13	.38
		E	.00	.13	.13
		F	.00	.50	.38
	RL	A	17.63	14.25	17.25
		B	53.50	40.00	46.00
		C	50	38	88
		D	1.00	.50	.13
		E	.00	.38	1.38
		F	.00	1.63	6.38

* AI: Attribute identification
RL: Rule learning

** A: Errors in original learning
B: Trials in original learning
C: Percent correct verbalization
D: Errors on retention test
E: Errors in relearning
F: Trials in relearning

to one another. Overall, only the difference between conditional and nonconditional concepts was statistically significant, $F(1,144) = 14.93$, $p < .01$. The Rule by Task interaction, $F(3,144) = 3.63$, $p < .05$, was marginally significant, and provides some additional clarification of rule order in retention. In rule learning, the four rules remain equivalently difficult across all retention tests. In attribute identification, however, there is a marked difference, with conditional requiring nearly three times as many trials and errors for solution as the next most difficult rule (disjunctive). Thus, it would appear that the primary, if not the only, significant loss of information about concepts over time occurs in the single case of conditional attribute identification problems. Furthermore, this loss is apparent only after relatively long retention intervals.

IV
Discussion

As in prose and other verbal material (Gagné, 1969), the retention of class concepts pertaining to pictorial stimuli is, in general, excellent. With one exception, there is little evidence of forgetting under any circumstances. The one exception, however, needs to be critically examined, for on the surface it is not clear why forgetting would be so limited.

Significant forgetting occurs only in the conditional attribute identification problem. Errors and trials to relearning in this case are two to three times as great as they are for any other problem after a one-week retention interval. Why performance should deteriorate under this condition and not in others is not obvious. First of all, while this is a difficult condition in original learning, it is certainly not the most difficult. If one were to argue that retention is inversely related to difficulty in original learning (Underwood, 1964), then biconditional problems should suffer at least as much retention loss as conditional ones. Moreover, at the end of original learning, Ss who have solved the conditional concept under rule learning and attribute identification conditions should have exactly the same knowledge. In either case, they should know both the rule and the attribute components of the concept. Why, then, should attribute identification Ss exhibit a retention loss nearly two and a half times the loss of rule learning Ss?

A plausible interpretation of this effect is based on the following considerations. First of all, performance on a retention test depends, as does original problem solving, on knowing both concept components. Under the conditions of the present study, there are more different attribute pairs than there are rules. With four dimensions and three values per dimension, there are 54 possible pairings of attributes. In contrast, there are only 16 ways of combining a pair of attributes to form concepts of the type considered here. Furthermore, some of those are probably not obvious or familiar enough to S to be considered as real possibilities (Haygood & Bourne, 1965). Considering both the larger pool of possibilities and the greater opportunity for interference, it seems reasonable to expect worse retention of the relevant attributes than of the rule of a concept. Evidence from the verbalization task would tend to substantiate this idea. While the verbalization measure is neither precise nor rigorous, 77% of failures to provide a correct verbalization were attributable to loss of one or both attributes, whereas only 54% involved an inaccurate statement of the rule. There is, therefore, more apparent forgetting of attributes than rules.

While it is true that every S presumably knew the attributes of his concept at the end of original training, the attributes are probably better learned after rule learning than after attribute identification. In the case of rule learning, S is given the relevant attributes at the outset of the problem. A reminder of the attributes is provided for him to examine throughout the problem. He uses these attributes continuously during the problem, in combination with one or another rule, in an effort to solve the problem. In attribute identification, however, S discovers the relevant attributes only at the end of the problem. Whenever he finally samples the correct pair of attributes and integrates them with the rule which he has been given, the problem is solved. The attributes, then, are probably at weaker strength after attribute identification than they are after rule learning. For that reason, we would expect more forgetting for attributes in the case of attribute identification than in rule learning, even though S presumably knows both the attributes and the rule at the end of training in either case. This possibility is also substantiated by the verbalization data. Considering only inaccurate verbalizations, 63% were accounted for by attribute loss in rule learning and 83% by attribute loss in attribute identification.

On the basis of the preceding argument, we would expect greater forgetting after attribute identification conditions. While this is true in general, the conditional problem still stands out as a special case. The reason for extraordinary forgetting of conditionals appears to be the asymmetry of this rule. The conditional concept, "if x, then y," is different from the conditional concept, "if y, then x." Thus, one could remember the two attributes, x and y, and still fail tests of retention simply by reversing their order. Once again, the verbalization data are suggestive of this possibility. Nine out of 12 Ss failed to provide an adequate verbalization of the conditional concept in the attribute identification condition after a one-week retention interval. Three of the nine failures named the correct pair of attributes in reversed order and apparently went on to use them that way.

Supporting this interpretation are not only the verbalization data but also the results of categorizing tests. On the blank trials test, the majority of errors in conditional problems were made on stimuli with one but not the other relevant attribute, the TF and FT instances. An average of 2.93 errors was made on these two stimulus classes in contrast to an average of .82 errors on TT and FF instances. Errors were nearly equally divided between TF and FT instances--1.44 and 1.48, respectively. In contrast, the usual distribution of errors in conditional rule learning problems shows a greater accumulation in TF and FF than in either of the other two classes. One would expect the usual result if the conditional rule and not the attributes had been forgotten.

Examination of the error pattern under all nonconditional rules shows a tendency for errors to be distributed equally across the classes of the truth table. This similarly can be taken as evidence of the forgetting of attributes rather than rules, for each rule tends to have its own characteristic distribution of errors across truth table categories (Bourne, 1970). Had the rule been forgotten, we would expect this pattern to be reflected in blank trials and the relearning data, just as they were in original learning.

One argument is, then, that forgetting tends to be greatest in conditional attribute identification problems because (a) attributes are harder to remember than rules, (b) more training is provided on attributes under rule learning than under attribute identification conditions, and (c) the conditional case requires not only the retention of the attributes but the retention of the order in which they are to be used.

While it is probably fortuitous, the order of rule difficulty in retention is the same as that reported by Giambra (1969), Laughlin (1969), and Taplin (1971) in attribute identification tasks using the selection paradigm. As noted, these results are different from the ordering obtained for the same rules in the reception paradigm used in the present study and elsewhere (Bourne, 1970). It is tempting to speculate about the possible difference in the role that memory plays in selection and reception procedures as a route to explaining the discrepancy in results. On the surface, however, the extent to which memory processing is required would appear to be greater in the reception than the selection paradigm, casting some doubt on the applicability of the results of this study to observed differences in the difficulty of rules.

Finally, we note the consistency in these data with Gagné's analysis of concept learning and retention (e.g., Gagné, 1969). First, when only a single concept is learned, thereby minimizing interference effects, retention is typically near perfect, even after a week. While some forgetting does occur, it is not nearly of the same magnitude found under rote learning conditions or when interference is high. Second, differential forgetting of attributes and rules points up the necessity to consider concept components or subordinate knowledge in any interpretation of learning processes. Both attributes and rules, in their proper relationship, are necessary for the retention and subsequent utilization of a concept. If S fails to retain one component, the entire concept is "forgotten." While the two subordinate knowledges might not be entirely independent, it is possible to retain one without the other, thereby failing to retain the concept. Forgetting might, in both cases, be a function of the number of competing possibilities, the number of different rules or attribute pairs in the available pool.

These findings suggest several lines of further research. For example, retention for concepts about pictorial material should be examined under conditions of greater interference, such as that provided by learning a number of different concepts simultaneously or in close succession. Furthermore, it would be appropriate to measure retention of rules and attributes where the number of both in the pool of possibilities is systematically varied. Expectations in both these cases follow straightforwardly from Gagné's analysis of prose concepts.

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References

Bourne, L. E., Jr. Knowing and using concepts. Psychological Review, 1970, 77, 546-556.

Bourne, L. E., Jr., & Haygood, R. C. The role of stimulus redundancy in concept identification. Journal of Experimental Psychology, 1959, 58, 232-238.

Bourne, L. E., Jr., & O'Banion, K. Conceptual rule learning and chronological age. Developmental Psychology, 1971, 5, 525-534.

Dominowski, R. L. Role of memory in concept learning. Psychological Bulletin, 1965, 63, 271-280.

Gagné, R. M. Context, isolation, and interference effects in the retention of fact. Journal of Educational Psychology, 1969, 60, 408-414.

Gagné, R. M., & Bassler, O. C. Study of retention of some topics of elementary nonmetric geometry. Journal of Educational Psychology, 1963, 54, 123-131.

Gagné, R. M. & Wiegand, V. K. Some factors in children's learning and retention of concrete rules. Journal of Educational Psychology, 1968, 59, 355-361.

Giambra L. M. Effect of number of irrelevant dimensions with ten concept types on the attribute identification task in the selection mode with exemplar and nonexemplar start cards. Psychonomic Science, 1969, 14, 75-76.

Haygood, R. C., & Bourne, L. E., Jr. Attribute- and rule-learning aspects of conceptual behavior. Psychological Review, 1965, 72, 175-195.

Laughlin, P. R. Selection versus reception concept-attainment paradigms as a function of memory, concept rule, and concept universe. Journal of Educational Psychology, 1969, 60, 267-273.

Lordahl, D. S., and Archer, E. J. Transfer effects on a rotary pursuit task as a function of first task difficulty. Journal of Experimental Psychology, 1958, 56, 421-426.

Neisser, U., & Weene, P. Hierarchies in concept attainment. Journal of Experimental Psychology, 1962, 64, 644-645.

Sawyer, C. R., & Johnson, P. J. A conceptual rule learning model. Paper presented at the meeting of the Rocky Mountain Psychological Association, Salt Lake City, May 1970.

Taplin, J. E. An experimental study of human reasoning and conceptual behavior. Unpublished Ph.D. dissertation, University of Adelaide, South Australia, 1971.

Underwood, B. J. Degree of learning and the measurement of forgetting. Journal of Verbal Learning and Verbal Behavior, 1964, 3, 112-129.

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