University of Windsor

Scholarship at UWindsor

Electronic Theses and Dissertations

Theses, Dissertations, and Major Papers

1-1-1970

Concept identification as a function of the conceptual rule and length of the post-informative feedback interval.

Robert N. Carey
University of Windsor

CONCEPT IDENTIFICATION AS A FUNCTION OF THE CONCEPTUAL RULE AND LENGTH OF THE POST-INFORMATIVE FEEDBACK INTERVAL

by

ROBERT N. CAREY
B.A., York University, 1969

A Thesis
Submitted to the Faculty of Graduate Studies through the
Department of Psychology in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts at the University of
Windsor

Windsor, Ontario, Canada
1970

UMI Number: EC52791

INFORMATION TO USERS

ProQuest LLC
789 E. Eisenhower Parkway
PO Box 1346
Ann Arbor, MI 48106-1346

AB53379

APPROVED BY:

Gediminas A. Nenke

Akira Nakagawa

R. Robert Orr

321804

ABSTRACT

Each of 144 Ss solved one of two rule learning problems in a study which combined four conceptual rules and three (1, 8 or 15 sec.) post-informative feedback intervals in an orthogonal design. Visual stimuli varying in three (2 relevant and 1 irrelevant) tri-level dimensions were sorted into one of two response categories with the restriction that each successive block of 12 stimuli would have an equal number of positive and negative instances. The restriction necessitated the duplication of some stimulus patterns. A criterion of 16 consecutive correct responses or a total of 96 trials was used. The task was paced with no correction permitted and no delay in the presentation of informative feedback.

Both errors-to-criterion and trials-to-criterion data indicated a hierarchy of problem difficulty running in the following order from the easiest to most difficult: conjunctive, inclusive disjunctive, exclusive disjunctive and biconditional rules. It is of interest to note that the latter two are complementary rules, however, the exclusive disjunctive rule was found to be significantly easier to learn than the biconditional rule. The range of post-informative feedback intervals used in the study did not produce differential performance on the task.

PREFACE

The current study began when the author became interested in concept acquisition tasks, especially those involving the identification of conceptual rules. Specifically, interest centered on what effect increasing the length of the post-informative feedback (PIF) interval would have on the identification of concepts based on different conceptual rules. It was felt that such research would add further important information on the effect of the PIF interval in concept learning tasks.

I would like to express my gratitude to Dr. G. Namikas, my director, whose helpful suggestions and lasting guidance made this paper possible. Thanks must also go to Dr. A. Kobasigawa and Dr. R. Orr for their valuable suggestions and criticisms. Finally, words of appreciation must be extended to Bill Somes, the laboratory technician, to George Andreoff who assisted in the experiment, and to all those subjects who kindly participated in the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

REVIEW OF THE LITERATURE

Bourne (1966) defines a concept as a category of things which are perceptible and have a real existence in the organism's environment; things being referred to as stimuli or stimulus objects. Stimuli vary along dimensions; however, not all of the dimensions on which the stimuli belonging to a certain conceptual class vary, are important in defining the concept. As Bourne (1966) points out, we refer to those dimensions which are important in delineating the concept as 'relevant' and those which are not important as 'irrelevant'. Furthermore, a dimension has (by definition) at least two and usually more discriminably different values or attributes. For example, red, green, blue, etc., are different values within the dimension of colour (or hue). Finally, some stimuli illustrate the concept and others do not. We refer to those stimuli which illustrate or exemplify the concept as 'positive instances' and those which do not exemplify the concept as 'negative instances'.

It is evident from the literature on concept learning, that the majority of studies in this area have concentrated on attribute identification (AI) problems, in order to determine if the complexity of the stimuli used affects problem acquisition when rule difficulty is held constant.

In attribute identification studies, the complexity of stimuli used (complexity determined by the number of relevant and irrelevant dimensions) varies, while the rule combining the attributes is held constant.

A second type of concept learning task is referred to as 'rule learning' (RL). The complexity of stimuli is held constant, while the conceptual rule varies in this task. The subject (S) is told the relevant attributes or dimensions and must attempt to identify the rule by which the attributes are combined.

If two attributes "red" and "square" are arbitrarily designated as relevant, then a conjunctive conceptual rule would be exemplified by all stimulus patterns which contain both the attributes 'red' and 'square' together. For inclusive disjunction ("and/or"), all stimulus patterns which are 'red' or 'square' or both are examples of this conceptual rule. In the case of exclusive disjunction ("or"), all patterns which are 'red' or 'square' but not both are examples of the rule. For the conditional rule ("if-then"), if a pattern is 'red' then it must also be 'square', for it to be an example of the rule. Finally for the bi-conditional rule, ("if and only if"), 'red' patterns are examples if and only if they are 'square'; while at the same time patterns which are not 'red' are examples if and only if they are not 'square' (Bourne, 1967).

Rule Learning

It is important to realize, as Haygood and Bourne (1965) have pointed out, that interest in most conceptual learning studies has centered primarily on the discovery or identification of relevant attributes (i.e., attribute identification problems). In studies of this sort, the typical procedure is to describe and illustrate the general form of the solution with preliminary instructions and practice problems. That is, the S is given the relevant rule or form of solution and must attempt to discover or identify the relevant attributes required for problem solution. As Haygood and Bourne (1965), point out, however, little concern has been fostered for the study of conceptual rule learning as a variable, for the purpose of determining whether rules are intrinsically different in difficulty when the subject is not required to identify relevant attributes. In conceptual rule learning or rule identification tasks, therefore, the S is told the relevant attributes and must thereby attempt to identify the rule by which these attributes are combined.

Bruner, Goodnow and Austin (1956) upon examination of their own studies and data provided by Hovland and Weiss (1953) for AI tasks, suggest that disjunctive conceptual rules may be more difficult to learn or identify than conjunctive conceptual rules, possibly as a result of the way in which Ss utilize positive and negative instances. They state that Ss do not seem to be as willing or able to use negative instances telling what the concept is not, as opposed to positive instances in attaining a concept. This reluctance appears to carry over to disjunctive categorizing.

The results of a study by Bourne and Guy (1968) show that in

AI tasks, performance with positive instances is best for conjunctive concepts. When a mixture of both positive and negative instances was used for both AI and RL tasks, the order of difficulty of the rules studied was: conjunction, inclusive disjunction and conditional, from easiest to hardest.

Neisser and Weene (1962), found that the difficulty of conceptual problems depended upon the rule used and that conceptual rules differed in difficulty according to the number of relevant and irrelevant dimensions. Conceptual rules consisting of univariate attributes, i.e., those defined by the presence or absence of a single attribute (redness, for example), constituted the first level of rule complexity or difficulty. The second level of conceptual rule complexity was the bi-variate group, consisting of six rules which involve single conjunctions or disjunctions of two relevant attributes (for example, red and square). Finally, the most complex rules, of level three, involved both conjunctive and disjunctive operations in a single conceptual problem, (e.g., "red and not square" or "not red and square").

No prediction was made concerning the relative difficulty of rules within a single level. However, it was observed that, within the second level of rule complexity, conjunctive problems were found to require fewer trials to criterion that disjunctive problems.

Additional evidence of the greater difficulty of learning or identifying disjunctive concepts as compared to conjunctive concepts, was provided by Conant and Trabasso (1964) when they found that the mean number of instances chosen to problem solution was greater for the inclusive disjunctive (D) set, than for the conjunctive (C) set, although the difference was not significant. They also found in summing the mean number of instances chosen over all problems, that Ss learned to select, within a problem, a positive instance under 'C' conditions more rapidly than a negative instance under 'D' conditions. They state that Ss appear to solve 'C' concepts sooner since they learn to choose positive instances within a 'C' problem more rapidly than negative instances within a 'D' problem. An informational analysis was performed on card choices with respect to the number of redundant and nonredundant card selections to solution; a card being defined as redundant if it could not eliminate at least one further incorrect solution beyond those already eliminated by the example card or preceeding card choices.

The mean number of nonredundant choices were nearly equal for 'C' and 'D' problems; however, the mean number of redundant choices was significantly greater in the case of 'D' than for 'C' problems.

Haygood and Bourne (1965) described three levels of conceptual problem difficulty as did Neisser and Weene (1962). In addition they conducted some experiments on rule learning in order to determine if rules did in fact differ in difficulty. They found that conjunctive problems required fewer trials to solution than inclusive disjunctive and conditional problems.

In another series of experiments, Bourne (1967) again showed that, with regard to rule learning problems, rules do indeed differ in difficulty, the order of increasing difficulty being; conjunctive, inclusive disjunctive, conditional and bi-conditional.

Furthermore, Bourne, Ekstrand and Montgomery (1969), have shown in a study involving attribute identification problems based on four different conceptual rules (conjunctive, inclusive disjunctive, conditional and bi-conditional) each combined factorially with four levels of feedback availability (feedback retained for all instances, for positive instances only, for negative instances only, and no feedback retained), that the order of problem difficulty varied with the rule used, that order remaining precisely the same as that reported in earlier work cited above (Bourne, 1967).

Some interesting results have been obtained by Bourne and Guy (1968), however, in relation to conceptual rules. Three types of concepts; conjunctive, inclusive disjunctive, and conditional were used, with two different task requirements; attribute identification (AI) and rule learning (RL). These authors found that AI tasks were more difficult that RL tasks and that performance was affected by the type of concept instance presented during the training series; mixed positive and negative instances being associated with fewest and all negative with most trials to solution. When a mixture of both positive and negative instances was used, the order of difficulty of the rules studied was: conjunction, inclusive disjunction and conditional from easiest to hardest for both RL and AI problems. However when only negative instances were used in AI problems this order was reversed: conditional, inclusive disjunction, conjunction from easiest to hardest.

The evidence indicates, therefore, that there is a consistent hierarchy of rule difficulty when both positive and negative instances are used for RL problems. The order of difficulty has been shown to be conjunctive, inclusive disjunctive, conditional and bi-conditional.

The Post-Informative Feedback (PIF) Interval

The recent interest in the RL aspect of concept acquisition has been paralleled by an increase in concern with informative feedback conditions. One aspect of such conditions is the informative feedback interval, (i.e., the time between the subject's response and the presentation of feedback). Another is the post-informative feedback interval (i.e., the time between the presentation of feedback and the occurrence of the next stimulus pattern).

In a study by Bourne (1957), Ss learned to solve one of three conjunctive problems, (A) orientation-form, (B) vertical position-size and (C) colour-number; each problem being defined as four combinations of two particular attributes of two relevant dimensions. Subjects were presented with a series of geometric patterns and were required to identify a category to which each pattern belonged by pressing one of four unlabelled response keys. Utilizing an informative feedback (IF) interval ranging from 0.0 to 8.0 seconds, Bourne concluded that performance was degraded as a function of increases in the length of the (IF) interval. As Bourne later indicated (Bourne and Bunderson, 1963) the conclusion was questionable since the study confounded the duration of the IF interval with the duration of the post-informative feedback (PIF) interval. Since the screen upon which a stimulus pattern had been presented became blank for 10.0 seconds, following S's response, the intertrial interval (i.e., IF interval plus PIF interval) used was 10.0 seconds. Since the informative feedback interval varied from 0.0 to 8.0 seconds, this meant that the PIF interval would also vary in length from 2.0 to 10.0 seconds.

In another study, Bourne and Bunderson (1963), used three conjunctive type problems, in a 3 x 3 x 2 factorial design with three delays of IF interval (0, 4 and 8 seconds), three lengths of post-IF interval (1, 5 and 9 seconds) and two degrees of task complexity (1 and 5 irrelevant dimensions). They found that performance improved linearly as the post-IF interval increased, with 5 seconds being the optimum for problems with one irrelevant dimension; while 9 seconds seemed best for problems with five irrelevant dimensions.

It was further shown in a study using conjunctive type conceptual problems with one and five irrelevant dimensions (Bourne, Guy, Dodd and Justesen, 1965), that errors to solution were reliably affected by three factors; number of irrelevant dimensions, length of the PIF interval, and the interaction of these two variables. For relatively easy problems with one irrelevant dimension, the optimum PIF interval was 9.0 seconds, while for relatively difficult problems, having five irrelevant dimensions, the optimum PIF interval was 15.0 seconds. In addition, moderate increases in the length of the PIF interval (to 9.0 seconds) resulted in reliable improvements in overall performance for both easy and difficult conceptual identification problems (difficulty being defined in terms of the number of irrelevant dimensions).

Finally, Roweton and Davis (1968), in a study of conjunctive problems in which S was presented a series of geometric-patterned stimuli, each pattern representing a combination of the levels of two relevant plus two or four irrelevant binary stimulus dimensions, found that although performance generally improved with longer PIF intervals (up to 20 seconds), the effect was non-significant.

It would appear, therefore, on the basis of the above studies (Bourne & Bunderson, 1963; Bourne et al., 1965; Roweton & Davis, 1968), that increases in the PIF interval facilitate performance on conceptual learning tasks, as a direct function of problem complexity. Roweton & Davis (1968), however, found that although performance generally improved with longer PIF intervals, the effect was non-significant. For relatively easy problems having one irrelevant dimension, the optimum PIF interval appears to be in the range of 5 to 9 seconds; while for more difficult problems with five irrelevant dimensions, the optimum PIF interval seems to be in the range of 9 to 15 seconds.

As indicated previously, the above functional relationship has been investigated by using differences in stimulus complexity to obtain differences in problem difficulty. In each case, the task given to the S was an AI task with the RL variable being held constant through the use of a single rule (conjunction) for all problems.

The data from RL studies have shown that problem difficulty may be varied through the use of conceptual problems requiring different rules. Moreover, a rather consistent hierarchy of rule difficulty has been observed, suggesting the extension of the study of PIF duration to concept acquisition situations in which problem difficulty is defined by the relative difficulty of the conceptual rule. In such a design, stimulus complexity would be held constant while the conceptual rules would differ for different problems.

The Present Study

The purpose was to study the effect of PIF interval length on concept acquisition tasks in which problem difficulty was a function of the relative difficulty of the conceptual rule, with stimulus complexity held constant.

As previously stated (Neisser & Weene, 1962; Conant & Trabasso, 1964) the acquisition of conjunctive problems requires fewer trials to solution than disjunctive problems. Furthermore, when a mixture of positive and negative instances was used in RL problems, the order of conceptual rule difficulty from easiest to hardest was conjunctive, inclusive-disjunctive, conditional and bi-conditional (Haygood & Bourne, 1965; Bourne, 1967; Bourne & Guy, 1968; Bourne et al., 1969).

On the basis of these findings, therefore, it was hypothesized that conjunctive, inclusive disjunctive and bi-conditional rules would differ in difficulty (measured in terms of mean number of trials and mean errors to criterion), the order being from easiest to hardest: conjunction, inclusive disjunction and bi-conditional. A condition utilizing an exclusive disjunctive rule was also included in the present study for comparative purposes, however, this condition was not expected to differ in objective difficulty from the bi-conditional rule condition, since these two rules are complementary to each other.

Secondly, it was stated above (Bourne & Bunderson, 1963; Bourne et al., 1965; Roweton & Davis, 1968) that increases in the PIF interval facilitate performance on conceptual tasks as a direct function of problem complexity; complexity measured in terms of the number of relevant and irrelevant dimensions. On the basis of the findings from these studies, two additional hypothesis were formulated.

It was hypothesized that increases in the length of the PIF interval would facilitate performance on concept identification tasks requiring a conjunctive, inclusive disjunctive, exclusive disjunctive and bi-conditional type of solution.

Finally, it was hypothesized that performance (measured in terms of both mean number of errors and trials to criterion) would improve for conjunctive, inclusive disjunctive, exclusive disjunctive and bi-conditional conceptual rule learning, as a function of moderate increases in the PIF interval. That is, it was hypothesized that optimal performance (measured in terms of both the mean number of errors and mean trials to criterion) will be associated with shorter PIF intervals for easier (conjunctive) conceptual rule learning task whereas the acquisition of more difficult conceptual rules (inclusive disjunction, exclusive disjunction and bi-conditional) will require longer PIF intervals for optimal performance.

CHAPTER II

METHODOLOGY AND PROCEDURE

Subjects. The Ss were 144 first and second year psychology students from the University of Windsor, assigned in order of appearance to one of 24 treatment conditions.

Apparatus. The Generalized Learning Apparatus (GLA) described in detail by Cervin et al., (1965), was used in the present experiment. Briefly, the GLA consists of a master control panel (19 in. x 86 in.) and six subject panels (19 in. x 14 in.) mounted on wooden frames and inclined at approximately 30° towards the S. The master control panel is located in a sound-proof room separated from the Ss room by a wall containing a one-way mirror.

On each of the S's panels there is a blue warning light (6.3 v., blue jewel) at the top, six white stimulus (CS) lights (NE 51 neon bulbs, white jewel) in a row across the middle of the panel, and a bottom row of six response buttons with an orange cue light (NE 51 neon bulbs) directly above each response button. On the left of each panel is a column of 7 green (positive reinforcement) lights (6.3 v., green jewel), and on the right a column of 7 red (negative reinforcement) lights (6.3 v., No 47 red jewel).

For the purposes of the present experiment, the following lights and buttons were exposed to the S: the blue warning light (6.3 v., blue jewel) at the top of the panel, a single white stimulus (CS) light (NE 51 neon bulb, white jewel) in the middle of the panel which served as a cue light, two response buttons located at the middle of the bottom row of response buttons. These two buttons were labelled with a positive (+) or a negative (-) sign to indicate a positive instance category (example) and a negative instance category (non-example), with which to classify the stimulus patterns. In addition, a single green (positive reinforcement) light on the left (6.3 v., green jewel) and a single red (negative reinforcement) light on the right (6.3 v., No. 47 red jewel) was exposed, through which feedback was presented to the S. All remaining lights not used in the experiment were taped over.

Stimuli. The stimulus patterns were geometric designs, prepared on photographic slides and varying along three tri-level dimensions. Dimensions and their corresponding attributes were: colour (red, yellow and blue), form (star, triangle and circle), and number (1, 2 or 3 identical figures). All possible combinations of these three tri-level dimensions result in 27 separate stimulus patterns ($3^3 = 27$). These 27 stimulus patterns (see Appendix A) were used in making up 24 different stimulus series, one series corresponding to each of the problems to be used in the 24 different treatment conditions.

With the GLA used in the present experiment the maximum number of trials which could be executed prior to the recycle phase was 36. When 36 trials had been executed, therefore, the machine recycled and began again at trial one. Each of the 24 stimulus series used in this experiment consisted of 96 stimulus patterns chosen from the original 27 patterns shown in Appendix A. That is, each stimulus series consisted of 96 tirals, a number felt to be adequate for the level of problem complexity used in the present study (see Haygood and Bourne, 1965). In order to equalize the number of positive and negative instances within each stimulus series (i.e., 96 trials), 6 positive and 6 negative instances were randomly assigned to each block of 12 stimulus patterns (i.e., 12 trials). In so doing, this held constant the number of positive and negative instances (examples, and non-examples) for each pair of relevant attributes chosen, over all rule-learning conditions.

The number of positive and negative instances for all treatment conditions, were equalized in an attempt to minimize the differential facilitating effects which might have resulted for the different rule-learning conditions, were positive and negative instances not equalized (Bourne and Guy, 1968). Equalizing positive and negative instances within blocks of 12 trials, however, necessitated replication of certain stimulus patterns shown in Appendix A.

The GLA was used to control the presentation of stimuli to the Ss, the length of time that the stimulus pattern remained on (stimulus interval), the presentation of a cue light to the S for 3.0 seconds during which time the S was required to respond (the response interval), the time between the S's response and the presentation of feedback (the informative feedback (IF) interval) and the length of time between feedback and the presentation of the next stimulus pattern (the post-informative feedback interval; PIF interval) (See figure 1). In addition the GLA was used to automatically record the S's response by means of an Esterline Angus Event Recorder. Responses were also recorded manually by the experimenter (E).

Colour slides were made to provide the complete stimulus series. The stimulus patterns were projected onto a white viewing screen centrally placed on the one-way mirror separating the E's control room from the S's experimental room. The stimulus patterns (colour slides) were projected onto this screen from the control room by means of a slide projector. Both the control room and the experimental room were semi-dark in order to produce a clear image for the Ss, since the one-way mirror cuts down considerably the transmitted light. The slide projector was controlled through the GLA control panel. Wooden partitions were placed on either side of S's panel so that no S could see the responses given by or the feedback presednted to any other S. The S's panel was situated so that he could clearly see the viewing screen.

Design. A 4 x 3 x 2 orthogonal design was used. Four types of conceptual rules (conjunctive, inclusive disjunctive, exclusive disjunction and bi-conditional) x three durations of post-informative feedback interval (1 second, 8 seconds, and 15 seconds) x two types of problems (Colour - Form and Number-Form).

Within each of these two problems; colour-form and number-form, there were nine different pairs of relevant attributes (see Appendix B). Each of the 24 different treatment conditions used, was randomly assigned a different pair of relevant attributes (see Appendix C),

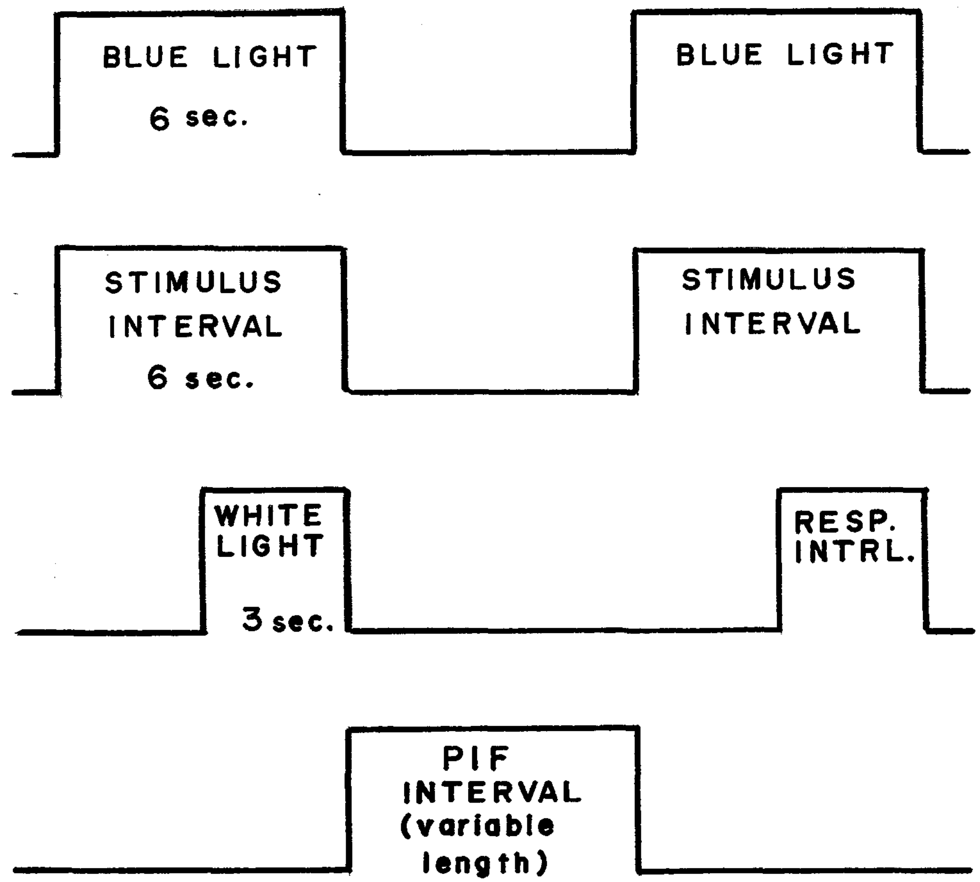

FIG. I. Diagramatic representation of time intervals controlled by the GLA.

in order to reduce the possible effect that the transmission of information from the experienced to the naive Ss might have had on the experimental results. That is, each of the 24 experimental groups (6 Ss per group) was assigned a single rule-learning problem, each of these problems based on a different pair of relevant attributes, whenever possible.

Procedure. The task required the S to classify a series of 96 stimulus patterns into either of two categories (positive or negative instances) according to some conceptual rule unknown to the S. The correct classification for any stimulus pattern was determined both by the pair of attributes relevant in the particular problem and by the conceptual rule which specifies the relationship between these attributes.

At the outset, all Ss were given detailed oral instructions describing the stimulus population and the task (see Appendix D). They were told that the stimulus patterns would be presented one at a time and that they must be classified into either of two categories (i.e., those that are and those that are not examples of the rule they are required to learn). All Ss were told that the stimulus patterns would vary along three dimensions, each dimension containing three attributes. The dimensions and their corresponding attributes were described. The Ss panel and the use of the various buttons on the panel which were pertinent to the experiment were explained to the S. Since this experiment consisted of rule learning tasks, all Ss were told the relevant attributes at the beginning of each problem but no instructions or explanation concerning the rule (that is, the way in which the attributes were to be combined), was given. A set of standard instructions was read to all Ss (see Appendix D).

For all Ss each stimulus pattern remained on for 6.0 seconds. A blue warning light appeared on the S's panel simultaneously with the presentation of the stimulus pattern on the screen. Three seconds after this blue light and the stimulus pattern appeared, a white cue light came on and remained on for 3.0 seconds. All Ss were instructed to place their finger on the response button of their choice (one of two buttons) but to respond only during the 3.0 second interval that the white cue light remained on. Following this three second response interval the blue light went off, the projector was advanced to a blank slide (no stimulus pattern), and the informative feedback lights came on. These IF lights remained on through the duration of the PIF interval. At the end of the PIF interval the blue light came on causing the feedback lights to go off, while at the same time the projector was advanced to the next stimulus pattern. The only interval that varied, therefore, was the PIF interval, taking on lengths of 1, 8, or 15 seconds.

Six Ss were run simultaneously on the GLA. When one or more of the subjects failed to show up they were run at a later time under the conditions specified for that treatment. In case of a single non-show S, an attempt was made to run two Ss at the same time; afterwhich one was discarded at random if only a single S was needed, in order to make the condition more analagous to the group situation in which the other Ss had been run.

The Ss were asked at the conclusion of the experiment to write down the rule they had arrived at in responding to the stimuli.

CHAPTER III

RESULTS

Number of Failing Subjects. One hundred and forty-four Ss were used in the present experiment, 36 being assigned to each of the four rule learning conditions. Of these 144 Ss, 59 (i.e., 41%) failed to reach the criterion of 16 consecutive correct responses within the 96 allotted trials.

Obtained frequencies for the number of failures for the rule variable are shown in Table 1. Chi-square analyses on the frequency of failures indicated that the rule variable was a significant determiner of failure ($X^2 = 30.153$, df = 3; $p < .01$). The significant chi-square is due primarily to the larger than expected number of failures in the biconditional group and the smaller than expected number of failures in the conjunctive group.

Of the 59 Ss who failed to reach the criterion (of 16 consecutive correct responses) the percentages accounted for by each of the rules was: biconditional, 52.54; exclusive disjunctive, 28.81; inclusive disjunctive, 11.86 and conjunctive, 6.78.

A chi-square analysis on the frequency of failures indicated that the PIF interval variable was not a significant determiner of failure ($X^2 = 2.576$, df = 2; $.10 > p > .05$).

Trials to Criterion.[1] Data on trials-to-criterion, total

---

1. Ss who did not reach the criterion of 16 consecutive correct responses were assigned a score of 96. The criterion run of 16 trials was not included in the total for each S.

TABLE I

NUMBER OF FAILURES AS A FUNCTION OF

THE CONCEPTUAL RULE USED

	RULES				
	Conjunctive	Inclusive Disjunctive	Exclusive Disjunctive	Biconditional	Total
Number of Failures	4	7	17	31	59
Percentage	6.78	11.86	28.81	52.54	

errors and the ability to verbalize the correct rule are shown (Appendix E) for each S as a function of the rule used. An analysis of variance on the trials-to-criterion data (Table 2), revealed a significant main effect for rules ($F = 34.77$, $df = 3/120$; $p < .01$) indicating that tasks based on conjunctive, inclusive disjunctive, exclusive disjunctive and biconditional conceptual rules differ in ease of acquisition. No other effects were found to be significant on the trials-to-criterion data.

Comparisons among the mean trials-to-criterion scores for rules were made, using the Newman-Keuls procedure (Winer, 1962), to determine which of the possible differences were significant.

Table 3 shows the results of these comparisons.

All rules differed significantly from each other at the .01 level of significance with the exception of the inclusive disjunctive rule which differed significantly from the conjunctive rule at the .05 level of significance.

Total Errors. It was considered worthwhile to look at error scores as a function of length of practice on the task for the different rules used. The trials were then grouped into blocks to twelve (see Table 4). An analyses of variance on error scores for Blocks of Trials (Table 5) confirmed the previous findings in that again a significant main effect for Rules ($F = 31.44$, $df = 3/120$; $p < .01$) was found. It is interesting to observe in Table 4, that for each of the 8 blocks of 12 trials mean errors increase from the conjunctive rule through the biconditional rule.

TABLE 2

SUMMARY OF AN ANALYSIS OF VARIANCE ON

TRIALS TO CRITERION

Source	df	MS	F
Rules (R)	3	33530.0625	34.768 **
Interval (I)	2	2524.5278	2.618
Problems (P)	1	2123.6736	2.202
R x I	6	1050.3889	1.089
R x P	3	1643.0625	1.704
I x P	2	744.1944	0.772
R x I x P	6	452.3333	0.469
Between Subjects	120	964.3819	
Total	143		

** $p < .01$

TABLE 3

NEWMAN-KEULS q_r VALUES FOR DIFFERENCES BETWEEN PAIRS OF ORDERED MEAN TRIALS-TO-CRITERION SCORES FOR RULES

RULES				
	Conjunctive	Inclusive Disjunctive	Exclusive Disjunctive	Biconditional
MEAN TRIALS	19.361	34.695	62.195	88.445
Conjunctive	______	15.334*	42.834**	69.084**
Inclusive Disjunctive		______	27.500**	53.750**
Exclusive Disjunctive			______	26.250**
Biconditional				______

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

TABLE 4

MEAN ERRORS FOR SUCCESSIVE BLOCKS OF 12 TRIALS

AS A FUNCTION OF THE CONCEPTUAL RULE

USED IN THE TASK

RULE	BLOCKS OF 12 TRIALS							
	1	2	3	4	5	6	7	8
Conjunctive	2.222	0.917	1.0	0.722	0.778	1.195	1.028	0.806
Inclusive Disjunctive	3.778	2.556	1.917	1.473	1.722	1.750	1.472	1.556
Exclusive Disjunctive	4.917	3.361	3.138	3.583	2.278	2.611	2.917	2.556
Biconditional	6.50	6.250	6.361	5.417	5.417	5.167	4.694	4.833
Mean:	4.354	3.271	3.125	2.799	2.549	2.681	2.528	2.438

TABLE 5

ANALYSIS OF VARIANCE FOR REPEATED MEASURES

ON ERROR SCORES FOR BLOCKS OF TRIALS

Source	df	MS	F
Rules (R)	3	1082.8018	31.440**
Problems (P)	1	40.1259	1.165
Interval (I)	2	101.9071	2.959
R x P	3	46.9291	1.363
R x I	6	32.7567	0.951
P x I	2	4.6988	0.136
R x P x I	6	17.3909	0.505
Subj. w. groups	120	34.4398	
Blocks of Trials (T)	7	57.6050	21.780**
T x R	21	5.2793	1.996**
T x P	7	3.1854	1.204
T x I	14	2.8327	1.071
T x R x P	21	2.6685	1.009
T x R x I	42	2.5447	0.962
T x P x I	14	1.7494	0.661
T x R x P x I	42	1.9151	0.724
T x Subjects w. groups	840	2.6449	
Total	1151		

** $p < .01$

A Newman-Keuls test (see Table 6) showed that all rules differed significantly from each other ($p < .01$).

The analysis of variance on error scores for Blocks of Trials (Table 5) also revealed a significant main effect for Blocks of Trials ($F = 21.78$, $df = 7/840$; $p < .01$) and a significant Rules X Blocks of Trials interaction ($F = 1.996$, $df = 21/840$; $p < .01$) was obtained. No other significant effects were found on the total errors data.

Comparisons among mean error scores for Blocks of Trials using the Newman-Keuls method (Winer, 1962) showed that there were significantly more errors in the first block of trials than in all other blocks ($p < .01$); that there were significantly more errors in the second block than in blocks 8, 7 and 5 ($p < .01$) and finally that there were a significantly greater number of errors in block 3 than in block 8 ($p < .01$). It was also shown that block 2 differed significantly from blocks 6 and 4, and that block 3 differed significantly from blocks 7 and 5 ($p < .05$). In addition it was found that of the 85 Ss who attained the criterion of 16 consecutive correct responses, 46(54.76%) did so during the first block of 12 trials, while 61 (71.76%) did so during the first 24 trials. Only 24 Ss (28.24%), however, attained the criterion of 16 consecutive correct responses in blocks 3 through 7.

The significant Trials main effect, therefore, is due mainly to the reduction in errors which occurs from the first block to the successive blocks of trials.

TABLE 6

NEWMAN-KEULS q_r VALUES FOR DIFFERENCES BETWEEN PAIRS OF ORDERED MEAN ERROR SCORES FOR THE RULE VARIABLE

	RULES			
	Conjunctive	Inclusive Disjunctive	Exclusive Disjunctive	Biconditional
MEAN ERRORS	8.667	16.306	25.361	44.639
Conjunctive	——	7.639**	16.694**	35.972**
Inclusive Disjunctive		——	9.055**	28.333**
Exclusive Disjunctive			——	19.278**
Biconditional				——

** $p < .01$

Mean errors for the Rules X Blocks of Trials interaction are shown in Figure 2, while Figure 3 shows average mean error scores of the four conceptual rules used in Blocks of Trials. The significant difference between the first Block of Trials and the other 7 Blocks of Trials is evident in Figure 3. It is further evident from Figure 2 that for all rules except the biconditional, the greatest decrease in mean number of errors occurs in the first Block of Trials.

Finally, the verbal responses obtained from all 144 Ss at the conclusion of the experiment showed that of the 36 Ss who worked on one of the 4 RL tasks, the number of Ss who were able to verbalize the rule correctly were 27, 7, 11 and 1 for the conjunctive, inclusive disjunctive, exclusive disjunctive and biconditional rule tasks respectively.

In summary, the findings from the chi-square analyses and the analyses of variance on trials-to-criterion and error scores show that rules do differ in difficulty. The significant main effect for Rules was mainly due to the significant difference in difficulty between the biconditional rule learning task and the conjunctive rule learning task, although the biconditional rule task also differed in difficulty from both the inclusive and exclusive disjunctive rule learning tasks. In addition the exclusive disjunctive rule task was shown to differ significantly in difficulty from both the conjunctive and inclusive disjunctive rule learning tasks. Finally, the inclusive disjunctive rule task differed significantly in difficulty from the conjunctive rule learning task. No significant main effects were found, however, for the PIF interval variable.

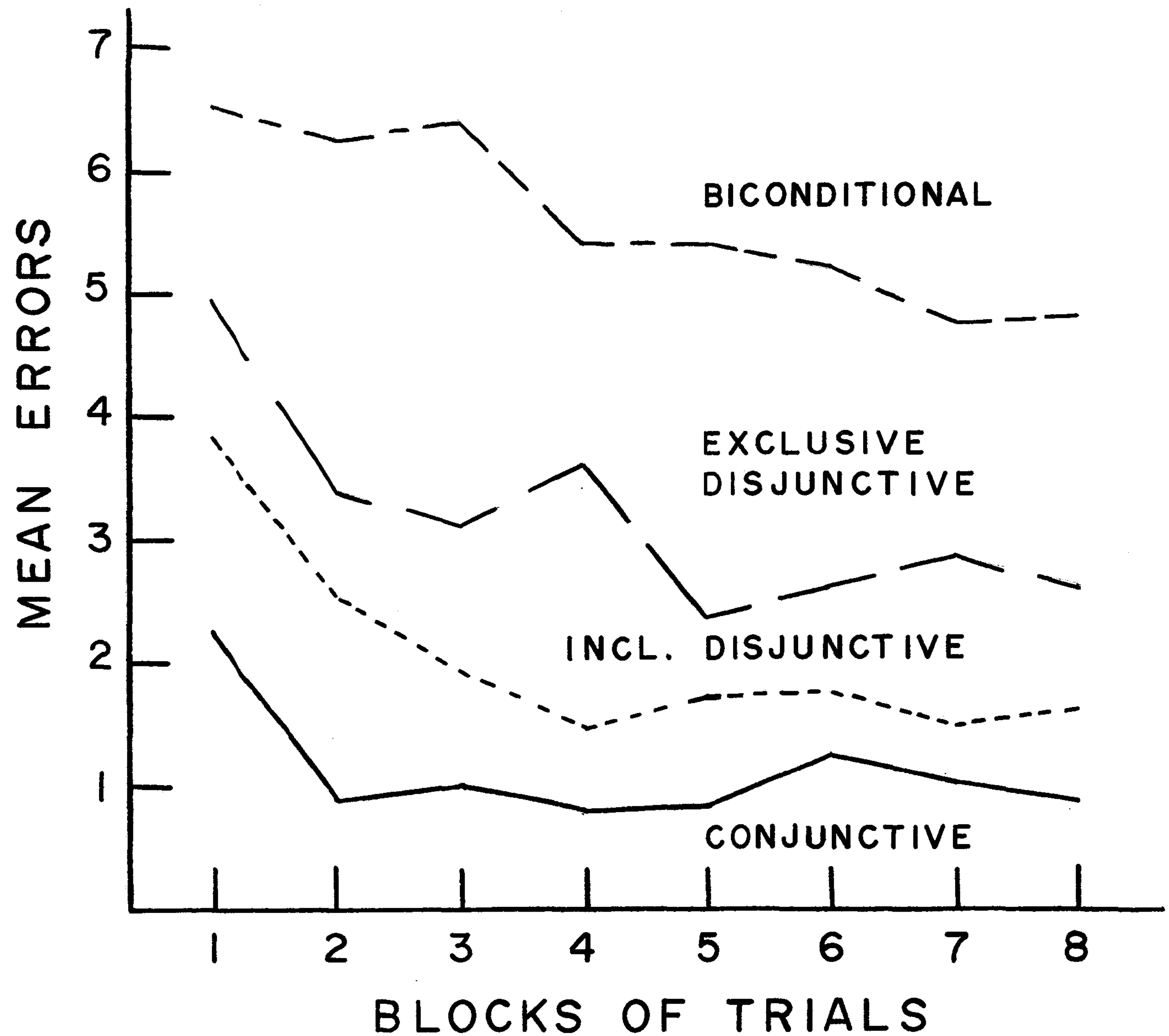

FIG. 2. Mean error scores for the four conceptual rules used shown in blocks of 12 trials each.

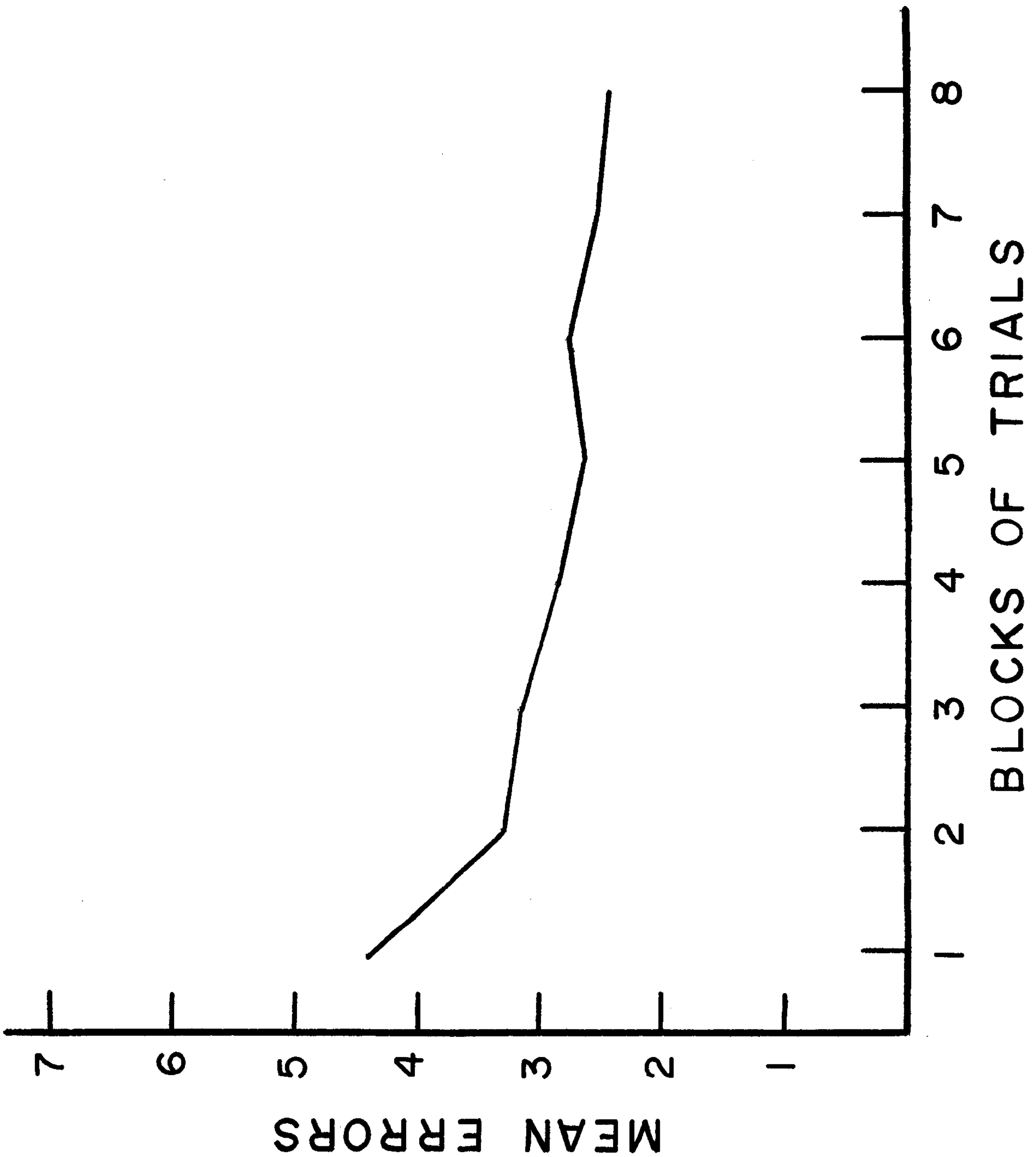

FIG. 3. Average mean error scores of the four conceptual rules used shown in blocks of 12 trials each.

An analysis of variance for repeated measures on errors for Blocks of Trials, revealed a significant main effect for Blocks of Trials and a significant Rules X Blocks of Trials interaction. The significant Trials main effect was due mainly to the reduction in errors which occurred from the first block to the successive blocks of trials.

CHAPTER IV

DISCUSSION

The preliminary analysis outlined in this paper revealed a significant main effect for both Rules and Blocks of Trials. A significant Rules X Blocks of Trials interaction was also found. No significant main effects were found, however, for the PIF interval variable.

Regarding conceptual rule difficulty the results of the present study are consistent with the previous finding that when a mixture of positive and negative instances are used in RL problems, the order of conceptual rule difficulty is conjunctive, inclusive disjunctive and biconditional (Haygood and Bourne, 1965; Bourne, 1967; Bourne and Guy, 1968; Bourne et al., 1969).

Contrary to expectation the biconditional rule was found to be significantly different from the complementary exclusive disjunctive rule, in the current study, based on both the mean trials-to-criterion and mean error score data.

The greater difficulty of the biconditional $[(R \cap S) \cup (\bar{R} \cap \bar{S})]$[2] as compared to the exclusive disjunctive $[(R \cap \bar{S}) \cup (\bar{R} \cap S)]$ rule, may have resulted from difficulty in the formulation of the biconditional rule because of its hierarchical organization as outlined by Neisser and Weene (1962). These authors state that conceptual rules can

---

2. R and S stand for red and star (relevant attributes) respectively. Symbolic descriptions using only three basic operations, $\cap$, $\cup$ and negation (-), are given in brackets, where $\cap$ = and, $\cup$ = or and negation (-) = not (e.g., $\bar{R}$ = not red).

be arranged in a hierarchy according to three distinct levels of difficulty. The simplest conceptual rules, those of level I, have one relevant dimension (e.g., R). Conceptual rules of level II involve single conjunctions or disjunctions of two relevant attributes (e.g., the inclusive disjunctive rule). Finally, level III conceptual rules have two relevant dimensions involving both conjunctive and disjunctive operations (e.g., the biconditional rule).

The possibility remains that Ss find the biconditional rule more difficult since they must have both the components $R \cap S$ and $\bar{R} \cap \bar{S}$ available for problem solution. If Ss are not aware that both components are essential, problem solution is not possible.

The conjunctive rule $[R \cap S]$, the inclusive disjunctive rule $[R \cup S]$ and the exclusive disjunctive rule $[R \bar{\cup} S]$ also require two components for problem solution.

For the conjunctive rule $[R \cap S]$ solution involves single conjunctions of both relevant attributes R and S, while solution for the inclusive disjunctive rule $[R \cup S]$ involves single disjunctions of both relevant attributes R and S.

The exclusive disjunctive rule $[(R \cap \bar{S}) \cup (\bar{R} \cap S)]$ and the biconditional rule $[(R \cap S) \cup (\bar{R} \cap \bar{S})]$, however, involve both conjunctive and disjunctive operations in their symbolic descriptions.

The verbal responses obtained from Ss who were assigned to the biconditional RL tasks, indicate that they found it difficult to formulate the $\bar{R} \cap \bar{S}$ component. Of the 36 Ss who worked on a biconditional RL task, 13 Ss (36%) were able to verbalize the $R \cap S$ component at the conclusion of the experiment. Of those 13 Ss only 1 acquired both components of the biconditional rule, which was necessary for correct solution. No such difficulty existed for the exclusive disjunctive rule, however, since Ss either verbalized both components or none at all. This may possibly explain the greater difficulty of the biconditional as compared to the exclusive disjunctive rule, observed in the present study.

The high failure rate for the biconditional rule (86.1%) indicates that there may be some special source of difficulty in this rule. Although no failure rates were given in the studies of Haygood and Bourne (1965); Bourne (1967), these authors found that conditional and biconditional rules differed significantly in difficulty from conjunctive and inclusive disjunctive rules. They stated that there may be some inherent difficulty in the conditional and biconditional rules and that a training series longer than their's(i.e., 5 successive problems) may be necessary to facilitate problem solution.

Neisser and Weene (1962) also found that some Ss failed to attain their criterion (i.e., 25 consecutive correct responses with only a single error) for the biconditional rule.

Perhaps the special difficulty with the biconditional rule can be found in the apparent inability of Ss to realize that a rule may be comprised of two essentially different operations (i.e., conjunctive and disjunctive).

The results of the analysis of variance on error scores for blocks of trials revealed some interesting findings. A significant main effect for Blocks of Trials and a significant Rules X Blocks of Trials interaction was found. The significance found for Blocks of Trials was shown to be due mainly to the reduction in errors which occurred from the first block to the successive blocks of trials. In fact, it was found that of the 85 Ss who attained the criterion of 16 consecutive correct responses, 46 (54.12%) did so during the first block of 12 trials, while 61 (71.76%) did so during the first 24 trials. Only 24 Ss (28.24%), however, attained the criterion of 16 consecutive correct responses in blocks 3 through 7. Therefore, while the majority of Ss who reached the criterion did so in the first 12 trials, some learning did occur after the first block of trials was over.

In addition, the significant Rules X Blocks of Trials interaction is interesting in view of Figure 2. The fact that this interaction is significant must be due in large part to the significant reduction in errors which occurs from the first block to successive blocks of trials. Figure 2 shows that for all rules except the biconditional, the greatest decrease in mean number of errors occurs in the first block of trials.

Another important variable in the present study was the PIF interval. The trend for mean trials-to-criterion and mean error scores indicated that a PIF interval of 8 seconds was best for performance while poorest performance seemed to occur at a 1 second PIF interval (e.g., mean error scores were 28.23, 20.13 and 22.88 for the 1, 8 and 15 second PIF intervals respectively).

Although the results were non-significant, the trend was in the same direction as that observed by Bourne and Bunderson (1963) and Bourne et al., (1965). They found that moderate increases in the length of the PIF interval (to 9 sec.) produced reliable improvement in overall performance on concept identification tasks.

Bourne et al., (1965) showed that for complex problems with five irrelevant dimensions, optimal performance was obtained at a PIF interval length of approximately 17 seconds. Simpler problems having one irrelevant dimension were best at a 9 second PIF interval.

Roweton and Davis (1968) also studied the effect of PIF interval length in concept acquisition tasks. They ran 36 Ss at each of 3 PIF interval lengths (0, 10 and 20 sec.) and found that performance generally improved with PIF interval lengths up to 20 seconds, although the results were not significant. Similarly, no significant interval main effect was found in the present study, using 48 Ss at each of the PIF interval lengths 1, 8 and 15 seconds.

The findings of this and the Roweton and Davis study (1968) suggest that PIF interval must be a relatively weak variable in concept acquisition tasks. It may be, however, that use of a greater range of intervals may result in significant effects for the PIF interval variable in concept acquisition tasks. In fact, Roweton and Davis (1968) stated that one reason for the non-significant main effect of the PIF variable may have resulted from the possibility that optimal PIF interval lengths simply were not included in their study. This possibility may also exist in the present author's study.

Another explanation of why the PIF interval variable may turn out to be non-significant was offered by Bourne et al., (1965). They state that interference through loss of memory (for information provided by previously displayed pattern stimuli) may result in poor performance on concept identification tasks. Indeed, they showed that fewest mean errors occurred in the condition where both stimulus and IF signal were on display throughout a 29 second PIF interval. They suggest that Ss deprived of stimuli during PIF intervals may retain but a fraction of the total information available from previous stimulus and feedback presentations. Since stimuli were not present during PIF intervals in the study presented here, this may possibly explain why the PIF interval variable was not significant.

No significant effects were found in the present study for the Rule X PIF interval interaction. It is possible, however, that PIF interval lengths in excess of 15 or 20 seconds may result in facilitating effects for difficult rules such as the biconditional RL task.

The findings of the current study immediately suggest that more research is needed on the effect of PIF interval lengths in concept acquisition tasks. A far greater range of PIF intervals are needed before any definitive statements can be made regarding the effect of this variable on concept acquisition tasks.

Finally, it remains to be investigated whether PIF intervals in excess of those used in previous research (i.e., 20 seconds or greater) will result in facilitating effects for rules comparable in difficulty to the biconditional.

BIBLIOGRAPHY

Bourne, L.E., Jr. Effects of delay of informative feedback and task complexity on the identification of concepts. J. Exp. Psychol., 1957, 54(3), 201-207.

Bourne, L.E., Jr. Human Conceptual Behavior. Boston: Allyn & Bacon, Inc., 1966.

Bourne, L.E., Jr. in B. Kleinmuntz (Ed.). Concepts and the Structure of Memory. New York: John Wiley & Sons, Inc., 1967.

Bourne, L.E., Jr., & Bunderson, C.V. Effects of delay of informative feedback and length of post-feedback interval on concept identification. J. Exp. Psychol., 1963, 65(1), 1-5.

Bourne, L.E., Jr., Ekstrand, B. R., & Montgomery, B. Conceptual learning as a function of the conceptual rule and the availability of positive and negative instances. J. Exp. Psychol., 1969, 82(3), 538-544.

Bourne, L.E., Jr., & Guy, D.E. Learning conceptual rules 11: the role of positive and negative instances. J. Exp. Psychol., 1968, 77(3), 488-494.

Bourne, L.E., Jr., Guy, D.E., Dodd, D. H., & Justesen, D.R. Concept identification: The effects of varying length and informational components of the intertrial interval. J. Exp. Psychol., 1965, 69(6), 624-629.

Bruner, J. S., Goodnow, J. J., & Austin, G. A. A Study of Thinking. New York: Wiley, 1956.

Cervin, V. B., Smith, A. A., & Kabish, C. H. Multiple S-R apparatus for individual and social learning. Psychol. Reports, 1965, 17, 499-510.

Conant, M. B., & Trabasso, T. Conjunctive and disjunctive concept formation under equal-information conditions. J. Exp. Psychol., 1964, 67(3), 250-255.

Haygood, R. C., & Bourne, L. E., Jr. Attribute and rule-learning aspects of conceptual behavior. Psychol. Review, 1965, 72(3), 175-195.

Hovland, C. I., & Weiss, W. Transmission of information concerning concepts through positive and negative instances. J. Exp. Psychol., 1953, 45(3), 175-182.

Neisser, U., & Weene, P. Hierarchies in concept attainment. J. Exp. Psychol., 1962, 64, 640-645.

Roweton, W.E., & Davis, G.A. Effects of pre-response interval, post-informative feedback interval and problem difficulty on the identification of concepts. _J. Exp. Psychol._, 1968, 78(4), 642-645.

Winer, B.J. _Statistical principles in experimental design_. New York: McGraw Hill, 1962.

APPENDIX A

STIMULUS PATTERNS USED

1. 1 red star
2. 1 red triangle
3. 1 red circle
4. 1 yellow star
5. 1 yellow triangle
6. 1 yellow circle
7. 1 blue star
8. 1 blue triangle
9. 1 blue circle
10. 2 red stars
11. 2 red triangles
12. 2 red circles
13. 2 yellow stars
14. 2 yellow triangles
15. 2 yellow circles
16. 2 blue stars
17. 2 blue triangles
18. 2 blue circles
19. 3 red stars
20. 3 red triangles
21. 3 red circles
22. 3 yellow stars
23. 3 yellow triangles
24. 3 yellow circles
25. 3 blue stars
26. 3 blue triangles
27. 3 blue circles

APPENDIX B

PROBLEMS AND CORRESPONDING ATTRIBUTES

Problems		Attributes
(A) Colour-Form	(1)	red;star
	(2)	red;circle
	(3)	red;triangle
	(4)	yellow;star
	(5)	yellow;circle
	(6)	yellow;triangle
	(7)	blue;star
	(8)	blue;circle
	(9)	blue;triangle
(B) Number-Form	(1)	1;star
	(2)	1;circle
	(3)	1;triangle
	(4)	2;stars
	(5)	2;circles
	(6)	2;triangles
	(7)	3;stars
	(8)	3;circles
	(9)	3;triangles

APPENDIX C

PROBLEMS USED FOR DIFFERENT TREATMENT CONDITIONS

PIF INTERVAL (seconds)

RULES	1	8	15
conjunctive	6 S's C-F (8) 6 S's N-F (1)	6 S's C-F (9) 6 S's N-F (3)	6 S's C-F (4) 6 S's N-F (2)
inclusive-disjunctive	6 S's C-F (6) 6 S's N-F (2)	6 S's C-F (2) 6 S's N-F (8)	6 S's C-F (8) 6 S's N-F (9)
exclusive-disjunctive	6 S's C-F (7) 6 S's N-F (8)	6 S's C-F (1) 6 S's N-F (4)	6 S's C-F (5) 6 S's N-F (5)
bi-conditional	6 S's C-F (6) 6 S's N-F (6)	6 S's C-F (2) 6 S's N-F (7)	6 S's C-F (3) 6 S's N-F (9)

* letters and numbers used within cells correspond to those shown in Appendix B.

i.e., C-F = colour-form
N-F = number-form
(1) = attribute pair #1
6 S's = six subjects

APPENDIX D

Instructions

"This is an experiment involving conceptual rule learning. I will show you a series of stimulus patterns projected onto that screen (E indicates viewing screen) one at a time. These patterns will vary along three dimensions: colour, form and number. Each of these dimensions will contain three attributes. The dimensions and their corresponding attributes are: colour (red, yellow and blue); form (star, triangle and circle) and number (1, 2 or 3 identical figures). I will name two attributes which will be relevant to the problem which you are to solve. Your task will be to find the rule which combines these two attributes; that is, to find the way in which they are related. When each stimulus pattern is flashed onto the screen, you must classify this pattern into one of two categories; either an example or a non-example of the rule you are trying to find.

On your panel are two response buttons (E indicates the two buttons) the left one labelled positive and the right one labelled negative. When each stimulus pattern appears you are to look at the pattern and then place your finger on the response button of your choice; the left button if you think the pattern represents an example of the rule you are trying to find and the right button if you think the pattern is not an example. A blue warning light will come on when the stimulus pattern appears on the screen (E indicates blue light). When you see this blue light look at the pattern on the screen and then rest your finger on the button of

Appendix D continued

your choice. Three seconds after the blue light and pattern appears a white cue light will come on and remain on for 3 seconds. You are to press the button of your choice and hold it down only during the 3 second interval that this white light remains on. Remember, your task is to find the correct rule which combines the two relevant attributes I will give you. If you think that a pattern is an example of the rule you are trying to find, push the response button at the left. If you think that the pattern is not an example of the rule you are trying to find push the response button on the right. Please remember to respond to all patterns and to respond only during the three seconds that the white light remains on. After you respond you will see one of two feedback lights; a green light on the left telling you that your response was correct, or a red light on the right telling you that your response was incorrect. The two attributes which are relevant to the problem which you are to solve are _;_. Any questions?" (If there are any questions the relevant part of the instructions will be repeated).

APPENDIX E

Trials-to-Criterion, Total Errors And Ability to Verbalize The Rule For Each Subject as a Function of The Rule Used

	Trials-to-Criterion								Total Errors							
S	Conjunctive	V	Inclusive Disjunc-tive	V	Exclusive Disjunc-tive	V	Bicondi-tional	V	Conjunctive	V	Inclusive Disjunc-tive	V	Exclusive Disjunc-tive	V	Bicondi-tional	V
1	1	Y	4	N	52	Y	96	N	3	Y	11	N	13	Y	52	N
2	7	Y	12	Y	37	Y	96	N	2	Y	5	Y	6	Y	55	N
3	19	Y	96	N	96	N	96	N	4	Y	39	N	39	N	59	N
4	6	Y	96	N	96	N	96	Y	6	Y	44	N	50	N	43	Y
5	4	Y	19	N	96	N	96	N	1	Y	10	N	39	N	51	N
6	10	Y	5	N	96	N	96	N	7	Y	6	N	34	N	59	N
7	7	N	96	N	96	N	96	N	2	N	69	N	17	N	65	N
8	0	Y	61	N	96	N	96	N	13	Y	29	N	34	N	49	N
9	29	Y	18	N	96	N	96	N	10	Y	9	N	48	N	73	N
10	4	Y	5	N	96	N	96	N	1	Y	1	N	59	N	42	N
11	96	N	8	N	73	Y	96	N	27	N	5	N	23	Y	46	N
12	96	N	2	N	58	Y	96	N	30	N	6	N	16	Y	43	N
13	9	N	31	N	27	N	96	N	6	N	29	N	12	N	61	N
14	2	Y	22	N	7	Y	69	N	1	Y	5	N	1	Y	24	N
15	15	Y	35	N	96	N	96	N	3	Y	7	N	33	N	48	N
16	10	Y	96	N	65	Y	46	N	4	Y	32	N	26	Y	11	N
17	14	Y	0	Y	96	N	96	N	2	Y	1	Y	16	N	46	N
18	10	Y	43	N	7	N	96	N	4	Y	17	N	3	N	36	N
19	0	Y	96	N	96	N	96	N	29	Y	68	N	42	N	40	N
20	19	N	7	N	57	N	32	N	6	N	4	N	30	N	16	N
21	7	Y	0	N	96	N	96	N	9	Y	17	N	31	N	36	N
22	19	Y	39	Y	96	N	31	N	2	Y	12	Y	69	N	15	N
23	2	Y	3	Y	21	N	96	N	1	Y	1	Y	7	N	46	N

Appendix E continued

	Trials-to-Criterion								Total Errors							
S	Conjunctive	V	Inclusive Disjunctive	V	Exclusive Disjunctive	V	Biconditional	V	Conjunctive	V	Inclusive Disjunctive	V	Exclusive Disjunctive	V	Biconditional	V
24	9	Y	50	N	15	N	96	N	8	Y	8	N	5	N	36	N
25	3	Y	12	N	96	N	96	N	2	Y	8	N	72	N	54	N
26	1	Y	8	N	21	Y	96	N	1	Y	20	N	8	Y	51	N
27	0	Y	96	N	96	Y	96	N	7	Y	41	N	54	Y	68	N
28	3	Y	24	Y	12	Y	96	N	1	Y	9	Y	3	Y	45	N
29	14	Y	10	N	7	N	96	N	2	Y	1	N	4	N	32	N
30	2	Y	9	Y	6	Y	96	N	1	Y	5	Y	1	Y	46	N
31	73	N	13	N	80	N	96	N	25	N	4	N	23	N	74	N
32	2	Y	96	N	52	N	96	N	18	Y	18	N	9	N	50	N
33	96	N	79	N	96	N	96	N	46	N	24	N	56	N	46	N
34	96	N	7	Y	5	Y	30	N	25	N	1	Y	2	Y	11	N
35	2	Y	14	N	96	N	96	N	1	Y	9	N	27	N	47	N
36	10	N	37	N	5	N	96	N	2	N	12	N	1	N	31	N

Note – The following abbreviations are used: S*= Subject; V = Verbalization; Y = Subject verbalized correctly; N = Subject verbalized incorrectly

* 36 different subjects served in each Rule Learning condition

VITA AUCTORIS

1944	Born in Toronto, Ontario, to Leslie C. and Edith V. Carey.
1951	Educated at George Webster Elementary School, Toronto, Ontario.
1965	Graduated from East York Collegiate Institute, Toronto, Ontario.
1969	Graduated with the degree of B.A., York University, Toronto.
1969	Registered as a full-time graduate student at the University of Windsor.