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Tests on the inference model of conceptual rule learning.

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TESTS ON THE INFERENCE MODEL OF CONCEPTUAL RULE LEARNING

by

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ABSTRACT

One hundred and sixty subjects participated in each of two stages of an experiment designed to test the predictive ability of a modified Inference model of conceptual rule learning. In Stage I, each subject solved one rule learning problem based on one of the four primary bidimensional rules (conjunction, inclusive disjunction, conditional, or biconditional). Visual stimuli varying on the three tri-valued dimensions of shape, colour, and number were sorted into one of two response categories until a criterion of 16 consecutive correct responses or 162 trials was reached. The subjects' preexperimental rule biases were inferred from their initial classification of stimuli, with the subjects predominantly expressing either initial conjunctive, disjunctive, or affirmative strategies. In Stage II, each subject solved a second rule learning problem which was again based on one of the four primary bidimensional rules. For the respective stages, with trials and errors scores as the dependent measures, the effects of either preexperimental rule bias or rule training upon conceptual performance were assessed in three ways: i) rule difficulty hierarchies, ii) within-rule solution difficulty, and iii) relative difficulty of truth table stimulus classes. Only minimal effects of preexperimental rule bias upon rule learning performance were observed, and the few differences were accounted for

as artifacts of a floor effect. The results were interpreted as indicating that while naive subjects may be familiar with different rule strategies, they are constrained in typical rule learning experiments to adopt a conjunctive bias, thereby accounting for the predictive success of the Inference model. On the other hand, considerable differences in conceptual performance as a function of training with either the same or a different primary bidimensional rule were observed, although it was concluded that one-problem practice was not sufficient to establish a rule bias for rules other than the conjunctive. Preliminary trends in the data were interpreted as indicating that the Inference model has predictive validity when modified with respect to various rule biases, thereby adding support to a view that the inference operations underlying the model actually reflect the processes involved in conceptual rule learning.

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INTRODUCTION

The present research involved an attempt to test the generality of a model constructed to account for observed differences in the ease of conceptual rule learning. The Inference model, proposed by Bourne (Bourne, 1974; Salatas and Bourne, 1974), has as a central assumption that people in the Western culture have experience primarily with conjunctive relationships (Bruner, Goodnow, and Austin, 1956). The model calculates the relative difficulty of rules in terms of differences or violations of the other rules from the conjunction in the assignment of stimuli to response categories, successfully predicting the empirical rule difficulty hierarchy.

Alternative explanations have attempted to account for the rule difficulty effect either in terms of: (a) logical complexity of the rules (Neisser and Weene, 1962), (b) a focussing strategy on the positive category of stimuli (Giambra, 1974; Gottwald, 1971; Peters and Denny, 1971; Seggie, 1969), or (c) a focussing strategy on the most homogeneous category of stimuli (Bourne and Guy, 1968b; Bourne, Ekstrand, and Montgomery, 1969). These alternative hypotheses fail to account for the observed differences in conceptual rule difficulty (Bourne, 1970; 1974). Thus, the Inference model represents the most viable explanation of relative rule difficulty, in terms of the model's ability to successfully predict the empirical rule difficulty order.

Recent studies, however, suggest that the assumption of predominant conjunctive bias may not be accurate (Dominowski and Wetherick, 1976; Gates, 1978; Reznick and Richman, 1976). Reznick and Richman proposed that the predictive ability of the Inference model would be increased if the set of inferences underlying the model were modified to take into account individual differences in rule bias. The rule difficulty hierarchy and the ease of learning a particular conceptual rule would be expected to differ depending on the rule bias held by a subject, both of which may be predicted by a modified Inference model.

The objectives of the present study were: first, to modify the Inference model assumptions to take into account various rule biases besides the conjunction; second, to determine the preexperimental rule biases of naive rule-learning subjects and to assess the effects of preexperimental bias upon conceptual performance; third, to establish in subjects particular solution rule biases by giving practice on a particular conceptual rule, assessing the effects of specific rule practice upon conceptual performance; and fourth, to assess the degree of agreement between obtained results and predictions of a modified Inference model.

In the following sections terminology and procedures central to the study of human conceptual behaviour will be explained, along with a presentation of Bourne's Inference model and a review of relevant research. Finally, the design and rationale for an experiment to test the predictive ability of a modified Inference model will be presented.

Terminology and Procedures

Much of the research in the area of human conceptual behaviour has involved analysis of the acquisition and utilization of 'class' or 'nominal' concepts. A class concept has the form of a relation or rule among selected attributes of the dimensions of the stimulus population (Bourne, 1970). Stimuli vary along dimensions, a term which refers to general characteristics or qualities such as shape, colour, number, size, etc. Further, a dimension, by definition, has at least two values or attributes. For example, square, circle, triangle are different attributes within the dimension of shape. Although complex stimuli may vary on a large number of dimensions, research problems have been primarily based on bidimensional class concepts. As the term implies, only two stimulus dimensions, with one particular or focal attribute from each dimension, are relevant (i.e. necessarily used in delineating the concept), while any number of irrelevant dimensions (i.e. cannot be used to define the concept) may be present in the stimulus set.

Haygood and Bourne (1965) pointed out that the stimulus population of a bidimensional class concept may be classified according to presence (denoted by T) and absence (denoted by F) of the two relevant stimulus attributes. The resultant truth table classes are: TT, both attributes are present; TF and FT, only one attribute is present; FF, neither attribute is present. For example, if the stimulus population has three attributes per dimension, there are $3^2 = 9$ unique combinations of attributes from the two relevant dimensions, which are distributed across the truth table classes in a 1 : 2 : 2 : 4 ratio for TT, TF, FT, and FF stimuli, respectively. An example of this arrangement is shown in Table 1.

The most simple partitioning of the stimulus population of a class concept is binary categorization, such that those stimuli which illustrate or exemplify the concept are designated as 'positive instances', while those stimuli which do not exemplify the concept are designated as 'negative instances'. For example, given the concept of "blue and square", a stimulus population may be divided into two categories — one composed of blue square objects (positive instances), and the other category consisting of objects that are not "blue and square" (negative instances).

Neisser and Weene (1962) described eight possible bidimensional rules, four of which are logical complements of the others, such that a positive instance of one primary rule is a negative instance of its complement, and vice versa. The four primary bidimensional rules, their comple-

Table 1

Assignment of Stimulus Classes to Response Categories

Under the Eight Bidimensional Rules

	Truth Table Classes				Verbal
	TT	TF	FT	FF	Description
Primary Rules					
Conjunction	+	-	-	-	Red <u>and</u> Star
Inclusive Disjunction	+	+	+	-	Red <u>or</u> Star
Conditional	+	-	+	+	<u>if</u> Red <u>then</u> Star
Biconditional	+	-	-	+	Red <u>if</u> <u>and</u> <u>only</u> <u>if</u> Star
Stimulus Set (tri-valued dimensions)	RS	RC, RTr	BS, YS	BC, BTr, YC, YTr	
Complementary Rules					
Alternative Denial	-	+	+	+	<u>not</u> Red <u>or</u> <u>not</u> Star
Joint Denial	-	-	-	+	<u>not</u> Red <u>and</u> <u>not</u> Star
Exclusion	-	+	-	-	Red <u>and</u> <u>not</u> Star
Exclusive Disjunction	-	+	+	-	<u>not</u> Red <u>if</u> <u>and</u> <u>only</u> <u>if</u> Star

Note: In the above example colour, varying on attributes red(R), blue(B), and yellow(Y), and shape, varying on attributes star(S), circle(C), and triangle(Tr), are the relevant dimensions. Red and Star are the respective relevant attributes.

ments, and verbal descriptions are presented in Table 1. As shown in Table 1, each rule makes a unique assignment of the truth table classes of stimuli to response categories. Depending on the rule, each of the truth table classes may map onto either the positive or negative response category.

Given that class concepts may differ with regard to the defining rule, dimensions, or attributes, it follows that different tasks have been devised to investigate concept attainment, in which one or more of these components are varied. Three types of tasks, which differ according to the aspects of the concept that are unknown to the subject at the outset of the problem, have been commonly employed in concept attainment studies. In an attribute identification (AI) task, the rule or general form of solution is given by instructions and/or practice problems, and the subjects' task is to discover or identify the relevant attributes which delineate the particular concept. As Haygood and Bourne (1965) pointed out, the AI task was widely used in earlier studies of conceptual behaviour which were concerned with the effects of such variables as number of relevant and irrelevant dimensions (Walker and Bourne, 1961), amount of intra- and interdimensional variability (Battig and Bourne, 1961), and redundancy between dimensions (Bourne and Haygood, 1959).

In a rule learning (RL) task, the relevant attributes are given by instructions, and the subjects' task is to discover the rule or relationship between the attributes which defines the concept. Haygood and Bourne (1965) noted that, until then, 'conceptual rule' had not been investigated as a variable affecting concept attainment, although available experimental evidence suggested that conceptual rules differ in their difficulty (Conant and Trabasso, 1964; Hunt and Hovland, 1960; Neisser and Weene, 1962; Shepard, Hovland, and Jenkins, 1961). For example, Conant and Trabasso (1964) found, in an AI task, that the inclusive disjunctive concept was more difficult, as measured by number of trials to solution, than the conjunctive concept. Neisser and Weene (1962) found that concepts with the most complex rules, the biconditional and exclusive disjunction, were more difficult to learn than less complex rules such as the conjunction and inclusive disjunction. Consequently, Haygood and Bourne (1965) were the first to systematically study the acquisition of bidimensional conceptual rules using the RL task.

In a complete learning (CL) task, neither the relevant attributes nor the rule is known to the subject at the outset, and the subject must attempt to discover both. Some studies have employed the CL task in order to assess the relative difficulty of concept attainment under the three tasks just described (eg. Giambra, 1970; Haygood and Bourne, 1965; Haygood and Devine, 1967). However, other experiments simply failed to separate the AI and RL components of concept learning, and therefore fall into this general paradigm (eg. Neisser and Weene, 1962; Wells, 1963).

Two methods of stimulus presentation have been used in studies employing the above tasks. These are called the reception and selection methods, referring respectively to whether the experimenter or the subject determines the order in which the stimuli are viewed and subsequently categorized by the subject.

The nature of conceptual tasks necessitates a distinction between two processes involved in conceptual behaviour — discovery or acquisition, and utilization. The process of acquisition entails learning or discovering the unknown component(s) — relevant attributes, or rule, or both — which together constitute the concept. Utilization of a concept refers to the classification of stimuli to appropriate response category according to the pertinent rule and relevant attributes. However, the experimental separation of these two distinct processes may seldom be apparent, since a generally accepted criterion for the acquisition of a concept is its successful utilization for some minimum number of correct assignments of stimuli to response categories.

Empirical Rule Difficulty Hierarchy

Haygood and Bourne (1965) conducted an experiment in which four groups of subjects each solved five successive RL problems with the same rule, with a different pair of relevant attributes for each problem. Each group learned a different rule — either the conjunction, inclusive disjunction, joint denial, or conditional — by assigning each stimulus to either the positive (Yes) or negative (No) response category, with feedback as to the correct category assignment provided after each response. The stimulus population, as in most subsequent related studies, consisted of geometric designs which varied on four, tri-valued dimensions (number, size, shape, and colour). Haygood and Bourne found that the rules differed in difficulty, as measured by the number of errors to solution, in increasing order of difficulty of conjunction, inclusive disjunction equal to joint denial, and conditional.

Subsequent research has confirmed the existence of a rule difficulty effect in RL tasks, with a stable hierarchy of difficulty. Bourne (Bourne, 1970; Bourne and Guy, 1968a,b) found the order of difficulty of the primary bidimensional rules to be: conjunction easier than inclusive disjunction easier than conditional easier than biconditional. More recent replications of the above-stated order of rule difficulty include studies by Neumann (1974) and Salatas and Bourne (1974), as well as numerous experiments involving partial replications in that only a subset of the primary bidimensional rules were compared within the particular experiment (eg. Bower, 1971; Miller, 1971; Namikas and Carey, 1971; Sawyer and Johnson, 1971).

Inference Model

Bruner, Goodnow, and Austin (1956) proposed that the predominant extra-experimental experience of people within the Western culture is with conjunctive relationships, and that naive subjects entering a concept attainment experiment would initially assume that a given problem required a conjunctive solution. As a test of the assumption that conjunctive bias determines rule difficulty, Bourne and Guy (1968a) conducted a RL study employing the four primary bidimensional rules. They compared the number of instances of each truth table stimulus class prior to last error on that class, for each rule, and found that greater numbers of trials (i.e.presentations of particular class instances) were required when conjunctive assumptions were contradicted in the correct assignment of a stimulus. Bourne and Guy suggested that untrained subjects find it easiest or more natural to associate TT instances with the positive category, FF instances with the negative category, and TF and FT instances with the same category, with a preference for assigning them to the negative category. The categorization of stimuli in the manner just described corresponds to the truth table categorization of the conjunction rule, as can be seen in Table 1.

Bourne further developed this line of reasoning and formulated an Inference model of bidimensional rule difficulty (Bourne, 1974; Salatas and Bourne, 1974), extending upon a earlier model proposed by Sawyer (1972). An integral aspect of the Inference model rests on the structure or organization of thought processes presumably imposed upon a subject as a consequence of the RL task requirements, in which a subject must discover the particular rule which partitions the stimulus population into positive and negative instances of the concept. As explained by Bourne (1970; 1974), a subject in a RL task must learn to attend, on instruction, only to the dimensions exemplified by the given relevant attributes. Then the subject must develop a method of responding which in effect corresponds to an intuitive version of the truth table, such that stimuli from four different classes, defined in terms of presence (T) and absence(F) of the two relevant attributes, are assigned to the appropriate response category. Naive RL subjects are assumed to encode stimuli directly in terms of their value on the relevant dimensions, but with experience develop a system of responding which resembles truth table encoding.

Bourne proposed that four generalized assumptions or inferences are held by naive subjects for the categorization of stimuli. Bourne described these assumptions as a set of initial states or processes that specify the response to any stimulus: (A) TT instances will be placed in the positive category; (B) FF instances will be placed in the negative category; (C) TF and FT instances will be placed in the same category as FF instances, whether positive or negative; and (D) TT and FF instances will be placed in different response categories.

Bourne devised a calculational scheme by which violation of any of the above assumptions results in an increment in problem difficulty. It was proposed that the increment of difficulty be equal to the number of unique stimulus patterns whose correct category assignment violate any of the assumptions. Further, Bourne proposed that a violation of assumption (D) would magnify the difficulty of a rule by the arbitrary factor of 2.

As an illustration of the calculational scheme of the Inference model, recall that the stimulus population in RL studies typically has two relevant dimensions and one or more irrelevant dimensions. As shown in Table 1, with three attributes per dimension, the nine unique combinations of attributes from the two relevant dimensions are distributed across the truth table classes in a 1 : 2 : 2 : 4 ratio for TT, TF, FT, and FF stimuli, respectively. The difficulty value of the conjunction rule is zero, since the conjunctive concept violates none of the preexperimental assumptions presumably held by a subject. The difficulty value of the biconditional rule, for example, is 16, and is determined in the following manner: four unique stimuli violate inference (B) since the biconditional rule assigns FF instances to the positive category;

two TF and two FT stimuli are assigned to a different category than FF instances, the negative category, in violation of inference (C); lastly, inference (D) is violated by the assignment of FF instances to the same (positive) category as TT instances, resulting in a magnification of the difficulty value of 4 + 2 + 2 = 8 by the arbitrary factor of 2, yielding a final biconditional rule difficulty value of 16. Difficulty values for the four primary bidimensional rules are shown in Table 2.

Salatas and Bourne (1974) calculated the difficulty values for all eight bidimensional rules, yielding the following predicted order of difficulty, from least to most difficult: conjunction, inclusive disjunction, alternative denial, exclusion, joint denial, exclusive disjunction, conditional, and biconditional. Salatas and Bourne then compared the difficulty of the eight rules in a RL experiment, and found that the predicted order of difficulty was confirmed, except for a reversal of the order for exclusion/alternative denial and for joint denial/exclusive disjunction. An analysis of truth table categorization errors combined across the eight rules, for rules that violated a particular inference versus those that did not, also provided support for the model. For each inference, significantly more errors were made when the particular inference was violated than when not.

Further support for the rule order predictions of the

Table 2

Difficulty Values and Truth Table Classes Predicted by the Inference Model to be Relatively Difficult, for the Primary Bidimensional Rules

Rules	Difficulty Values	Truth Table Classes			
		TT	TF	FT	FF
Conjunction	0	+	-	-	-
Inclusive Disjunction	4	+	+*	+*	-
Conditional	12	+	-*	+	+*
Biconditional	16	+	-*	-*	+*

Note: Truth table classes predicted by the model to be relatively difficult when the indicated rule applies are marked with an asterisk(*).

Inference model was provided in a RL experiment by Neumann (1974), who obtained precisely the hierarchy of bidimensional rule difficulty predicted by the model.

The Inference model also predicts which truth table classes of stimuli will result in the most errors under any rule. That is, for each rule, those truth table classes which violate an inference are expected to be more difficult than those that do not violate an inference. For each primary bidimensional rule, truth table classes predicted by the Inference model to be relatively difficult are shown in Table 2.

Salatas and Bourne (1974) analysed the error distributions on each truth table class, within each of the eight bidimensional rules, and found considerable support for the predictions of relative truth table class difficulty. Differences between expected 'difficult' versus 'easy' classes were all in the predicted direction, and were statistically significant within all rules except the inclusive disjunction and alternate denial.

Additional support is provided by inspection of the data in Haygood and Bourne's (1965) RL experiment. Error patterns on the truth table classes, within each of the four primary bidimensional rules, were consistent with the Inference model predictions of relative truth table class difficulty.

Related Research Findings

The Inference model accounts for observed differences in bidimensional rule difficulty in terms of a set of inferences which guide or direct a naive subject's attempts to solve a RL problem. The basic assumption underlying the set of inferences is that naive subjects assume that the problem to be solved requires a conjunctive solution. Now, if it is assumed that a conjunctive bias is held by naive subjects, which is a bidimensional bias in that the joint presence of two relevant attributes defines the concept, an assumption implicit in the model is that a RL subject attends to both relevant stimulus dimensions as he begins to solve a RL problem.

Also, several studies have examined the effects upon RL problem performance of receiving prior practice either with the same rule, or with one or more other conceptual rules, thereby allowing an assessment of intrarule and interrule transfer effects (Bourne, 1970; Bourne and Guy, 1968a; Bower, 1971; Bower and King, 1967; Guy, 1969; Haygood and Bourne, 1965; Lee, 1968). Demonstrations of significant intra- and interrule transfer effects have indicated theoretical constraints for the Inference model with regard to its applicability in accounting for the behaviour of experienced RL subjects.

In the following section research findings bearing upon each of the above-mentioned issues will be examined.

Preexperimental Rule bias Dominowski and Wetherick (1976) assessed the initial rule biases of naive RL subjects by having them classify the nine stimuli generated by two tri-valued dimensions, colour and shape, after being told the relevant attributes, but with no informative feedback provided. They found that approximately 16 percent of the subjects demonstrated a conjunctive bias, while 58 percent used an inclusive disjunctive strategy. The remaining subjects used either an affirmative(6 percent) or an unsystematic strategy(20 percent).

Using a standard RL design, Reznick and Richman (1976) confirmed that a substantial proportion of naive subjects may demonstrate either a disjunctive or affirmative bias, by analysing the way in which subjects classified the first four stimuli presented, each of which represented one of the truth table classes. They found, with colour and shape as the relevant dimensions, that 12 percent of the subjects demonstrated a conjunctive bias, while 44 percent used an inclusive disjunctive strategy, and 28 percent demonstrated an affirmative bias.

Gates (1978) assessed the preexperimental rule biases of naive RL subjects in a manner similar to that employed by Reznick and Richman (1976), by analysing the way in which subjects classified the first stimulus presentation of each truth table class. However, the stimulus presentation order employed by Gates meant that the subject may have classified and received feedback for as many as eight stimuli before seeing one example from each truth table class, thereby confounding the bias assessment by the differential experience of subjects with other reinforced stimuli. Gates found, with colour and shape as the relevant dimensions, that approximately 19 percent of the subjects demonstrated a conjunctive bias, while 15 percent used an inclusive disjunctive strategy, and 23 percent demonstrated an affirmative bias.

The above experiments suggest that people show individual differences regarding their initial rule biases, implying that optimal use of the Inference model may depend on first determining the particular rule bias held by a subject.

<u>Attention to dimensions</u> An implicit assumption of the Inference model is that naive RL subjects take into consideration the particular values on both relevant dimensions of a stimulus when assigning it to one or the other response category. Sawyer (1972) conducted a study pertinent to this issue, in which a series of four stimuli varying on two bi-valued dimensions were presented to subjects. Sawyer either reinforced the assignment of the first presented stimulus (TT) to one category, or he reinforced the assignment of the first two stimuli presented(TT and TF) to either the same or different categories, with the remaining stimuli serving as nonreinforced test stimuli. Using this procedure, Sawyer provided evidence that naive subjects may attend to

only one stimulus dimension during the initial stages of rule learning, assigning stimuli to one or the other response category on the basis of presence or absence of one criterial attribute. For example, for the case in which TT and TF were assigned to category 1 by reinforcement, subjects showed a strong tendency to place FT and FF stimuli in category 2, indicating attention to the first dimension. When TT was assigned to category 1 and TF to category 2, subjects showed a strong tendency to assign FT to category 1 and FF to category 2, indicating attention to the second dimension.

Clearly, the above-described assignment of stimuli corresponds to a unidimensional bias, the affirmation. Sawyer's demonstration of unidimensional affirmative bias is supported by the rule bias assessment procedures and findings of Dominowski and Wetherick (1976), Reznick and Richman (1976), and Gates (1978), and adds further support to the claim that optimal use of the Inference model may depend upon knowledge of a person's rule bias.

Transfer experiments Wells (1963) conducted an experiment which demonstrated that the prior learning of conceptual rules is a factor in concept learning difficulty. Wells found, in a CL task, that pretraining on disjunctive problems significantly increased the proportion of subjects who offered a disjunctive solution to a series of stimuli for which either a conjunctive or disjunctive solution was possible, thereby showing that a rule bias can be modified by training and familiarization with other conceptual rules.

Subsequent experiments have demonstrated the existence of significant intra- and interrule transfer effects in the RL paradigm. Intrarule transfer refers to the effect on RL problem performance following solution of a problem or problems based on the same rule, usually with the relevant attributes changed from problem to problem. Interrule transfer refers to the effect of practice with one rule or different rules upon RL performance in problems based on another rule, typically with the relevant attributes changed from problem to problem (Bourne, 1970).

Intrarule transfer: As mentioned earlier, Haygood and Bourne (1965) conducted a RL experiment in which four groups of subjects solved five successive problems with the same rule — either the conjunction, inclusive disjunction, joint denial, or conditional. The rules differed generally in difficulty, corresponding to the usually observed hierarchy of primary rule difficulty. Further, there was a steady improvement in performance over problems, such that essentially perfect performance was reached by subjects by the third problem on all rules except the conditional, thereby demonstrating positive intrarule transfer.

One of the training conditions employed in the Bourne and Guy (1968a) experiment allows an examination of intrarule transfer, in which subjects solved six successive problems.

based on the same rule — either the conjunction, inclusive disjunction, or conditional. Initial differences in rule difficulty were found, in the usual difficulty order, but over the six problems the differences among the rules, as measured by trials to criterion of solution, were eliminated. Further, after the third problem all but one subject performed without error.

Bourne (1970) conducted a RL experiment in which four groups of subjects solved a series of nine successive problems based on the same rule — either the conjunction, inclusive disjunction, conditional, or biconditional. Initial inter-rule differences were in the usual order, but after six problems on the same rule all subjects achieved an errorless level of performance. Inspection of Bourne's graphs indicates that by problem 3 the mean number of trials to solution, for each rule problem, had converged in a uniform fashion towards the level of errorless performance.

Bower (1971) also conducted a RL experiment in which intrarule transfer was demonstrated. Three groups of subjects each solved three successive problems based on the same rule — either the joint denial, inclusive disjunction, or biconditional. Bower found the usual rule difficulty order, and that by problem 2 the errors and trials to solution were not significantly different for the rules. In partial support of Bower's (1971) findings, Bower and King (1967) had their subjects solve three successive RL problems based on the biconditional rule only, and also found a significant decrease in mean numbers of errors to solution from problem 1 to problem 2, such that problems 2 and 3 did not differ in difficulty.

In summary, the intrarule transfer studies cited above indicate that the order of rule difficulty is not static or invariant, in that it can be changed by giving experience with the RL paradigm. Subjects improve to the point of efficient and even errorless performance over a series of problems, all based on the same rule but differing in relevant attributes, in spite of initial differences in rule difficulty.

General interrule transfer: Haygood and Bourne (1965) conducted a study in which subjects solved three successive RL problems based on the inclusive disjunction, conditional, and biconditional rules, with the order of presentation counterbalanced among subjects, after receiving a detailed explanation of the conjunction rule during initial instructions. Then the subjects solved a fourth RL problem (termed by Haygood and Bourne a rule identification problem), which for equal numbers of subjects was one of the four primary rules experienced earlier. For the fourth problem, while it was found that biconditional and conditional problems produced a greater number of errors than the conjunction and disjunction, the number of errors made over the four rules was significantly attenuated in comparison to the

RL situation in which subjects have no prior exposure to other conceptual rules, a result attributable to positive general interrule transfer.

Bourne (1970), in an extension of the Haygood and Bourne (1965) study, had the subjects solve twelve successive RL problems, three of which were based on each of the four primary bidimensional rules, with order of presentation counterbalanced. Following solution of the twelfth problem, the subjects solved a thirteenth RL problem (termed by Bourne a rule identification problem), which was based on one of the previously encountered rules. Significant positive general interrule transfer over the first twelve problems was demonstrated by a large reduction in trials to solution across successive three-problem blocks. Also, by the twelfth problem, 90 percent of the subjects solved without error. Further evidence of dramatic transfer was provided by an examination of the subjects' performance on problem 13, wherein 83 percent of the subjects were able to identify the unknown rule with a minimal amount of information i.e. making no more than one error per truth table class.

Lee (1968) conducted an experiment in which subjects solved RL problems based on various combinations of the conjunction, joint denial, or conditional rules. Following training, all subjects solved a transfer problem based on the biconditional rule. Lee reported that performance on the biconditional problem was significantly better in the conditions where all three rules, versus one or two rules, were encountered during training.

In a similar experiment, Bourne and Guy's (1968a) subjects solved six RL problems based on various combinations of the conjunction, inclusive disjunction, or conditional rules. Following training, all subjects solved two transfer problems based on the biconditional. Bourne and Guy found that performance on the biconditional problems improved with the number of rules encountered during training, a finding attributable to positive general interrule transfer.

Specific interrule transfer: The training conditions employed in the Bourne and Guy (1968a) study allow an examination of specific interrule transfer effects. For instance, biconditional performance was facilitated most by training on conditional problems only, next best by training on inclusive disjunction problems only, and least by training on conjunction problems only, though the effect was not statistically significant. Also, for the training condition in which subjects solved three problems based on one rule and three problems based on another rule, those subjects who solved conditional problems performed significantly better than subjects trained exclusively in conjunctions and disjunctions. Bourne and Guy interpreted the facilitative effect of conditional rule training upon biconditional performance as being due to the conditional rule forcing attention to the distinction between TF and FT instances, thereby promoting the utilization of a truth table strategy of classifying stimuli, and to the similarity of the conditional and biconditional rules in their assignment of FF instances to the positive response category.

Guy (1969) conducted a RL experiment which examined specific interrule transfer effects, using the conjunction and inclusive disjunction rules and their complements. Guy found that subjects made significantly fewer errors in solving a second problem when, following training on a particular rule, the second problem was a complement of the first rule versus a noncomplementary rule. For example, if the first problem was based on the conjunction rule, subjects found it easier to solve an alternative denial problem than a joint denial problem.

Bower's (1971) RL experiment also provided suggestive evidence of specific interrule transfer effects, in which some subjects solved three biconditional problems followed by either three inclusive disjunction or three joint denial problems. Other subjects solved either three inclusive disjunction or three joint denial problems, followed by three biconditional problems. Control subjects solved either three disjunction, or three joint denial, or three bicondit- problems. Bower found that biconditional pretraining facilitated joint denial rule learning when compared with its control, but there was no significant improvement for the inclusive disjunction over its control. Also, joint denial pretraining facilitated biconditional performance moreso than disjunction pretraining. Although Bower's results are suggestive of specific interrule transfer effects, it should be pointed out that the experimental design employed by Bower provided no adequate baseline for determining the amount of transfer from RL training. The control subjects were at a disadvantage in relation to the other groups, due to the lack of general transfer effects such as 'warm up' and 'learning to learn'.

In summary, the studies cited above which were designed to investigate general interrule transfer, indicate that RL performance improves over a series of problems in which both rule and attributes change from one problem to the next. Differences in rule difficulty disappear, and after a sufficient number of problems the majority of subjects are able to solve for any unknown rule in the minimum number of trials. The few studies which have permitted a fragmentary assessment of specific interrule transfer, suggest that practice with a single rule may differentially facilitate or even inhibit subsequent RL performance depending upon the particular rule to be learned.

Theoretical implications of transfer: On the basis of demonstrations of significant intra- and interrule transfer effects, Bourne (1970; 1974) has formalized a theoretical distinction between the underlying states or processes which presumably govern the behaviour of naive versus experienced rule learners. The Inference model, it will be recalled, provides a formula for calculating the relative difficulty values of conceptual rules in terms of a set of inferences which direct a naive subject's attempts to solve a RL problem. The naive subject presumably utilizes inferences which apply uniquely to each stimulus input, or to each unique attribute combination on the relevant stimulus attributes providing that he ignores irrelevant attributes. With RL practice, however, which involves the processes of intra- and interrule transfer, underlying changes in the subject's strategies (Bourne, 1970) and system of inferences (Bourne, 1974) are presumed to occur.

Transfer, according to Bourne, involves the acquisition of a more general set of operations, corresponding to a bidimensional truth table strategy, wherein the subject learns to collapse the stimulus population presented to him into four truth table classes. A change in inferences occurs as well. Instead of predetermining the assignment of particular stimuli to response categories, as do the inferences of naive subjects, the operations of an experienced subject allow the stimulus itself to determine its own assignment, corresponding to what Bourne (1974, p. 251) described as the development of "open ended" inferences. For example, instead of inference operation (A) - all stimuli with both given relevant attributes are positive, the experienced subject is presumed to operate with inference (A') - the category assignment of the first instance with both relevant attributes determines the assignment for all stimuli with both attributes. Therefore, an experienced subject lets his observation of the category assignment of a single stimulus determine the assignment of all stimuli belonging to the same subset. Similar revised inferences (B'), (C'), and (D') would also apply, of course, to the remaining truth table stimulus classes.

As described above, the operations of naive versus experienced RL subjects are presumed to be very different, as reflected by their differential performance with regard to rule difficulty differences and rule identification errors. The Inference model, therefore, can only be expected to apply to the performance of naive or relatively naive RL subjects who have not had extensive training either on problems based on the same rule or on problems based on different rules, to the point where, according to Bourne, a general truth table strategy and 'open ended' inferences have developed.

As a final point of interest and clarification, the relationship between the theoretical processes proposed by Bourne and the processes of discovery and utilization, which were alluded to earlier as being involved in conceptual behaviour, may be explained. The discovery or acquisition phase of rule learning could be regarded as a gradual progression from the initial set of inferences held by naive RL subjects, to the mastery of a general truth table strategy with its corresponding 'open ended' inferences. The utilization phase, then, would simply involve making use of the mastered strategies and revised inferences to 'identify' the rules of unsolved problems with the logically minimal amount of information.

The Present Study

As described in the preceding literature review, several RL experiments have attempted to assess specific interrule transfer effects i.e. the effects of practice with a single rule upon performance in a problem based on another rule (Bower, 1971; Bourne and Guy, 1968a; Guy, 1969). No studies to date have attempted a factorial comparison of the effects of one-problem practice with a primary bidimensional rule upon RL problem performance based either on the same or a different primary bidimensional rule.

The present study attempted such a comparison, for two reasons. First, the present study involved an extension upon the limited RL experiments which have examined specific interrule transfer. Second, it was hoped that the design of the present study would permit testable evaluation of the generality of the Inference model, when the model is modified to take into account various rule biases besides the conjunction.

Reznick and Richman (1976), it will be recalled, assessed the preexperimental rule biases of their subjects in a RL experiment, and found that a significant proportion of naive subjects demonstrated either a conjunctive, inclusive disjunctive, or affirmative bias. Further, Reznick and Richman showed that there were differential effects of learning a particular rule depending upon a person's preexperimental bias. For example, a conjunction RL problem was easiest for subjects with a conjunctive bias, followed by affirmative biased subjects, and hardest for disjunctive biased subjects. For the inclusive disjunction problem, disjunctive bias was easiest, followed by affirmative bias, and hardest was conjunctive bias. Within the conditional rule the effect of bias was not significant. For the biconditional problem, the effect of bias was also not significant, although the observed trend indicated that conjunctive and affirmative biased subjects made fewer errors than disjunctive biased subjects.

Reznick and Richman calculated the difficulty values for the four primary bidimensional rules according to their interpretation of conjunctive, inclusive disjunctive, and affirmative bias, and noted some degree of correspondence between the predictions of their modified Inference model and the above-described results. They concluded that the predictive validity of the Inference model is greatly enhanced if modified to take into account a person's rule bias, and proposed that the set of inferences may be readily modified to accommodate any rule bias.

However, the present author contends that the way in which Reznick and Richman modified the Inference model to take into account the various rule biases is suspect. It will be recalled that assumptions (A), (B), (C), and (D) of the Inference model describe the truth table classification of stimuli to response categories according to the conjunction rule. As shown in Table 2, with tri-valued dimensions the difficulty values calculated from the Inference model for the conjunction, inclusive disjunction, conditional, and biconditional rules are 0, 4, 12, and 16 respectively, which accurately predict the usually observed rule difficulty hierarchy. Recall that inference (C) states that 'TF and FT instances will be placed in the same category as FF instances, whether positive or negative'. Inference (C), then, suggests that subjects use the category assignment of FF instances as a referent in determining to which response category they will assign TF and FT instances.

Reznick and Richman, however, chose to interpret inference (C) as meaning that 'TF and FT instances will be placed in the negative category', thereby ignoring the FF referent. When Reznick and Richman's interpretation of inference (C) is substituted for the original, it is clear that the set of inferences also describe the way in which the conjunction rule assigns truth table stimulus classes to response categories. However, altered difficulty values arise. Specifically, difficulty values for the conjunction, inclusive disjunction, conditional, and biconditional rules become 0, 4, 12, and 8, respectively, leading to a predicted rule difficulty hierarchy of conjunction easier than inclusive disjunction easier than biconditional easier than conditional. Clearly, these predictions do not conform to the empirical rule difficulty order.

Similarly, in order to represent an inclusive disjunctive rule bias, Reznick and Richman changed inference (C) to 'TF and FT instances will be placed in the positive category', again ignoring the FF referent, with subsequent effects upon calculated difficulty values and predictions of rule difficulty. To represent affirmative bias, Reznick and Richman changed inference (C) to 'TF and FT instances will be placed in different response categories'. Thus, in describing affirmative bias Reznick and Richman not only deleted the FF referent, but they also failed to make the potentially important distinction between affirmative biased subjects who attend to one(i.e. the first) stimulus dimension versus those who attend to the other(i.e. the second) relevant stimulus dimension.

Considering the success of the Inference model in predicting the empirical rule difficulty hierarchy, there was felt to be no a priori justification for modifying the Inference model in the manner employed by Reznick and Richman (1976). Consequently, for the purposes of the present experiment, modifications necessary to represent various rule biases were made according to the specific terminology of the Inference model (Bourne, 1974; Salatas and Bourne, 1974).

Table 3 shows the modifications of assumptions of the Inference model necessary to represent each primary rule bias, according to Inference model terminology. To illustrate how the Inference model modifications were arrived at, the biconditional rule bias will be considered. It will be recalled from Table 1 that the biconditional rule assigns TT and FF instances to the positive response category, and TF and FT instances to the negative category. Therefore, assumption (A) of the Inference model, which reads 'TT instances will be placed in the positive category', need not be changed, since the biconditional rule assigns TT instances to the positive category. Inference (B), however, which reads 'FF instances will be placed in the negative category', must be modified to $(B)^{Bd}$ FF instances in the positive category. Similarly, inference (C), which reads 'TF and FT instances will be placed in the same category as FF instances', must be modified to $(C)^{Bd}$ TF and FT instances in a different category than FF instances. Finally, inference (D), which reads 'TT and FF instances will be placed in different response categories', must be modified to $(D)^{Bd}$ TT and FF instances in the same response category.

Also shown in Table 3 are the difficulty values for the four primary bidimensional rules calculated to take into account each primary rule bias. The calculational scheme

Table 3

Difficulty Values for the Four Primary Bidimensional Rules Using a Modified Inference Model

Model Bias	Modified Inferences	Rule Cj	Rule Dj	Rule Cd	Rule Bd
Conjunctive		0	4	12	16
Inclusive Disjunctive	$(C)^{Dj}$ TFs and FTs in a different category than FFs.	4	0	12	8
Conditional	$(B)^{Cd}$ FFs in positive category.	12	12	0	2
	$(C)^{Cd}$ TFs in different category than FFs, and FTs in same category as FFs.				
	$(D)^{Cd}$ TTs and FFs in same category.				
Biconditional	$(B)^{Bd}$ FFs in positive category.	16	8	2	0
	$(C)^{Bd}$ TFs and FTs in different category than FFs.				
	$(D)^{Bd}$ TTs and FFs in same category.				
Affirmative(1st dimension)	$(C)^{Af,1st}$ TFs in different category than FFs, and FTs in same category as FFs.	2	2	8	12
Affirmative(2nd dimension)	$(C)^{Af,2nd}$ TFs in same category as FFs, and FTs in different category than FFs.	2	2	16	12

used to determine these difficulty values was the same as that employed in the unmodified Inference model. That is, the increment in problem difficulty is equal to the number of unique stimulus patterns whose correct category assignment violate any of the particular rule bias inferences. Also, a violation of inference $(D)^{-}$ magnifies the rule difficulty by a factor of 2. As an illustration of the calculational scheme, it will be recalled from Table 1 that with two tri-valued relevant dimensions, the 9 unique attribute combinations are distributed across the truth table classes in a 1:2:2:4 ratio for TT, TF, FT, and FF stimuli, respectively. Therefore, for a person operating with a biconditional rule bias, the difficulty value of the conjunction rule, for example, is 16, and is determined in the following manner: four unique stimuli violate inference $(B)^{Bd}$ since the conjunction rule assigns FF stimuli to the negative category; two TF stimuli and two FT stimuli are assigned to the same category as FF instances, in violation of assumption $(C)^{Bd}$; lastly, inference $(D)^{Bd}$ is violated by the assignment of FF and TT stimuli to different categories, resulting in a magnification of the difficulty value of 8 by a factor of 2, yielding a final conjunction rule difficulty value of 16.

The present experiment consisted of two stages. Stage I involved solution of a RL problem based on one of the four primary bidimensional rules — either the conjunction, inclusive disjunction, conditional, or biconditional, to a criterion number of correct categorizations of stimuli to response categories. The preexperimental rule biases of the subjects solving the Stage I RL problem were assessed using the procedure employed by Reznick and Richman (1976); that is, by analysing the way in which each subject categorized the first stimulus presentation of each truth table class, which were represented within the first four stimulus presentations. The above rule bias assessment procedure thereby permitted an examination of RL problem performance as a function of preexperimental rule bias. As Reznick and Richman (1976) noted, this rule bias assessment procedure likely does not provide an uncontaminated or truly valid indication of the preexperimental rule bias held by a subject, in that feedback on one instance may well affect subsequent responding on other instances. However, the above procedure was readily employed within the design of the present study as an indicator of rule bias, rather than using the procedures employed by Dominowski and Wetherick (1976) or Gates (1978), which were mentioned in an earlier section.

In addition to allowing an examination of the effects of preexperimental rule bias upon RL performance, the methodological aim of Stage I was to experimentally induce in the subjects a solution rule bias for the particular rule that they had solved. In Stage II, the subjects solved one RL problem based on one of the four primary bidimensional rules, thereby allowing an examination of RL problem performance following practice with either the same or a different primary bidimensional rule. Also, the above-described rule assessment procedure was used to infer the solution rule biases of the subjects as they began to solve the Stage II RL problem. For each rule, the proportion of subjects who demonstrated the 'desired' solution rule bias induced in Stage I, was determined, as an indicator of the degree of success of the methodological aim of Stage I.

At this point, some justification for the design of the present experiment is in order. The Inference model applies only to the performance of naive subjects; that is, to the performance of subjects who have not had extensive RL training in the laboratory. As was explained at some length in the preceding section, the operations and strategies employed by naive subjects are presumed to be very different from those of experienced RL subjects. Since the present study attempted to test the generality of the Inference model when modified to take into account various rule biases, the Stage I procedure of distinguishing between subjects on the basis of their demonstrated preexperimental rule biases as they began solving the RL problem, was considered to be especially appropriate to the purposes of the present study. That is, the above-described rule bias assessment procedure was expected to permit an examination of the effects of preexperimental rule bias upon RL problem performance, without the potentially confounding necessity of pre-experiment sorting or training of subjects.

Now, the few studies which have assessed the preexperimental biases of their subjects (Dominowski and Wetherick, 1976; Gates, 1978; Reznick and Richman, 1976) suggest that subjects predominantly demonstrate either conjunctive, inclusive disjunctive, or affirmative biases. This implies that if one wishes to examine the effects of rule biases other than those above, such as a conditional or biconditional bias, it may well be necessary to experimentally train or induce in subjects the particular rule bias. In this regard, the Stage I procedure of giving the subjects training by solving only one RL problem, with the aim of establishing a particular solution rule bias, was considered to provide a more reasonable starting point to such an investigation than giving training solving several RL problems based on the same rule. Although the latter procedure would likely increase the proportion of subjects who would initially begin solving the Stage II RL problem with the 'desired' solution bias, the likelihood that the operations and strategies of these subjects might be different from those employed by more inexperienced subjects would also be increased, thereby changing the nature of the task to the degree that the experiment would not be an adequate test of the generality of the Inference model.

Hypotheses

Rule difficulty hierarchy: According to the difficulty values generated by the modified Inference model for the primary bidimensional rules, predictions were made concerning the relative ease of solving RL problems based on these rules, as a function of rule bias. The difficulty values shown in Table 3 were used to generate the predictions shown in Table 4.

With regard to Stage I of the present experiment, the order of primary bidimensional rule difficulty was expected to change depending upon the particular preexperimental rule bias held by the subjects, as shown in the upper part of Table 4. For example, the predicted order of rule difficulty for affirmative biased subjects who attended to the first relevant stimulus dimension, was: conjunction equal to inclusive disjunction easier than conditional easier than biconditional.

With regard to Stage II of the present experiment, the order of primary bidimensional rule difficulty was expected to change depending upon the particular solution rule bias held by the subjects, as shown in the lower part of Table 4. For example, for those subjects who solved the Stage II RL problem following practice with the inclusive disjunction rule (and presumably forming an inclusive disjunctive solution rule bias), the predicted order of rule difficulty was: inclusive disjunction easier than conjunction easier than biconditional easier than conditional.

Rule bias difficulty order within each rule: A second set

Table 4

Predicted Rule Difficulty Order Depending Upon Preexperimental Bias, and Upon Solution Bias

Preexperimental Bias	Predicted Order
Conjunctive	Cj < Dj < Cd < Bd
Inclusive Disjunctive	Dj < Cj < Bd < Cd
Affirmative(1st dim.)	Cj = Dj < Cd < Bd
Affirmative(2nd dim.)	Cj = Dj < Bd < Cd

Solution Bias	Predicted Order
Conjunctive	Cj < Dj < Cd < Bd
Inclusive Disjunctive	Dj < Cj < Bd < Cd
Conditional	Cd < Bd < Cj = Dj
Biconditional	Bd < Cd < Dj < Cj

of predictions, the corollary of the above predictions, were also derived from the difficulty values generated by the modified Inference model. The difficulty values shown in Table 3 were used to generate the predictions shown in Table 5. As Table 5 indicates, it was possible to predict that the ease of learning a conceptual rule would differ depending upon the particular rule bias held by the subjects.

With regard to Stage I of the present experiment, it was predicted that the ease of solving a particular RL problem would differ as a function of preexperimental rule bias, as shown in the upper part of Table 5. For example, given the conjunction RL problem, it was predicted that conjunctive bias would lead to fastest solution, followed by affirmative(attending to first dimension) bias equal to affirmative (attending to second dimension), and inclusive disjunctive bias, in increasing order of difficulty.

With regard to Stage II of the present experiment, it was predicted that the ease of solving a particular RL problem would differ as a function of solution rule bias, as shown in the lower part of Table 5. For example, given the biconditional RL problem, it was predicted that biconditional bias would lead to fastest solution, followed by conditional bias, inclusive disjunctive bias, and conjunctive bias, in increasing order of difficulty.

Difficulty of truth table categories: A final set of predictions was also derived from the assumptions of the

Table 5

Predicted Order of Difficulty of Preexperimental Biases and Solution Biases Within Each Rule

Rule	Predicted Preexperimental Bias Difficulty Order
Conjunction	Cj < Af(1st) = Af(2nd) < Dj
Inclusive Disjunction	Dj < Af(1st) = Af(2nd) < Cj
Conditional	Af(1st) < Cj = Dj < Af(2nd)
Biconditional	Dj < Af(1st) = Af(2nd) < Cj

Rule	Predicted Solution Bias Difficulty Order
Conjunction	Cj < Dj < Cd < Bd
Inclusive Disjunction	Dj < Cj < Bd < Cd
Conditional	Cd < Bd < Cj = Dj
Biconditional	Bd < Cd < Dj < Cj

modified Inference model. It will be recalled from Table 2 that the Inference model predicts which truth table classes of stimuli will be relatively difficult under any rule. Specifically, given a particular rule, those truth table categories which violate an inference are expected to be more difficult than those that do not violate an inference. Extending these predictions for rule biases other than the conjunction, it was predicted that, for each rule, there would be differences in the relative difficulty of the truth table stimulus classes depending upon the particular rule bias held by the subjects.

With regard to Stage I of the present experiment, differences in the relative difficulty of the truth table classes were expected, within each rule, as a function of preexperimental rule bias. Table 6 shows these predictions. For example, affirmative(first dimension) biased subjects who solved the conjunction RL problem were expected to have more difficulty with TF instances than with TT, FT, or FF instances, whereas affirmative(second dimension) biased subjects who solved the conjunction RL problem were expected to have particular difficulty with FT instances.

With regard to Stage II of the present experiment, it was predicted that differences in the relative difficulty of the truth table categories would result, within each rule, as a function of solution rule bias. Table 7 shows these predictions. For example, conditional biased subjects who

Table 6

Predicted Relative Difficulty of Truth Table Categories When the Indicated Preexperimental Bias Applies

Rule	Preexperimental Bias	Truth Table Category TT	TF	FT	FF
Cj	Conjunctive	+	-	-	-
	Disjunctive	+	-*	-*	-
	Affirmative(1st)	+	-*	-	-
	Affirmative(2nd)	+	-	-*	-
Dj	Conjunctive	+	+*	+*	-
	Disjunctive	+	+	+	-
	Affirmative(1st)	+	+	+*	-
	Affirmative(2nd)	+	+*	+	-
Cd	Conjunctive	+	-*	+	+*
	Disjunctive	+	-	+*	+*
	Affirmative(1st)	+	-	+	+*
	Affirmative(2nd)	+	-*	+*	+*
Bd	Conjunctive	+	-*	-*	+*
	Disjunctive	+	-	-	+*
	Affirmative(1st)	+	-	-*	+*
	Affirmative(2nd)	+	-*	-	+*

Note: Truth table categories which the model predicts to be relatively difficult when the indicated preexperimental bias applies are marked with an asterisk(*).

Table 7

Predicted Relative Difficulty of Truth Table Categories When the Indicated Solution Bias Applies

Rule	Solution Bias	Truth Table Category			
		TT	TF	FT	FF
Cj	Conjunctive	+	-	-	-
	Disjunctive	+	-*	-*	-
	Conditional	+	-*	-	-*
	Biconditional	+	-*	-*	-*
Dj	Conjunctive	+	+*	+*	-
	Disjunctive	+	+	+	-
	Conditional	+	+	+*	-*
	Biconditional	+	+	+	-*
Cd	Conjunctive	+	-*	+	+*
	Disjunctive	+	-	+*	+*
	Conditional	+	-	+	+
	Biconditional	+	-	+*	+
Bd	Conjunctive	+	-*	-*	+*
	Disjunctive	+	-	-	+*
	Conditional	+	-	-*	+
	Biconditional	+	-	-	+

Note: Truth table categories which the model predicts to be relatively difficult when the indicated solution bias applies are marked with an asterisk(*).

solved the inclusive disjunction RL problem were expected to have more difficulty with FT and FF instances than with TT and TF instances, whereas biconditional biased subjects were expected to have particular difficulty only with FF instances on the inclusive disjunction RL problem.

Chapter 2

METHOD

Subjects and Design

The subjects were 231 students enrolled in introductory and second year psychology courses at the University of Windsor, each of whom received supplementary course credit for participation in the experiment. Assignment of subjects to treatment conditions was random, according to their order of appearance at the experimental room. Of the 231 subjects, the data for 160 was subsequently used in the statistical analyses. The data for the remaining 71 subjects was discarded, for the following reasons: 49, for failure to reach the rule-learning criterion within 162 trials on Problem 1; 9, for failure to follow instructions; 5, due to equipment failure; 3, due to experimenter error; 3, for taking or having taken a course in logic; 1, for having participated in a similar experiment; and 1, due to colour blindness.

For all subjects, the design consisted of two stages. In Stage I, four groups of 40 subjects each solved one RL problem based on one of the primary bidimensional rules — either the conjunction, inclusive disjunction, conditional, or biconditional. In Stage II, the subjects solved a second RL problem which, for equal numbers of subjects (10) per Stage I group, was again based on one of the four primary bidimensional rules — either the conjunction, inclusive disjunction, conditional, or biconditional. Therefore, the experiment contained 16 experimental conditions or groups, in terms of rule solved in Problem 1 - rule solved in Problem 2, with 10 subjects per condition.

Stimuli

The stimuli were slides of geometric designs varying on three tri-valued dimensions: shape (star, triangle, or circle), colour (yellow, red, or blue), and number (1, 2, or 3 identical designs), which generate a stimulus population of 27 different patterns.

The stimulus presentation orders were constructed randomly, but with three constraints: (a) the four truth table stimulus classes — TT, TF, FT, and FF— were represented in their natural proportions i.e. in a 1:2:2:4 ratio, respectively, within each subset of nine stimuli and therefore over the entire set of 27 stimuli as well; (b) the number of successive stimuli from the same truth table category was restricted to two; and (c) one example from each truth table category was represented within the first four stimulus presentations over each subset of nine stimuli.

Colour and shape were the relevant dimensions for all problems, and each value of the relevant attribute combination was changed from Problem 1 to Problem 2. With the stimuli of the present study, 36 different permutations of pairings of relevant attribute combinations may be generated for which both relevant attributes are changed from the first to the second problem. However, the relevant attributes for Problem 1 and those for Problem 2 were interchanged for half of the subjects within each condition, thereby reducing the number of different pairings of relevant attributes to 18. For example, if five subjects solved Problem 1 with 'yellow, triangle' as the relevant attributes and Problem 2 with 'blue, circle' as the relevant attributes, then the other five subjects within that treatment condition solved Problem 1 with 'blue, circle' as the relevant attributes and Problem 2 with 'yellow, triangle' as the relevant attributes. The above procedure of interchanging the relevant attributes for half of the subjects on each problem, was employed to equate, within a treatment condition, for possible interaction effects between conceptual rule and particular relevant attributes, thereby avoiding confounding with ordinal position.

A different pairing of relevant attribute combinations was randomly assigned to each of the 16 treatment conditions of the present experiment, resulting in the random discard of two of the possible pairings. The relevant attribute pairs, and the stimulus sequences constructed for each experimental condition, are presented in Appendix A.

Feedback slides were prepared by hand lettering with pencil on Kodak Ektagraphic write-on slides.

Apparatus

The Generalized Learning Apparatus (GLA_6) described by Cervin, Smith, and Kabisch (1965) was used to control the presentation of stimulus patterns and feedback slides. The GLA_6 consists of six subject panels (48.26 cm by 35.56 cm) which are connected to timing and relay circuits in an adjacent control room. The subject panels are inclined at an angle of approximately 30° towards the subject, and are separated by vertical wooden partitions, making it difficult for any subject to observe the responses made by another subject. The panels were arranged so that each was about 3 m away from the stimulus projection screen. For the present experiment, only a blue warning light (6.3 V, blue jewel) centered at the top of each panel, a green light (6.3 V, green jewel) located at the left side of each panel, and two response buttons located near the bottom left and right corners of each panel, were used. All other buttons and lights, as described by Cervin, Smith, and Kabisch (1965), were covered by black tape.

The subjects' responses were automatically recorded by means of an Esterline Angus Event Recorder. The responses were also recorded manually by the experimenter onto data sheets.

The stimulus and feedback slides were rear-projected with a GAF Anscorama auto-focus slide projector onto a translucent window separating the control room from the subject room. Both rooms were kept at a lowered level of illumination during the experiment in order to ensure maximum visibility of the stimulus patterns.

Procedure

The experimental tasks performed by the subjects corresponded to the Rule Learning condition described by Haygood and Bourne (1965). For all subjects, the stimulus population was described with the aid of a card showing three stimuli which displayed in combination all nine attributes. Subjects were told that their task was to classify a series of visually presented stimuli according to an unknown conceptual relationship between two relevant attributes, by pressing one of two buttons, labelled 'POSITIVE' and 'NEGATIVE'; the 'POSITIVE' button was to be pressed if the subject believed the stimulus to be an example of the concept, and the 'NEGATIVE' button was to be pressed if the subject believed the stimulus not to be an example of the concept. For half of the subject panels the left-hand response button was labelled 'POSITIVE' and the right-hand button labelled 'NEGATIVE', while for the remaining three panels the left-hand response button was labelled 'NEGATIVE' and the right-hand button labelled 'POSITIVE'. An attempt was made to ensure that approximately equal numbers of subjects within each condition sat at one or the other type of panel.

The subjects were told that there would be two problems. Prior to each problem, the two attributes relevant to concept solution were named, and a card listing the relevant attributes was placed on each subject's panel as a memory aid. Prior to Problem 2, the subjects were told that the relationship learned in Problem 1 might or might not be the same for Problem 2. Before each problem, the subjects also received instructions directing them to begin an interpolated task, if they received a signal (flashing green light) to stop responding to the stimuli presented on the screen. The procedure of having subjects perform an interpolated task after solving Problem 1 to a criterion number of errorless responses, was employed in an attempt to equate, between subjects in a given condition, the degree of learning or successful experience with the given conceptual rule prior to solving the second problem. Subjects also performed the interpolated task after solving Problem 2, so as to maintain similar instructional and procedural conditions for the two problems. The interpolated task materials, consisting of 'connect-the-numbers' problems, are presented in Appendix B.

The experimenter inquired of each group whether the instructions were understood, and repeated relevant portions when necessary. Then, the experiment was begun. Complete instructions to subjects are presented in Appendix C.

Each trial began with the presentation of a stimulus slide and a blue warning light. After 5 seconds the blue light went off, signalling the beginning of a 2 second response interval. Responses which occurred during this interval were scored as correct or incorrect, and failure to respond at all was scored as an incorrect response. Also, based on Bourne and Bunderson's (1963) finding that delays of up to

8 seconds between the subject's response and informative feedback as to the correct response had no significant effect on conceptual performance, anticipatory responses were also scored as correct or incorrect in the present experiment. At the end of the response interval, the stimulus slide was replaced by a feedback slide which named the correct response category for the stimulus just presented; that is, the feedback slide contained the printed word 'POSITIVE' or the printed word 'NEGATIVE'. The feedback interval lasted for 5 seconds, and then the above sequence of events was repeated. The sequence of events in a trial is illustrated in Figure 1.

For each problem, stimulus presentations continued until a solution criterion of 16 consecutively correct responses was reached by every member in the group, or until 162 trials had occurred. After the second problem, each subject was asked to write down on a piece of paper the relationship between the two relevant attributes that he or she had learned in order to correctly categorize the stimuli, for each problem. Half of the subjects in each treatment condition were asked to first write down the relationship learned in Problem 1 and then to write down the relationship learned in Problem 2, while for the other half of the subjects in each condition the order of verbalization of relationships was reversed.

At this time the card containing the three example

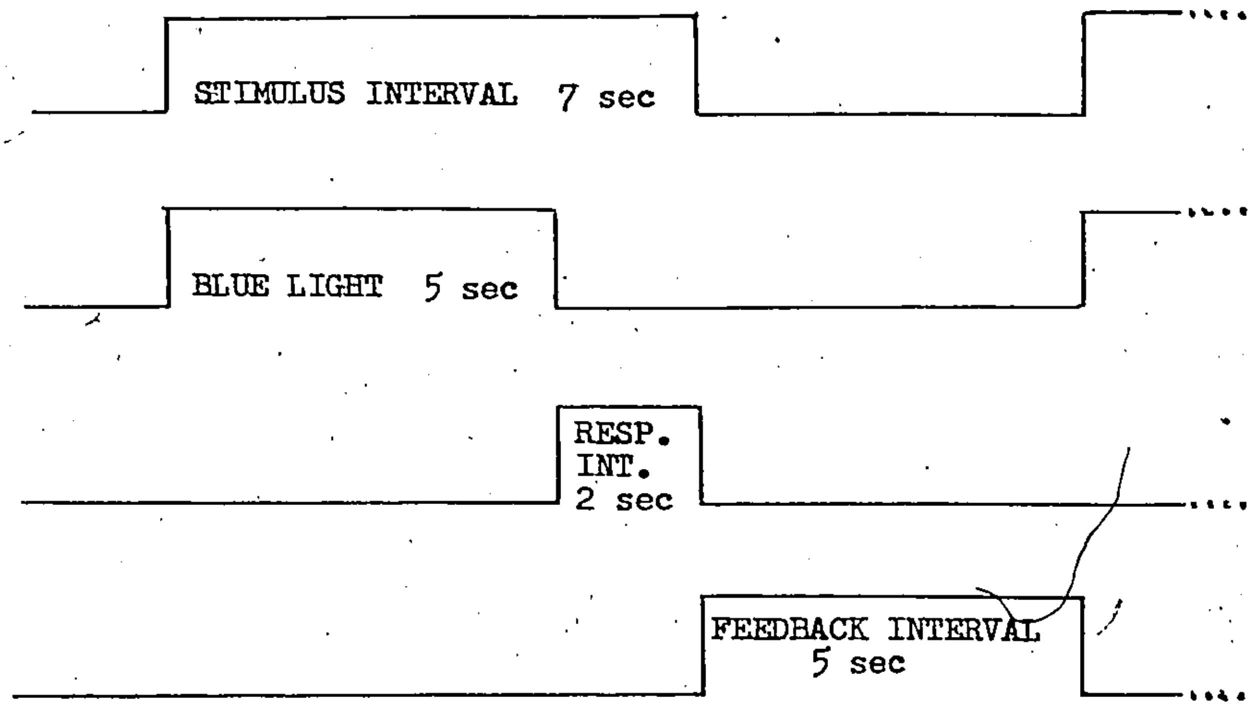

Figure 1. Sequence of events in a trial.

stimuli was again displayed, and each subject was asked to write down the colour of each stimulus in the order pointed out by the experimenter. One subject was unable to do so, and was replaced. The subjects were also asked if they had taken or were taking a course in logic. Three subjects responded affirmatively to the above question, and were replaced. Also, the subjects were asked if they had ever participated in a similar experiment. One subject responded affirmatively to the above question and was replaced.

Subjects were recruited as needed to ensure that 10 subjects per experimental condition fulfilled the following requirement, in addition to the above-described restrictions — namely, that the subject solved Problem 1 to a criterion number (16) of consecutively correct responses within 162 trials. A total of 49 subjects failed to reach the RL criterion on Problem 1, and were replaced.

Up to five subjects participated simultaneously in each experimental session. When fewer than five subjects appeared for a session, or when any of those present failed to meet the above-described restrictions, extra subjects were recruited for another session under the same treatment conditions. A minimum of two subjects participated in any session, so as to maintain the group nature of the experiment. When more subjects were present than were needed in order to fulfill the above requirements, the extra subjects were discarded at random. A total of nine subjects were discarded for this reason in the following Problem 1 rule - Problem 2 rule conditions: conjunction-conjunction, 1; conjunction-conditional, 1; conjunction-biconditional, 1; inclusive disjunction-conditional, 1; conditional-conjunction, 1; conditional-biconditional, 2; biconditional-conjunction, 1; and biconditional-conditional, 1.

Chapter 3

RESULTS

Stage I: Problem 1 Performance

Preexperimental Bias

The preexperimental bias of each of the 160 subjects was determined by examining the pattern of responses to the first four stimuli, which consisted of one example from each truth table category. For example, people who initially responded with pattern TT = +, TF = -, FT = -, FF = - were classified as having expressed a conjunctive bias. Table 8 shows the frequency of preexperimental biases according to Problem 1 rule condition and Problem 2 rule condition. As seen in Table 8, four main bias types were observed: conjunctive, inclusive disjunctive, affirmative(attending to first dimension), and affirmative (attending to second dimension).

Different distributions of preexperimental biases were found in the Problem 1 rule conditions, $\chi^2(9) = 26.78$, $p < .05$, this difference being primarily due to a smaller than expected number of people (0) demonstrating a conjunctive bias coupled with a larger than expected number of people (19) demonstrating an inclusive disjunctive bias in the conditional rule problem. Also, different distributions of preexperimental biases were found over the sixteen Problem 2 conditions, $\chi^2(45) = 63.73$, $.025 < p < .05$. However, collapsing across Problem 1 rule and considering

Table 8

Frequency of Preexperimental Bias Types According to Problem 1 Condition and Problem 2 Condition

		Primary Biases						Complementary Biases						U[1]
		Af1st	Af2nd	Cj	Dj	Cd	Bd	Ne1st	Ne2nd	AD	JD	Ex	ED	
Problem 1 Rule	Cj	9	10	10	8	1	0	0	0	0	0	0	0	2
	Dj	13	8	8	5	0	2	0	0	1	0	0	0	3
	Cd	8	5	0	19	1	0	0	0	0	0	2	2	3
	Bd	3	8	8	12	0	1	1	1	3	0	1	1	1
Percentage of Total		20.6	19.4	16.3	27.5	1.3	1.9	0.6	0.6	2.5	0	1.9	1.9	5.6
Problem 2 Rule	Cj	10	8	4	11	0	0	0	0	2	0	0	1	4
	Dj	6	8	6	14	2	2	0	0	2	0	0	0	0
	Cd	10	5	7	10	0	1	1	1	0	0	1	0	4
	Bd	7	10	9	9	0	0	0	0	0	0	2	2	1

[1]Note: 'U' category refers to the situation in which a subject initially assigned all stimuli to either the positive or negative category.

the particular Problem 2 rules, the same distribution of preexperimental biases was found in the Problem 2 rule conditions, $\chi^2(9) = 6.30$, $p > .05$.

Overall Rule Difficulty

The dependent variables were trials and errors to criterion. The mean trials to criterion for the conjunction, inclusive disjunction, conditional, and biconditional rules were 4.90, 4.95, 63.25, and 63.20 respectively, while the mean errors to criterion were 2.00, 1.88, 25.88, and 24.70 respectively. The Problem 1 trials and errors scores for each subject are presented in Appendix D.

For the trials data, Hartley's and Cochran's tests (Winer, 1971) indicated that the assumption of homogeneity of variance was violated ($F_{max}(4,39) = 39.67$, $p < .01$; $C(4,39) = .53$, $p < .01$). Therefore a log(x+1) transformation was performed in order to make the data more compatible with the homogeneity of variance assumption ($F_{max}(4,39) = 3.13$, $p < .01$; $C(4,39) = .38$, $.05 > p > .01$).

Analysis of variance[1] on the transformed trials data indicated a significant effect of rules ($F(3,156) = 140.25$, $p < .05$). A Neuman-Keuls test(Winer, 1971) revealed that the conjunction and inclusive disjunction rules required significantly fewer trials to solution than did the conditional and biconditional rules ($p < .05$), with no

[1]Note: Nonparametric statistical analyses i.e. Kruskal-Wallis ANOVA by ranks, Wilcoxon ranked-sum test(Ferguson, 1971) were performed on all data sets in the present study in which the homogeneity of variance assumption was not satisfied by a transformation. Since the alternate analyses yielded comparable results, only the parametric test results are reported throughout.

difference between the conjunction and disjunction, and no difference between the conditional and biconditional.

For the errors data, Hartley's and Cochran's tests indicated that the assumption of homogeneity of variance was violated (F_{max} (4,39) = 66.22, $p < .01$; C (4,39) = .52, $p < .01$). Therefore a log(x+1) transformation was performed in order to make the errors data more compatible with the homogeneity of variance assumption, as indicated by Hartley's and Cochran's tests (F_{max} (4,39) = 3.79, $p < .01$; C (4,39) = .47, $p < .01$).

Analysis of variance on the transformed errors data indicated a significant effect of rules (F (3,156) = 135.63, $p < .05$). A Neuman-Keuls test revealed the same order of rule difficulty as for the trials data — conjunction equal to inclusive disjunction easier than conditional equal to biconditional ($p < .05$). Summaries of the above analyses are presented in Appendix E.

It was mentioned earlier that 49 people failed to reach the rule learning criterion within 162 trials on Problem 1, and so were replaced. Of these 49 people, 12 failed to solve the conditional rule problem while over three times as many (37) failed to solve the biconditional rule problem. Thus, although in the present study analyses of trials and errors scores revealed no difference between the conditional and biconditional rules, in terms of their ability to be solved the biconditional was certainly more difficult than the conditional.

Finally, the preexperimental biases of the nonsolvers were examined in order to determine if a pattern existed which might in part explain the inability of these people to solve the problem. In the conditional rule, the number of nonsolvers demonstrating a particular bias were: conjunctive, 4; inclusive disjunctive, 3; affirmative(first dimension), 1; affirmative(second dimension), 2; negational(second dimension), 1; U(see Table 8), 1. In the biconditional rule, the number of nonsolvers demonstrating a particular bias were: conjunctive, 9; inclusive disjunctive, 11; affirmative(first dimension), 6; affirmative (second dimension), 8; exclusion, 1; exclusive disjunctive, 1; U, 1. Clearly, no discernible pattern or predominant bias type is evident.

Rule Difficulty Order as a Function of Preexperimental Bias

For each rule of Problem 1, the mean trials and errors scores for the four main preexperimental bias types — conjunctive, inclusive disjunctive, affirmative(first dimension), and affirmative(second dimension) — were determined. The mean scores for each group are shown in Figures 2 and 3, illustrating the trials to criterion and errors to criterion, respectively.

In order to assess rule difficulty order as a function of preexperimental bias, a 1 (bias) X 4 (rules) unweighted-means analysis of variance(Winer, 1971) was

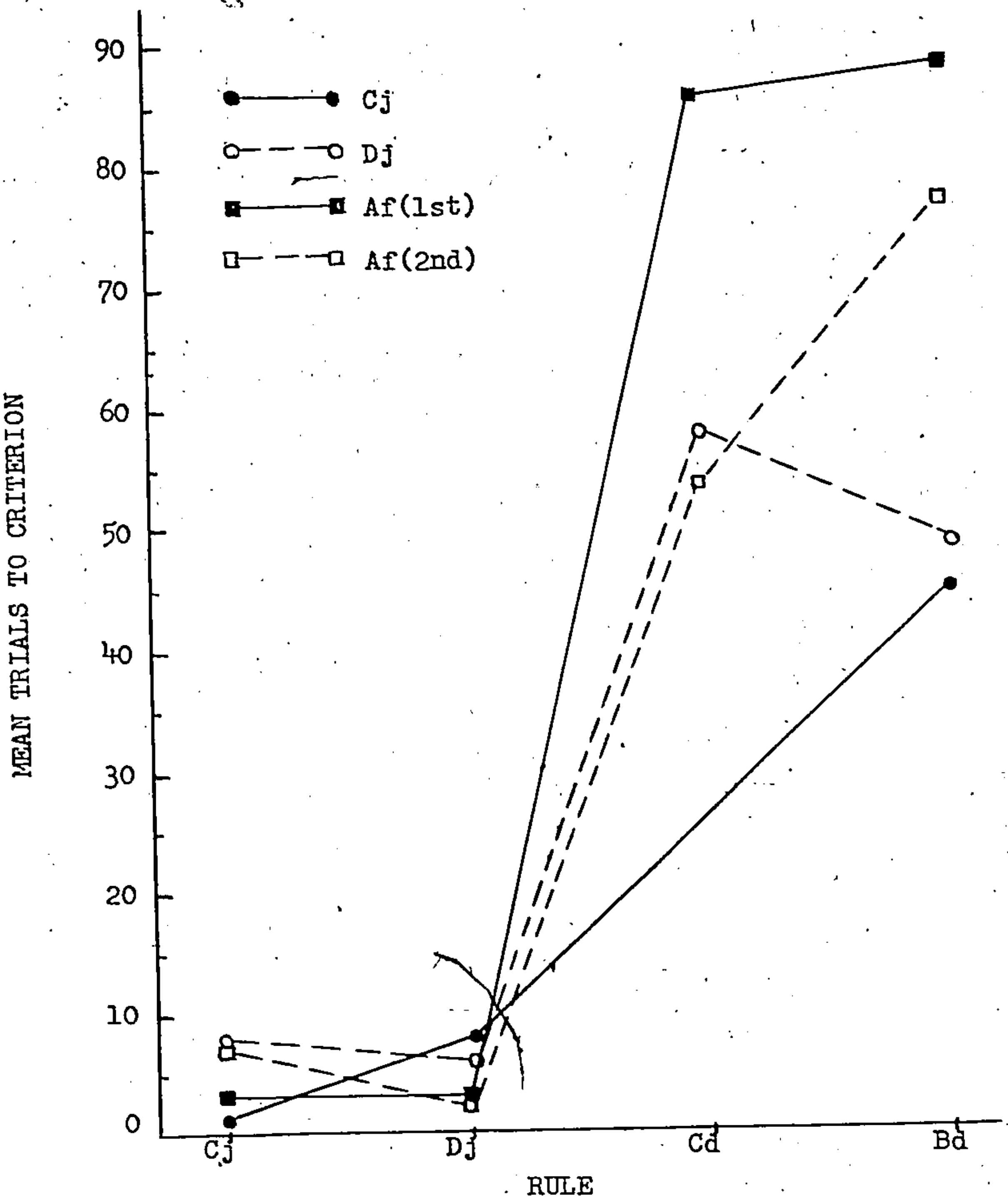

Figure 2. Mean trials to criterion for each rule as a function of preexperimental bias.

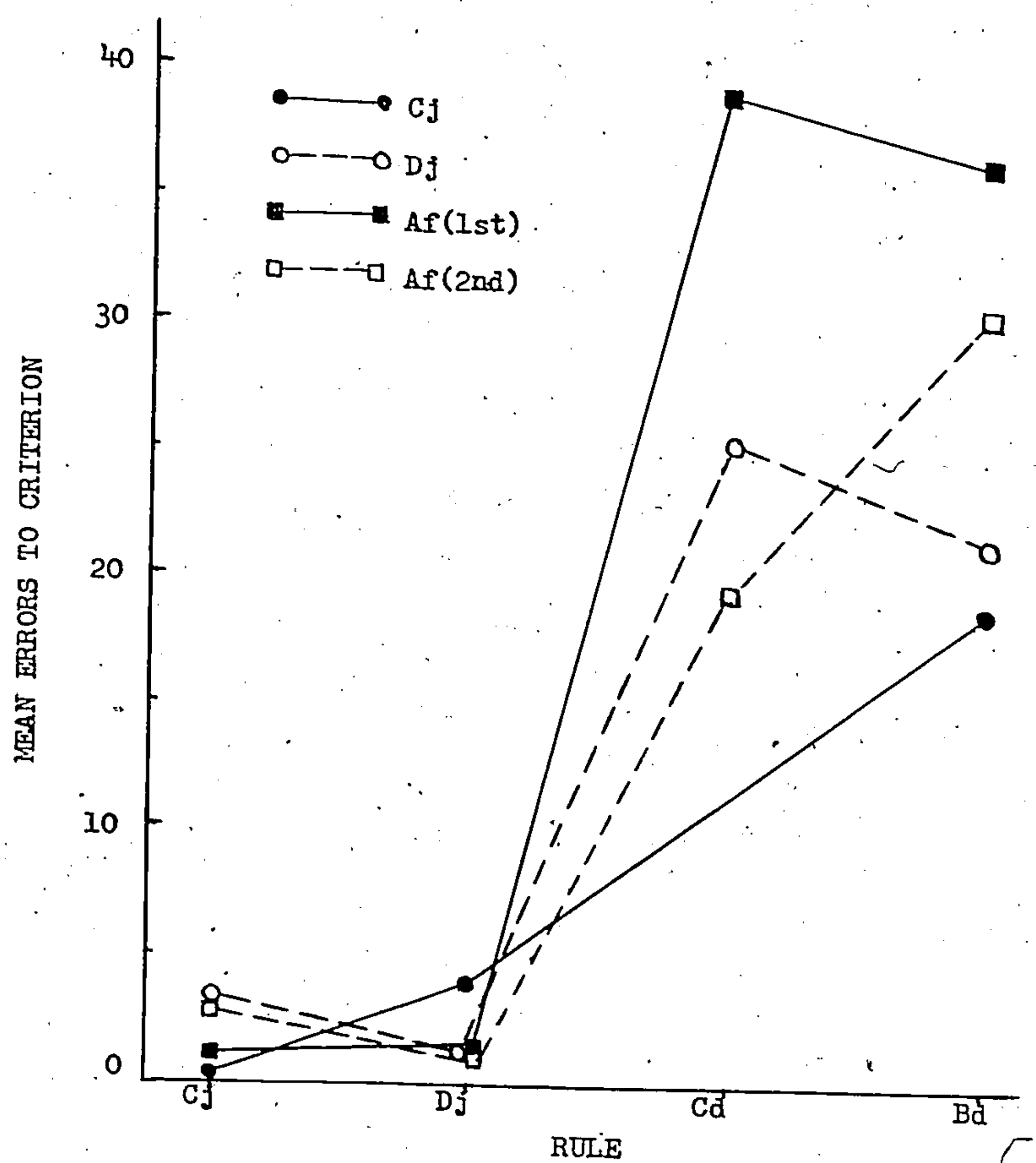

Figure 3. Mean errors to criterion for each rule as a function of preexperimental bias.

performed for each bias on both the trials and errors data. The Neuman-Keuls ($p < .05$) procedure was used to compare means, and all analyses were conducted on the log(x+1) data, summaries of which are presented in Appendix E.

Results of the analyses are summarized in Table 9, which shows the rule difficulty order for each bias on both the trials and errors data. As seen in Table 9, the trials and errors data yielded the same rule difficulty orders. Identical rule difficulty orders were obtained for inclusive disjunctive, affirmative(first dimension), and affirmative(second dimension) biased subjects, with the rule order being precisely that found above for the overall Problem 1 rule difficulty. Namely, the conjunction rule was equal to the inclusive disjunction, both of which were easier than the conditional and biconditional rules, which did not differ in difficulty. Only for conjunctively biased people was the inclusive disjunction rule more difficult than the conjunction.

<u>Preexperimental Bias Difficulty Order Within Each Rule</u>

In order to assess the effects of preexperimental bias upon learning a particular rule, a 1 (rule) X 4 (bias) unweighted-means analysis of variance was performed for each rule on both the log(x+1) transformed trials and errors data. The Neuman-Keuls ($p < .05$) procedure was used to compare means, and summaries of the

Table 9

Observed Rule Difficulty Order as a Function of Preexperimental Bias for the Trials to Criterion and Errors to Criterion Data

Trials to Criterion Data

Preexperimental Bias	Rule Order	$p < .05$
Cj	Cj < Dj < Bd	$F(2,23) = 44.60$
Dj	Dj = Cj < Bd = Cd	$F(3,40) = 26.02$
Af(1st)	Cj = Dj < Cd = Bd	$F(3,29) = 44.32$
Af(2nd)	Cj = Dj < Bd = Cd	$F(3,27) = 37.00$

Errors to Criterion Data

Preexperimental Bias	Rule Order	$p < .05$
Cj	Cj < Dj < Bd	$F(2,23) = 44.33$
Dj	Dj = Cj < Bd = Cd	$F(3,40) = 19.46$
Af(1st)	Cj = Dj < Cd = Bd	$F(3,29) = 53.00$
Af(2nd)	Cj = Dj < Bd = Cd	$F(3,27) = 38.17$

analyses are presented in Appendix E. The results are summarized in Table 10, which shows the observed preexperimental bias difficulty order within each rule for both the trials and errors data. Results for the trials and errors scores were not identical, and so are reported separately below.

For the trials data, only within the conjunction rule did people perform at varying rates as a function of their preexperimental bias. People with a conjunctive bias required significantly fewer trials to criterion than did affirmative or disjunctive biased people, with no difference between the latter groups. No effect of preexperimental bias was found within the inclusive disjunction, conditional, or biconditional rules.

For the errors data, people performed at varying rates within the conjunction rule as a function of their preexperimental bias. Conjunctive biased people made significantly fewer errors than did affirmative or disjunctive biased people, with no difference between the latter groups. Within the inclusive disjunction rule, the effect of preexperimental bias was also significant. Disjunctive and affirmative biased people made fewer errors than did people expressing a conjunctive bias, with no difference between the former groups. Again, as with the trials data, no effect of preexperimental bias was found within the conditional and biconditional

Table 10

Observed Preexperimental Bias Difficulty Order Within Each Rule, for the Trials to Criterion and Errors to Criterion Data

Trials to Criterion Data

Rule	Bias Order	$p < .05$
Cj	Cj $<$ Af(1st) = Af(2nd) = Dj	$F(3,33) = 8.00$
Dj	Dj = Af(1st) = Af(2nd) = Cj	$F(3,30) = 1.75$
Cd	Af(1st) = Dj = Af(2nd)	$F(2,29) = 0.67$
Bd	Dj = Af(1st) = Af(2nd) = Cj	$F(3,27) = 1.25$

Errors to Criterion Data

Rule	Bias Order	$p < .05$
Cj	Cj $<$ Af(1st) = Af(2nd) = Dj	$F(3,33) = 12.25$
Dj	Dj = Af(1st) = Af(2nd) $<$ Cj	$F(3,30) = 4.67$
Cd	Af(1st) = Dj = Af(2nd)	$F(2,29) = 1.83$
Bd	Dj = Af(1st) = Af(2nd) = Cj	$F(3,27) = 0.83$

rules.

Difficulty of Truth Table Categories

For each subject, the percentage of his or her total errors occurring in each truth table category was determined. Then, for each Problem 1 rule the percentages within each truth table category were averaged according to major preexperimental bias type to obtain the mean percentage of total errors within that category, as shown in Table 11. Also shown in Table 11 are the overall mean percentages of total errors in each truth table category for each rule of Problem 1, which were obtained by combining the data from all 40 subjects who solved each rule.

These data were then examined by visually comparing the observed error patterns across the four truth table classes for each rule and preexperimental bias type with the predicted error patterns (shown in Table 11 and also in Table 6).

First, for the combined data the error patterns exhibited by subjects in the conjunction, inclusive disjunction, conditional, and biconditional rules were in essential agreement with the patterns predicted by an unmodified, conjunctive biased Inference model. However, as indicated in Table 11, subjects who made errors in the conjunction RL problem primarily did so on TF and FT instances.

Within the conjunction and inclusive disjunction rules, the error patterns observed according to bias type were in perfect agreement with the error patterns

Table 11

Mean Percentage of Total Errors in Each Truth Table Category, for the Combined Data of All Subjects Solving the Rule and According to Preexperimental Bias

Rule	Preexperimental Bias	Truth Table Category TT	TF	FT	FF	n
	Combined	7.7	33.3	33.4	3.2	40
	Conjunctive	10.0	0	0	0	10
Cj	Disjunctive	3.1	46.3*	50.6*	0	8
	Affirmative(1st)	0	96.3*	3.7	0	9
	Affirmative(2nd)	5.0	3.1	88.1*	3.8	10
	Combined	0.8	31.8*	46.4*	14.7	40
	Conjunctive	0	49.4*	50.6*	0	8
Dj	Disjunctive	0	10.0	15.0	35.0	5
	Affirmative(1st)	0	0	100*	0	13
	Affirmative(2nd)	0	100*	0	0	8
	Combined	6.6	31.0*	14.6	47.8*	40
	Conjunctive	—	—*	—	—*	0
Cd	Disjunctive	5.3	33.1	13.9*	46.6*	19
	Affirmative(1st)	3.9	31.5	17.7	46.9*	8
	Affirmative(2nd)	2.7	19.0*	10.8*	67.6*	5
	Combined	8.8	22.7*	22.6*	46.0*	40
	Conjunctive	5.1	21.6*	14.1*	59.2*	8
Bd	Disjunctive	9.2	25.3	27.1	38.4*	12
	Affirmative(1st)	9.0	23.2	14.2*	53.6*	3
	Affirmative(2nd)	5.0	21.6*	26.5	47.0*	8

Note: Truth table categories predicted by the model to be relatively difficult when the indicated preexperimental bias applies are marked with an asterisk(*).

predicted by the model when modified to take into account the respective biases.

However, with the conditional rule the observed error patterns were not in agreement with predictions of relative truth table class difficulty when the model is modified with respect to the applicable biases. Specifically, in contrast to the predicted configurations, inclusive disjunctive biased subjects had greater difficulty with the TF category than with the FT category. Affirmative(first dimension) biased subjects also had more difficulty with the TF than with the FT category, as did affirmative(second dimension) biased subjects. It is therefore evident that subjects in the conditional RL problem, regardless of having been labeled as possessing disjunctive, affirmative(first dimension), or affirmative(second dimension) biases, tended to exhibit error patterns consonant with predictions of the unmodified, conjunctive biased Inference model.

Within the biconditional rule, the observed error pattern for conjunctive biased subjects conformed to predictions of the unmodified, conjunctive biased model. Further, all subjects had particular difficulty with the FF category. However, in contrast to predictions of an inclusive disjunctive biased model, inclusive disjunctive biased subjects had greater difficulty with TF and FT instances than with TT instances. Further, in contrast to predictions of an affirmative(first dimension) biased model, affirmative (first dimension) biased subjects did not have more difficulty with the FT than with the TF category. Also, in contrast to predictions, affirmative(second dimension) biased subjects did not have more difficulty with the TF than with the FT category. In all, observation of the error patterns within the biconditional rule indicates that subjects, regardless of their preexperimental bias label, tended to exhibit error patterns predicted by the unmodified, conjunctive biased Inference model.

Stage II: Problem 2 Performance

Solution Bias

The solution bias expressed by each subject beginning Problem 2, following attainment of the particular Problem 1 relationship, was determined by classifying the pattern of responses to the first example of each truth table category, which appeared within the first four stimulus presentations. Table 12 shows the frequency of each response bias according to Problem 1 rule condition and Problem 2 rule condition.

Of the 40 subjects for whom Problem 1 involved the conjunctive relationship, 31 (78 percent) demonstrated a conjunctive bias beginning Problem 2. Also, 31 of the 40 people expressed a different initial bias from Problem 1 to Problem 2.

Twenty seven of 40 or 68 percent of the subjects for

Table 12

Frequency of Solution Bias Types According to Problem 1 Condition and Problem 2 Condition

		Primary Biases						Complementary Biases						U[1]
		Af1st	Af2nd	Cj	Dj	Cd	Bd	Ne1st	Ne2nd	AD	JD	Ex	ED	
Problem 1 Rule	Cj	2	3	31	3	0	0	0	0	0	0	0	0	1
	Dj	3	2	0	27	0	1	0	0	0	0	1	2	4
	Cd	4	5	1	4	7	5	1	0	2	0	1	1	9
	Bd	4	6	6	2	7	8	0	0	1	1	0	0	5
Percentage of Total		8.1	10.0	23.8	22.5	8.8	8.8	0.6	0	1.9	0.6	1.3	1.9	11.9
Problem 2 Rule	Cj	2	4	10	7	4	3	0	0	1	0	0	0	9
	Dj	5	4	11	13	1	4	0	0	0	1	0	0	1
	Cd	2	4	10	9	5	1	1	0	1	0	1	2	4
	Bd	4	4	7	7	4	6	0	0	1	0	1	1	5

[1]Note: 'U' category refers to the situation in which a subject initially assigned all stimuli to either the positive or negative category.

whom Problem 1 involved the inclusive disjunction rule expressed an inclusive disjunctive bias beginning Problem 2. Also, 33 of the 40 people expressed a different initial bias in Problem 2 than in Problem 1.

Of the 40 subjects for whom Problem 1 involved the conditional relationship, only 7 (18 percent) expressed a conditional bias beginning Problem 2. Also, 35 of the 40 people demonstrated a different initial bias in Problem 2 than in Problem 1.

Eight of 40 or 20 percent of the subjects for whom Problem 1 involved the biconditional rule demonstrated a biconditional bias beginning Problem 2. Also, 33 of the 40 people expressed a different initial bias in Prob- 2 than in Problem 1.

The above results indicate that the majority of the subjects (83 percent overall) changed their initial bias from the first to the second problem, although not necessarily representing the bias of the Problem 1 rule. The subjects were far more likely to express a conjunctive or inclusive disjunctive bias following practice with the respective rule than they were likely to express a conditional or biconditional solution bias after practice with the respective rule.

Overall Rule Difficulty

The trial of last error, and the number of errors made were the dependent variables. Those subjects who failed to reach the rule learning criterion on Problem 2 were not replaced, allowing a possible maximum score, on both measures, of 162.

Problem 2 involved solution of either the conjunction, inclusive disjunction, conditional, or biconditional rule, with one quarter of the subjects per group having had previous experience with one of the above rules in Problem 1. The mean trial of last error, combined across particular Problem 1 rule, for the conjunction, inclusive disjunction, conditional, and biconditional rules was 9.15, 10.08, 39.55, and 40.20 respectively, while the mean errors were 3.75, 4.0, 16.70, and 15.25 respectively. The Problem 2 trial of last error and error scores for each subject are presented in Appendix D.

For the trial of last error data, Hartley's and Cochran's tests indicated that the assumption of homogeneity of variance was violated ($F_{max}(4,39) = 24.32$, $p < .01$; $C(4,39) = .51$, $p < .01$). Therefore a $\log(x+1)$ transformation was performed on the trial of last error data in order to satisfy the homogeneity of variance assumption, as indicated by Hartley's and Cochran's tests ($F_{max}(4,39) = 1.38$, $p > .05$; $C(4,39) = .29$, $p > .05$). Analysis of variance on the transformed trials data revealed a significant effect of rules ($F(3,156) = 17.40$, $p < .05$). A Neuman-Keuls test indicated that the conjunction and inclusive disjunction rules were significantly less difficult than the conditional and biconditional rules ($p < .05$), with no difference between the conjunction and disjunction, and no difference between the conditional and biconditional.

For the errors data, the assumption of homogeneity of variance was also violated, as indicated by Hartley's and Cochran's tests ($F_{max}(4,39) = 51.44$, $p < .01$; $C(4,39) = .64$, $p < .01$). Therefore a $\log(x+1)$ transformation was performed on the errors data in order to satisfy the homogeneity of variance assumption ($F_{max}(4,39) = 1.81$, $p > .05$; $C(4,39) = .32$, $p > .05$). Analysis of variance on the transformed errors data indicated a significant effect of rules ($F(3,156) = 17.70$, $p < .05$), and a Neuman-Keuls ($p < .05$) test revealed the same rule difficulty order as for the trials data. Namely, conjunction was equal to inclusive disjunction easier than conditional equal to biconditional. Summaries of the above analyses are presented in Appendix F.

<u>Effect of Practice With the Same Rule</u>

The treatment conditions employed in the present study meant that four groups of 10 subjects each encountered the same primary bidimensional rule in Problem 2 as in Problem 1. Figures 4 and 5 show the mean trial and error scores, respectively, for the four same-rule groups on Problems 1 and 2. As seen in these figures, there was a great improvement in performance from Problem 1 to Problem 2, such that initial differences in rule difficulty were largely attenuated

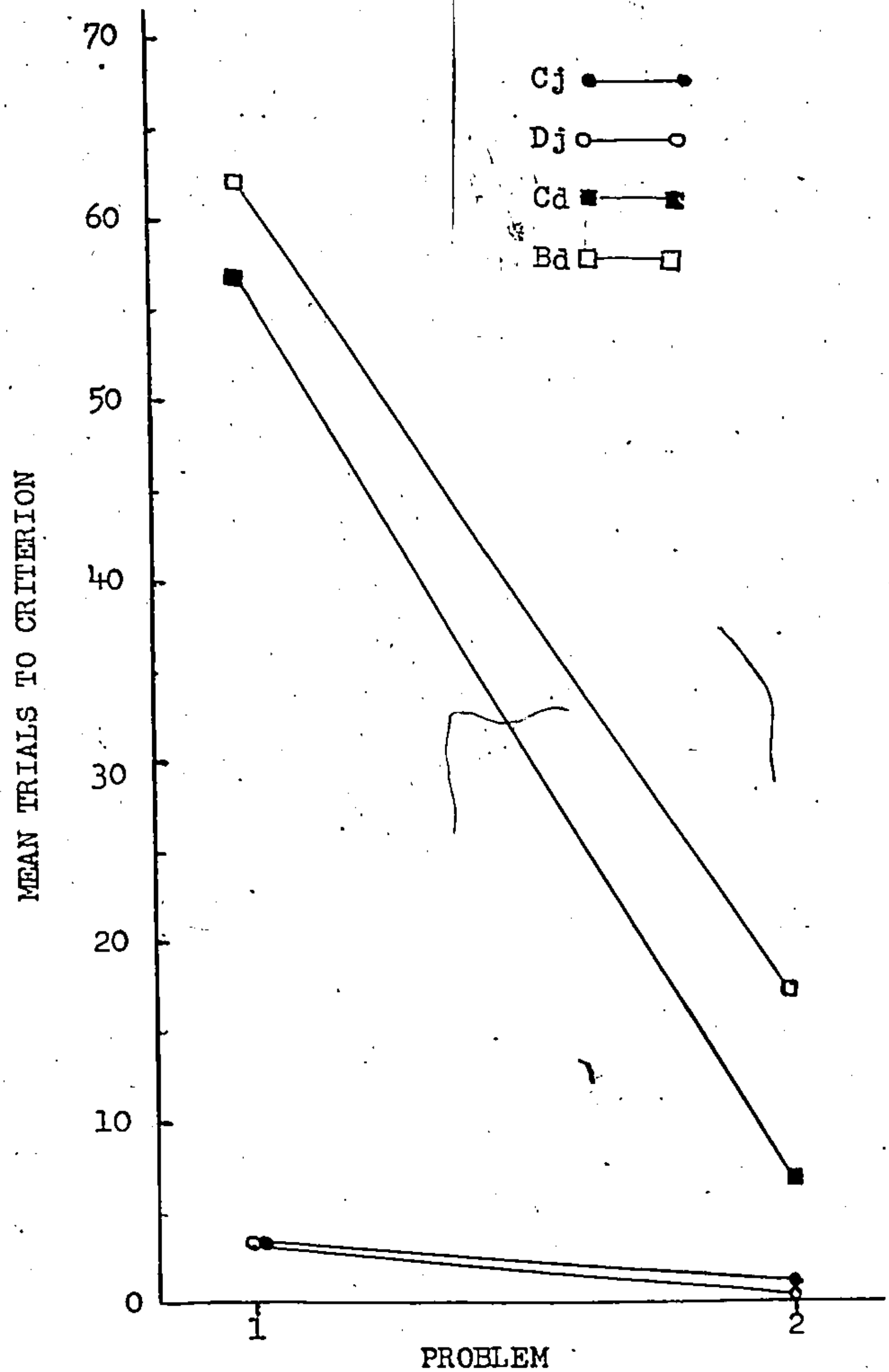

Figure 4. Mean trials to criterion for each rule, over two RL problems.

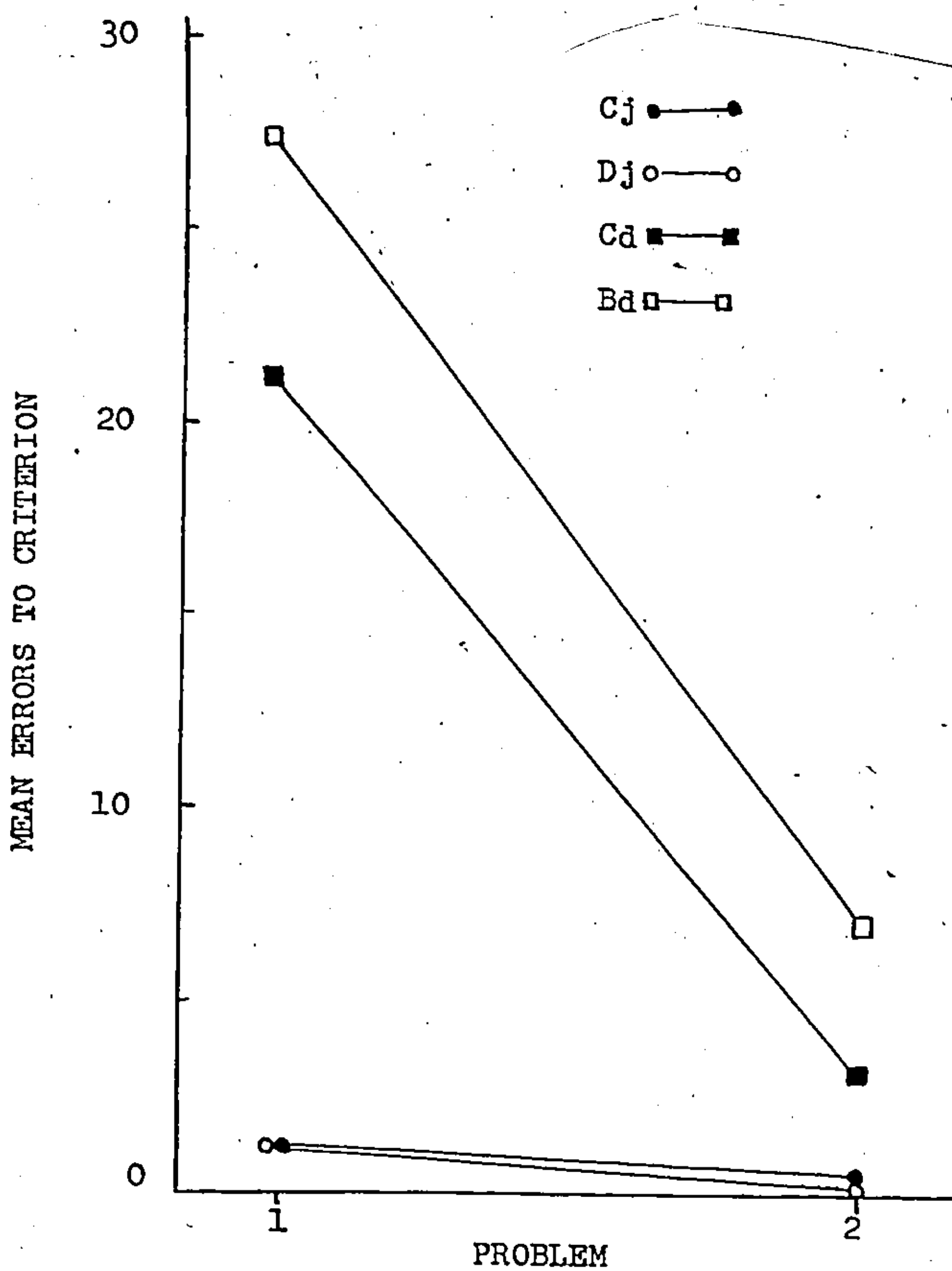

Figure 5. Mean errors to criterion for each rule, over 2 RL problems.

by the second RL problem. To assess the effects of practice with the same rule, a 4(Rules) X 2(Problems) analysis of variance with the second factor repeated (Winer, 1971) was conducted on both the log(x+1) transformed trials and errors scores, summaries of which are presented in Appendix F.

Analysis of variance on the trials data indicated a significant effect of Rules ($F(3,36) = 38.19$, $p < .05$) and a significant effect of Problems ($F(1,36) = 111.80$, $p < .05$), although the Rules X Problems interaction was not significant ($F(3,36) = 2.40$, $.10 > p > .05$).

Analysis of variance on the errors data yielded similar results as for the trials data, with a significant effect of Rules ($F(3,36) = 43.44$, $p < .05$) and a significant improvement over Problems ($F(1,36) = 162.25$, $p < .05$). Also, a significant Rules X Problems interaction was evident ($F(3,36) = 11.50$, $p < .05$), reflecting the large improvement in performance from Problem 1 to Problem 2, especially for the conditional and biconditional rules.

<u>Rule Difficulty Order as a Function of Previous Rule Experience</u>

The mean scores for the 16 experimental groups of Stage II are shown in Figures 6 and 7, illustrating the trial of last error and number of errors, respectively. In order to assess rule difficulty order as a function of previous rule experience, a 1 (rule solved in

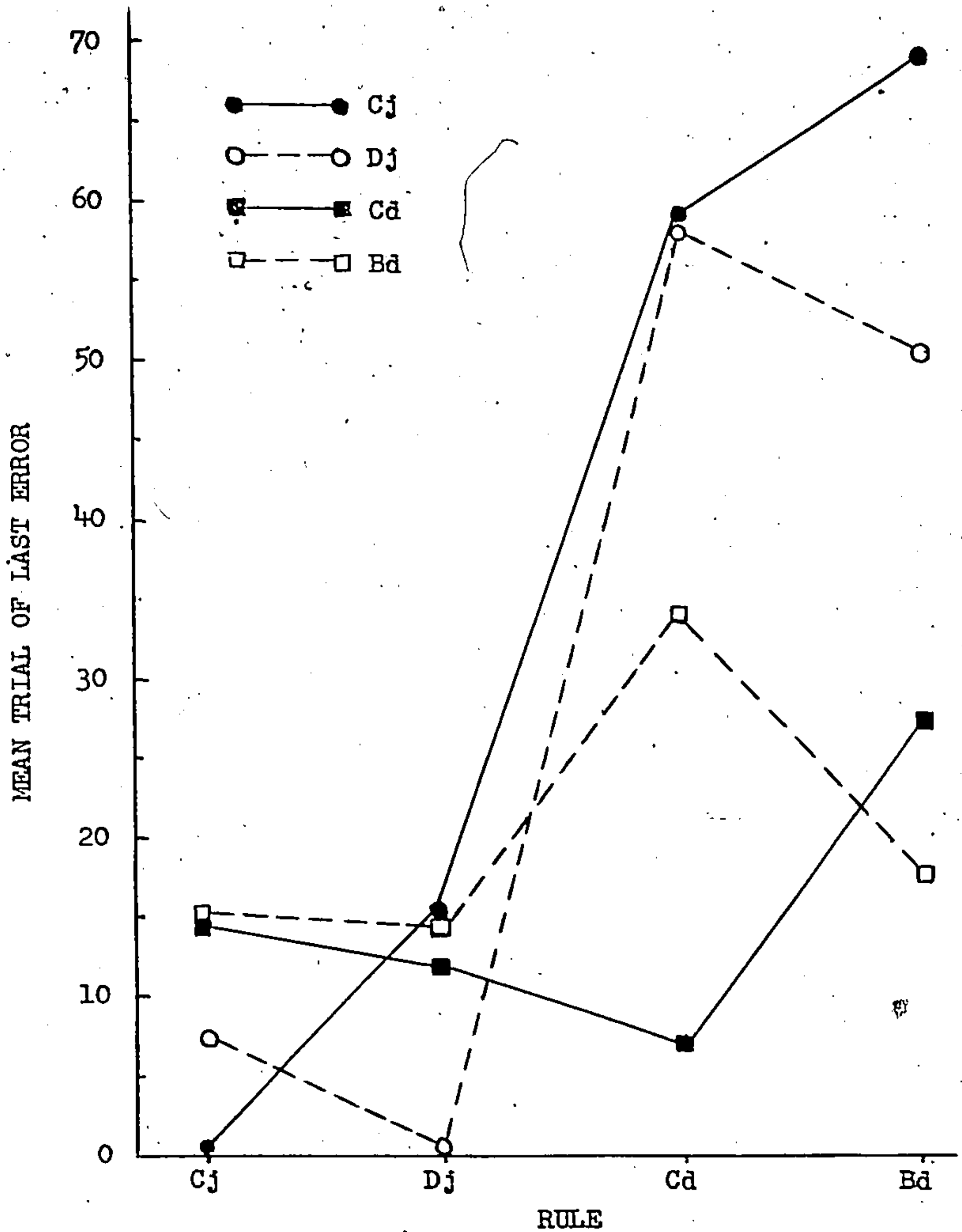

Figure 6. Mean trial of last error for each rule as a function of the rule solved in problem 1.

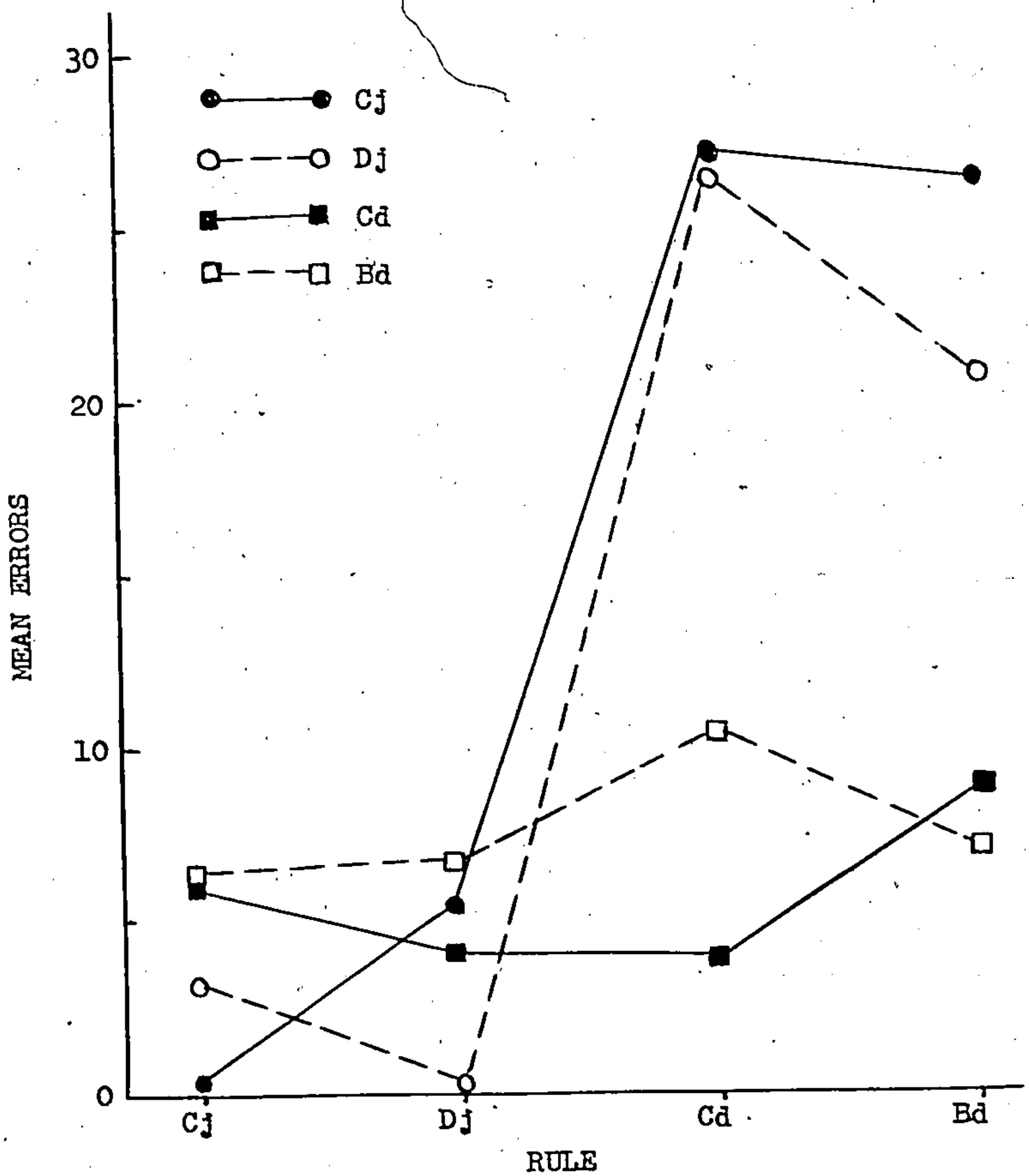

Figure 7. Mean number of errors for each rule as a function of the rule solved in problem 1.

Problem 1) X 4 (Rules) independent groups analysis of variance(Winer, 1971) was performed for each Problem 1 rule on both the trials and errors data. Comparisons between cell totals were made using the Neuman-Keuls ($p < .05$) procedure. All analyses were conducted on the log(x+1) transformed data, summaries of which are presented in Appendix F.

The results are summarized in Table 13, which shows the obtained rule difficulty orders following practice with one of the primary bidimensional rules, for both the trials and errors data. As seen in Table 13, rule difficulty order varied depending upon the rule previously solved in Problem 1. Results for the trials and errors data were not identical and so are reported separately below.

For the trial of last error data, following practice with the conjunction rule the conjunction was less difficult than the inclusive disjunction, which was in turn less difficult than the conditional and biconditional rules, with no difference between the latter two rules. Following practice with the inclusive disjunction rule, the rule difficulty in increasing order was inclusive disjunction, conjunction, biconditional equal to conditional. After practice with the conditional relationship, only the biconditional was more difficult than the conditional rule on Problem 2. Finally, following practice with the

Table 13

Observed Rule Difficulty Order Following Practice With a Primary Bidimensional Rule, for the Trial of Last Error and Errors Data

Trial of Last Error Data

Rule Solved in Problem 1	Rule Order	$p < .05$
Cj	Cj < Dj < Cd = Bd	$F(3,36) = 43.21$
Dj	Dj < Cj < Bd = Cd	$F(3,36) = 30.77$
Cd	Cd = Dj = Cj < Bd = Cj	$F(3,36) = 5.87$
Bd	Bd = Cd = Dj = Cj	$F(3,36) = 2.36$

Errors Data

Rule Solved in Problem 1	Rule Order	$p < .05$
Cj	Cj < Dj < Cd = Bd	$F(3,36) = 38.00$
Dj	Dj < Cj < Bd = Cd	$F(3,36) = 27.17$
Cd	Cd = Dj < Cj = Bd	$F(3,36) = 6.88$
Bd	Bd = Cd = Dj = Cj	$F(3,36) = 1.80$

biconditional rule no significant difference was found between the four rules.

For the errors data, rule difficulty orders were the same as those reported above for the trials data following conjunction, inclusive disjunction, and biconditional rule practice. However, following conditional rule practice, analysis of the errors data indicated that both the conjunction and biconditional rules were more difficult than the conditional rule.

<u>Within-Rule Difficulty as a Function of Prior Rule Practice</u>

In order to assess the effects upon learning a particular rule, of practice with either the same or a different rule, a 1 (Rule) X 4 (Rule solved in Problem 1) independent groups analysis of variance was performed for each Problem 2 rule on both the log(x+1) transformed trial of last error and errors data. The Neuman-Keuls ($p < .05$) procedure was used to compare cell totals, and analysis summaries are presented in Appendix F.

The results are summarized in Table 14, which shows the rule practice difficulty order within each rule for both the trials and errors data. Results for the trials and errors scores were not identical, and so are presented separately below.

For the trial of last error data, within the conjunction rule conjunctive practice was more beneficial than inclusive disjunctive, conditional, or biconditional

Table 14

Observed Within-Rule Difficulty Order as a Function of Primary Bidimensional Rule Practice, for the Trial of Last Error and Errors Data

Trial of Last Error Data		
Rule	Rule Practice Order	$p < .05$
Cj	Cj < Dj = Cd = Bd	$F(3,36) = 36.00$
Dj	Dj < Cd = Bd = Cd	$F(3,36) = 9.65$
Cd	Cd < Bd = Cj = Dj	$F(3,36) = 9.59$
Bd	Bd < Cd = Dj = Cj	$F(3,36) = 5.22$
Errors Data		
Rule	Rule Practice Order	$p < .05$
Cj	Cj < Dj < Cd = Bd	$F(3,36) = 55.20$
Dj	Dj < Cj = Bd = Cd	$F(3,36) = 8.08$
Cd	Cd < Bd = Cj = Dj	$F(3,36) = 10.30$
Bd	Bd < Cd = Dj = Cj	$F(3,36) = 6.75$

rule practice, with the latter three rules showing no difference between them. Within the inclusive disjunction rule, disjunctive practice was best, with no significant difference between conjunctive, conditional, or biconditional practice. For the conditional rule, conditional rule practice was more beneficial than biconditional, inclusive disjunctive, or conjunctive practice, with no significant difference between the latter three. In the biconditional rule, biconditional practice was best, with no significant difference between conditional, conjunctive, or inclusive disjunctive rule practice.

For the errors data, the same orders of rule practice effects as for the trials data were found within the inclusive disjunction, conditional, and biconditional rules. However, within the conjunction rule conjunctive practice was more beneficial than inclusive disjunctive practice, which was in turn better than conditional or biconditional practice, with no difference between the latter two.

Difficulty of Truth Table Categories

For each subject, the percentage of his or her total errors occurring in each truth table category was determined. Then, for each Problem 2 rule the percentages within each truth table category were averaged according to rule solved in Problem 1 to obtain the mean percentage of total errors within that category, as shown in Table 15.

Table 15

Mean Percentage of Total Errors in Each Truth Table Category According to Rule Solved in Problem 1

Rule	Rule Solved in Problem 1	Truth Table Category TT	TF	FT	FF n=10
Cj	Cj	0	0	10.0	0
	Dj	2.5	50.8*	44.2*	2.5
	Cd	4.0	34.4*	27.1	35.5*
	Bd	3.3	21.4*	30.6*	44.8*
Dj	Cj	0	55.2*	38.9*	5.9
	Dj	0	0	0	0
	Cd	0	29.2	26.9*	23.9*
	Bd	1.7	23.7	40.2	24.5*
Cd	Cj	2.5	28.1*	18.0	51.4*
	Dj	9.0	33.9	13.1*	44.0*
	Cd	24.1	34.9	7.3	23.7
	Bd	4.8	22.9	42.0*	30.3
Bd	Cj	5.7	14.6*	9.5*	70.2*
	Dj	5.5	24.8	18.0	41.7*
	Cd	10.9	31.8	33.2*	24.2
	Bd	0	20.5	16.0	33.5

Note: Truth table categories predicted by the model to be relatively difficult are marked with an asterisk.

These data were then examined by visually comparing the observed error patterns, across the four truth table categories for each rule and rule practiced, with the predicted error patterns (shown in Table 15 and also in Table 7).

Following practice with the conjunction rule, virtually errorless performance was demonstrated by subjects who solved the conjunction rule in Problem 2, and the observed error patterns were also in agreement with predicted configurations in the inclusive disjunction, conditional, and biconditional RL problems.

Following practice with the inclusive disjunction rule, virtually errorless performance was demonstrated by subjects who solved the inclusive disjunction rule in Problem 2. In the conjunction rule, disjunction-practiced subjects had more difficulty with the TF and FT classes than with the other classes, also in agreement with predictions of the disjunctive-biased model. However, in contrast to predictions, subjects had more difficulty with the TF than with the FT class in the conditional rule, thereby demonstrating an error pattern consistent with predictions of the conjunctive-biased model. In the biconditional rule, subjects had the greatest difficulty with FF instances, and there was no apparent difference in the relative difficulty of the TF and FT classes, both findings in agreement with the disjunctive-biased model predictions. However, the greater relative difficulty with the TF and FT classes versus the TT class suggests that the error pattern observed for disjunction-practiced subjects in the biconditional rule may be better accounted for by predictions of the conjunctive-biased model.

Following practice with the conditional rule, subjects who solved the conditional rule in Problem 2 still made errors, having the greatest difficulty with TF instances and the least difficulty with FT instances. In the conjunction rule, conditional-practiced subjects had the greatest difficulty with the TF and FF classes, in agreement with predictions, although substantial relative difficulty with the FT category was also evident. In the inclusive disjunction rule, contrary to predictions, subjects had as much difficulty with the TF category as with the FT and FF categories. In the biconditional rule, contrary to predictions, conditional-practiced subjects did not have substantially greater difficulty with the FT class than with the other truth table classes.

After practice with the biconditional rule, subjects who solved the biconditional rule in Problem 2 still tended to make errors, having greater difficulty with the TF, FT, and FF categories than with the TT category. In the conjunction rule, subjects had the most difficulty with TF, FT, and FF instances, in agreement with predictions. In the inclusive disjunction rule, however, in contrast to predictions, subjects did not have more difficulty with the FF category than with the other categories. Finally, in the conditional rule, biconditional-practiced subjects had the greatest difficulty with the FT class, in support of predictions, although substantial relative difficulty with the FF class was also evident.

Relative FF Category Difficulty: The above-described findings indicate that rule practice was at least somewhat effective in altering subjects' response tendencies. For example, consider the effects upon the difficulty of the FF stimulus class, of training with the conditional or biconditional rules, which require the assignment of FF stimuli to the positive response category, versus training with the conjunction or inclusive disjunction rules, which require the assignment of FF stimuli to the negative category. Table 15 shows that, in terms of percentage of total errors, conditional or biconditional-practiced subjects had greater difficulty with FF instances on the Stage II conjunction and inclusive disjunction RL problems than did conjunction or disjunction-practiced subjects. Conversely, conjunction or disjunction-practiced subjects had greater difficulty with the FF class on the Stage II conditional and biconditional RL problems than did conditional or biconditional-practiced subjects. These trends were therefore consistent with expectations.

However, the error patterns shown in Table 15 do not reflect the disparity that existed between the relative effectiveness of conditional or biconditional practice versus conjunction or disjunction practice, in terms of persistence of responding in a manner consistent with the practiced rule strategies. This disparity is revealed in the number of errors made on the FF class. That is, conditional and biconditional-practiced subjects made an average of only 2.35 errors on the FF class in the conjunction and disjunction RL problems, while conjunction and disjunction-practiced subjects made an average of 14.35 errors on the FF class in the conditional and biconditional RL problems.

Post-Experiment Verbalizations of Relationships

The subjects' statements were examined for their ability to verbalize the relationships encountered in the two RL problems. Table 16 shows, at each Stage, and combined across conditions, the percentage of subjects who were able to verbalize the particular rule that they had solved. As seen in Table 16, most of the subjects correctly verbalized the conjunction and inclusive disjunction relationships. On the other hand, the conditional relationship was correctly verbalized only about half of the time it was solved, while an even smaller percentage of subjects (33 %) were able to correctly verbalize the biconditional relationship.

Table 16

Percentage of Subjects Able to Correctly Verbalize the Rule Solved

Rule	As Problem 1		As Problem 2		Combined % Able to Verbalize
	Number of Solvers	% Able to[1] Verbalize	Number of[2] Solvers	% Able to Verbalize	
Cj	40	85.0	40	80.0	82.5
Dj	40	87.5	40	77.5	82.5
Cd	40	40.0	38	63.2	51.3
Bd	40	30.0	38	36.8	33.3

[1]Note: Subjects who wrote lists of the stimuli according to positive and/or negative category, without describing in words the correct partitioning of stimuli, were considered as unable to correctly verbalize the relationship.

[2]Note: Four subjects failed to solve the conditional or biconditional rules as Problem 2. Although not indicated above, none of these nonsolvers was able to verbalize the relationship.

Chapter 4

DISCUSSION

Since the purpose of the present experiment was to test the predictive ability of the Inference model when modified with respect to various rule biases, the methodological aims concerned a practicable test of predictions derived from the modified model, predictions regarding rule difficulty order, within-rule solution difficulty, and relative difficulty of truth table stimulus classes as a function of rule bias. Two methods of doing so were employed, relying upon: a) the assumption that naive RL subjects show differences in their initial response tendencies or preexperimental rule biases, and that conceptual performance is a function of preexperimental rule bias (Dominowski and Wetherick, 1976; Gates, 1978; Reznick and Richman, 1976); and b) the assumption that rule bias may be instilled and/or modified via explicit rule training, with effects upon subsequent RL performance (Bourne, 1970; Bourne and Guy, 1968a; Bower, 1971; Guy, 1969; Haygood and Bourne, 1965; Lee, 1968). The findings and theoretical implications for each method in permitting an assessment of the predictive ability of a modified Inference model, are considered below.

<u>Preexperimental Rule Bias</u> With regard to the observed frequencies of preexperimental bias types, the present findings (shown in Table 8) were comparable to those of

Dominowski and Wetherick (1976), Gates (1978), and Reznick and Richman (1976), in that a substantial proportion of naive RL subjects demonstrated either conjunctive, inclusive disjunctive, or affirmative biases. However, almost no effects of preexperimental rule bias upon the rule difficulty hierarchy were observed. As shown in Table 9, the only suggestion of a possible differential effect of preexperimental bias was found for conjunctive biased subjects who, in contrast to other-biased subjects, required significantly fewer trials and errors to criterion in the conjunction than in the inclusive disjunction RL problem. Also, very limited effects of preexperimental bias upon the ease of learning a particular rule were observed, as shown in Table 10. Only within the conjunction and inclusive disjunction rules were any differences found. The strongest support for the view that preexperimental rule bias affects RL performance came from an examination of the relative difficulty of truth table stimulus classes within each rule. As shown in Table 11, different error patterns were observed within both the conjunction and inclusive disjunction rules, and further were in agreement with Inference model predictions modified with respect to conjunctive, disjunctive, affirmative (first dimension), and affirmative (second dimension) biases. Not so, however, within the conditional and biconditional rules where, regardless of rule bias, error patterns conformed to predictions of the unmodified, conjunctive biased Inference model. As discussed below, the present findings concerning preexperimental rule bias may be interpreted in various ways. Regardless of interpretation, however, since so few differences in RL performance attributable to preexperimental bias were observed, it must be concluded that the procedure of differentiating between subjects on the basis of their inferred preexperimental rule bias did not provide an appropriate test of predictions of the modified Inference model.

One possibility is the position offered by Reznick and Richman (1976), that people indeed possess different preexperimental rule biases that affect RL performance, as reflected especially in the present study by the different truth table class error patterns within the conjunction and inclusive disjunction rules, and somewhat by the very limited differences with respect to rule difficulty hierarchy and within-rule solution difficulty. If this is the case, serious difficulties are posed for the Inference model (Bourne, 1974; Salatas and Bourne, 1974) in terms of its validity in accounting for the behaviour of naive RL subjects. Reznick and Richman's position suggests that the difficulty of solving a particular RL problem, and hence the overall rule difficulty order, is not a consequence of subjects' conjunctive biased inference operations, but rather depends upon the relative proportions of preexperimental rule biases held by subjects solving the particular rule. Now, one could argue that some factor of conditional and biconditional relationships, such as their unnatural assignment of FF stimuli to the same (positive) response category as TT instances, disrupted and hence forced the subjects to abandon their initial rule bias in favour of a conjunctive strategy, thereby masking the effect of preexperimental bias in these rules. If this were so, differences in the conditional or biconditional rules would not be expected to be observed, as was found for all measures in the present study, and also in the Reznick and Richman (1976) experiment for within-rule difficulty effects. Such an interpretation would, however, necessitate the consideration of preexperimental rule bias as a relevant variable in RL experiments, at least with the conjunction and inclusive disjunction rules, or more generally perhaps for rules that do not require the unfamiliar or unnatural assignment of TT and FF instances to the same response category.

An alternative explanation of the present findings seems equally plausible. The suggestion is similar to that above, in that observed differences in RL performance as a function of preexperimental rule bias would only be expected to emerge for rules that are easily solved by subjects, such as the conjunction and inclusive disjunction rules of the present experiment. However, rather than attributing the lack of observed preexperimental bias effects in the conditional and biconditional rules to some masking effect, it could be argued that the present findings of <u>any</u> differences in RL performance as a function of preexperimental bias did not reflect a real differential effect, but rather were artifacts of the extreme ease with which most subjects solved the conjunction and inclusive disjunction rules. Examination of the error scores for subjects who solved the conjunction and inclusive disjunction RL problems in Stage I (shown in Appendix D) indicates that a floor effect existed for these rules. That is, 32 of the 40 subjects who solved the conjunction RL problem made no more than one error per truth table stimulus class, and 33 of the subjects made a total of two or fewer errors. Of the 40 subjects who solved the disjunction RL problem, 33 made no more than one error per truth table class, and 34 of the subjects made a total of two or fewer errors. The floor effect for these rules indicates that the majority of subjects, regardless of inferred preexperimental bias type, were able to attend to the feedback as to correct category assignment of stimuli with a minimum of difficulty. Thus, 'preexperimental rule bias' did not impose any particular difficulty upon solving the conjunction or inclusive disjunction RL problems in terms of any sort of persistent responding. Rather, observed differences in RL performance that were attributed to preexperimental rule bias were simply the consequence of the fact that some subjects made no errors whatsoever, while others made a small number of errors before responding perfectly. For example, the different truth table error patterns observed within the conjunction and inclusive disjunction rules according to preexperimental bias, did not reflect real difficulty with the rules; rather, a relatively high 'mean percentage of total errors' value for (a) particular truth table class(es) reflected the only truth table class(es) in which subjects tended to make an error before responding perfectly. It should be pointed out that this interpretation also accounts for the findings of Reznick and Richman (1976) regarding significant preexperimental rule bias effects only within the conjunction and disjunction rules, and not within the conditional or biconditional rules — Reznick and Richman found a floor effect for the conjunction and inclusive disjunction rules, as did the present experiment.

The above explanation of significant preexperimental rule bias effects, in the present study and in Reznick and Richman's (1976) experiment, as artifacts of a floor effect, suggests that 'preexperimental rule bias' need not be considered as an important or relevant variable in RL research. However, one is left with the problem of accounting for the present and other experimental findings (Dominowski and Wetherick, 1976; Gates, 1978; Reznick and Richman, 1976) of predominantly-expressed rule strategies in the initial classification of stimuli — namely, conjunctive, inclusive disjunctive, and affirmative strategies. In this regard, Bourne (cited in Dominowski and Wetherick, 1976) has offered a position which may obviate Reznick and Richman's (1976) contention that subjects differ in their preexperimental rule biases. Bourne has suggested that in an initial classification test, the occurrence of frequently expressed rule types other than the conjunctive may be explained as a response to a demand characteristic of the classification test which would not be important once the subjects began receiving (or more importantly attending to) category information for stimuli. It can be seen in Table 2 that with three attributes per stimulus dimension, as in the present study and those of Dominowski and Wetherick (1976), Gates (1978), and Reznick and Richman (1976), the conjunction rule generates a 1:8 split of positive and negative instances, while the inclusive disjunction rule generates a 5:4 split of positive and negative instances. An affirmation rule generates a 3:6 split of positive/negative instances. Bourne has suggested that subjects, having received a description of the stimulus population and categorization task, in the absence of conflicting category feedback information, might initially feel constrained to assign roughly equal numbers of stimuli to the positive and negative response categories. Consequently, without possessing a formal strategy for these rules, subjects would initially tend to sort disjunctively or even affirmatively, rather than conjunctively.

Sawyer's (1972) findings, which were mentioned in an earlier chapter, of a strong tendency for his subjects to respond in an affirmative manner, could also be explained in terms of the above account, i.e. as a response to demand characteristics of the task. Sawyer used a simple population of four stimuli varying on two bi-leveled dimensions, resulting in a 1:1:1:1 distribution across the truth table stimulus classes. According to Bourne's interpretation, Sawyer's (1972) subjects would have felt constrained to assign equal numbers of stimuli to the two response categories, thereby tending to respond in an affirmative manner so as to achieve an even (2:2) split, rather than categorizing conjunctively or disjunctively, which would have generated a 1:3 or 3:1 split, respectively.

Some support for Bourne's position is provided by studies involving unreinforced stimulus sorting tasks (eg. Imai, 1966), which indicate that subjects demonstrate a preference for numerical balance of stimuli to categories. However, Imai's subjects were aware, at the outset of the task, of the number of stimuli (12) to be sorted. It seems to the present author that a prerequisite for the assumption of sorting solely on the basis of a numerical balance tendency, is that the subjects have at least implicit knowledge of the number of stimuli to be sorted. In none of the above-mentioned RL studies were the subjects informed as to the stimulus population size prior to the RL task. Now, it is possible in Sawyer's (1972) experiment, with stimuli varying on only two bi-valued dimensions, and in Dominowski and Wetherick's (1976) study, in which the stimuli varied on only two tri-valued dimensions, that the subjects were able to deduce the population sizes of four and nine stimuli, respectively, from the stimulus descriptions given prior to the task. However, it seems much less likely, with more complex stimulus populations varying on either three (the present study; Gates, 1978) or four (Reznick and Richman, 1976) tri-valued dimensions, that naive subjects would have been able to deduce the population sizes of 27 or 81, respectively, and then proceed to respond so as to achieve a roughly even split of stimuli to response categories, solely on the basis of a numerical balance tendency. It is therefore questionable whether a 'numerical balance tendency' hypothesis provides a complete explanation of the predominantly expressed initial rule strategies.

Thus, the following explanation seems reasonable. Rather than concluding, as did Reznick and Richman (1976), that a subject's initial classification of stimuli indicates an actual bias or 'set' for a particular rule strategy, it is possible that frequent demonstrations of disjunctive and affirmative strategies in the various preexperimental bias assessment procedures simply reflect the fact that subjects are somewhat familiar with these strategies <u>in addition to</u> the conjunctive, as they begin the RL task. Indirect support for this view is provided in two ways: first, from the universal RL finding, as in the present experiment, that the performance of naive subjects on a conjunction RL problem is not perfect (Bourne, 1970; Bourne and Guy, 1968a,b; Gates, 1978; Haygood and Bourne, 1965; Neumann, 1974; Reznick and Richman, 1976; Salatas and Bourne, 1974) — subjects make some errors, in the main on TF and FT instances, reflecting the present suggestion that some subjects may initially begin responding in a disjunctive or affirmative manner, but with feedback quickly shift their pattern of responding consistent with a conjunctive strategy; and second, from the present subjects' ability to verbalize relationships (summarized in Table 16), where, over all conditions of the present study, subjects were equally able to verbalize the conjunctive and inclusive disjunctive rules.

Now, the statement that naive RL subjects may be familiar with disjunctive and affirmative strategies in addition to the conjunctive, suggests that RL problems based on these rules should be solved with equal facility. As was reported earlier, though, this is usually not the case, the typical bidimensional RL finding being that the inclusive disjunction rule is somewhat more difficult than the conjunction rule, in terms of trials and errors to criterion. However, the reason for this difference may be due to the fact that RL subjects are typically constrained to adopt a conjunctive strategy as a consequence of the demand characteristics of most RL tasks. That is, it is likely that the structure of typical RL situations, by such features as instructional 'set', task difficulty i.e. stimulus composition, rule complexity, acts to restrict the initial utilization of strategies other than the conjunctive with which subjects may be familiar, at the same time enhancing the probability of initial utilization of a conjunctive strategy. The implications of this position for the overall Problem 1 rule difficulty hierarchy observed in the present experiment, will be discussed in a later section. It will simply be pointed out here that although the present position questions the validity of the statement that naive subjects are predominantly familiar only with a conjunctive strategy (Bourne, 1974; Salatas and Bourne, 1974), no difficulties are posed for the practical application of the Inference model in accounting for RL behaviour. The present position supports, for practical purposes, the central assumption underlying the inference operations of the model that naive subjects employ a conjunctive strategy, yet it admits the possibility that people may be familiar with other strategies as well.

<u>Effects of Rule Practice</u> A methodological aim of the Stage I RL problem was to establish a solution bias or 'set' for the particular bidimensional rule solved in Problem 1, with the Stage II rule conditions permitting assessment of the effects of either same- or different-rule practice upon subsequent RL performance. As seen in Tables 13, 14, and 15,

considerable differences in the rule difficulty hierarchies, within-rule solution difficulty, and within-rule relative difficulties of truth table classes, as a function of prior rule practice, were observed. Therefore, it may be concluded that the aim of altering or instilling response tendencies via rule practice was successful, at least to a degree. Now, comparison of the present findings (summarized in Tables 13, 14, and 15) with the modified Inference model predictions (summarized in Tables 4, 5, and 7, respectively) certainly do not indicate an overwhelming degree of correspondence. However, a number of apparent trends in the present data permitted a tentative evaluation of the predictive ability of the Inference model when modified to take into account various rule biases. The following trends, as revealed by inspection of the log(x+1) transformed cell totals data (shown in Appendix F), were entirely consistent with predictions.

Rule difficulty hierarchy: Following practice with the conjunction rule, the trend for rule difficulty, for both the trials and errors data, was conjunction easier than inclusive disjunction easier than conditional easier than biconditional, although as shown in Table 13 the trials and errors differences between the conditional and biconditional rules were not statistically significant.

Following practice with the inclusive disjunction rule, the rule difficulty trend, for both the trials and errors data, was inclusive disjunction easier than conjunction easier than biconditional easier than conditional. Again however, the trials and errors differences between the biconditional and conditional rules were not statistically significant, as shown in Table 13.

Within-rule solution difficulty: Within the conditional rule, the trend for rule practice effects, for both the trials and errors data, was conditional practice better than biconditional practice better than inclusive disjunctive practice equal to conjunctive practice, although only the trials and errors differences between conditional and other-rule practice were statistically significant, as shown in Table 14.

Within the biconditional rule, the trend for rule practice effects, for both the trials and errors data, was biconditional practice better than conditional practice better than disjunctive practice better than conjunctive practice, although as shown in Table 14, only the trials and errors differences between biconditional and other-rule practice were statistically significant. As a point of comparison, Bourne and Guy (1968a) also found that biconditional RL performance was facilitated more by conditional practice than by inclusive disjunctive practice, and least by conjunctive practice, although as in the present study the trend was not statistically significant.

Relative truth table class difficulty: The following error patterns (shown in Table 15) were consistent with predictions: for conjunctive-practiced subjects, in the conjunction, inclusive disjunction, conditional, and biconditional rules; for disjunctive-practiced subjects, within the conjunction and inclusive disjunction rules; for conditional-practiced subjects, only in the conjunction rule; and for biconditional-practiced subjects, within the conjunction and conditional rules.

Failure to Establish Solution Bias. While the above trends are taken as providing tentative support for predictions derived from the modified Inference model, it was also evident that a number of trends in the present data were not consistent with predictions. However, the failure of some trends to conform to predictions may be explained by the fact that the methodological aim was not entirely successful; that is, although response patterns were clearly altered via rule training, one-problem practice with the inclusive disjunction, conditional, or biconditional rules was not sufficient to establish a solution bias for that rule.

Conditional and biconditional practice: A number of features in the present data indicate that neither a conditional nor a biconditional solution bias was achieved via one-problem practice. First, only a small percentage of conditional or biconditional-practiced subjects, 18 and 20 percent over all conditions, responded in a conditional or biconditional manner as they began the second RL problem.

Conjointly, as shown in Figures 4 and 5, although subjects who solved two conditional or two biconditional RL problems demonstrated considerable improvement from Problem 1 to Problem 2, the majority of subjects in each condition still made errors on the second problem. Further, the truth table class error patterns exhibited by subjects following same-rule practice, for both the conditional and biconditional rule conditions (shown in Table 15), indicate that the within-class transfer, from Problem 1 to Problem 2, was not equal; that is, conditional-practiced subjects had the least difficulty with FT instances on the second conditional RL problem, while biconditional-practiced subjects had the least difficulty with TT instances on the second biconditional problem. These latter findings suggest that the elements or inference operations consistent with the particular strategy were not all equally available to the respective-practiced subjects, in spite of having earlier achieved a level of errorless performance with the rule. Lastly, the lack of a conditional or biconditional solution bias was especially evident in the relative ability of the subjects to solve RL problems based on rules not initially experienced in the RL situation. For example, Figures 6 and 7 show that conditional and biconditional-practiced subjects had considerably less difficulty in solving the Stage II conjunction or inclusive disjunction RL problems than did conjunctive or disjunctive-practiced subjects in solving

Stage II conditional and biconditional RL problems. This pattern was reflected in the number of errors made on the FF stimulus class.—conditional and biconditional-practiced subjects made an average of only 2.35 errors on the FF class in the conjunction and disjunction problems, while conjunctive and disjunctive-practiced subjects made an average of 14.35 FF class errors in the conditional and biconditional problems. These findings suggest several things: a) that in the absence of explicit training to the contrary, subjects show a strong tendency to assign FF stimuli to the negative category (Bourne, 1974; Salatas and Bourne, 1974), b) that in spite of explicit training to the contrary, conditional and biconditional-practiced subjects were familiar with the possibility that FF stimuli may be assigned to the negative response category, and c) that conditional and biconditional-practiced subjects were able to readily abandon the particular conflicting elements of their strategy in favour of inference operations consistent with conjunctive or inclusive disjunctive strategies. Consequently, the predicted rule difficulty hierarchies following conditional or biconditional rule practice, and the predicted within-rule solution difficulty orders for the conjunction and inclusive disjunction rules, were not observed in the present study, as shown in Tables 13 and 14.

Now, having pointed out that a conditional or biconditional solution bias was not achieved, is not to deny that subjects were familiar with these strategies as a consequence of training. For example, examination of the raw data scores revealed that eight of the conditional-practiced subjects solved the second conditional RL problem with the logically minimal amount of information i.e. making no more than one error per truth table class, while six of the 10 biconditional-practiced subjects solved the second biconditional RL problem with the logically minimal amount of information. The point to be emphasized, though, is similar to that made in an earlier section, that familiarity with a rule strategy does not necessarily imply a solution bias for that rule.

Inclusive disjunctive practice: That one-problem practice with the inclusive disjunction rule was not sufficient to establish a solution bias for the rule, is not as readily apparent from the data as for the conditional and biconditional rules. That is, a majority of subjects, 68 percent over all conditions, who solved the disjunction rule in Problem 1, responded in a disjunctive manner during the initial stages of Problem 2. Further, virtually errorless performance was achieved by disjunctive-practiced subjects on the second disjunction RL problem. However, as shown in Table 15, disjunctive-practiced subjects exhibited error patterns on the Problem 2 conditional and biconditional RL problems that were consistent with those of conjunctive biased subjects, according to Inference model predictions. This latter finding points to the suggestion that disjunctive-practiced subjects did not possess an actual solution bias or 'set' for the inclusive disjunction rule, in spite of the fact that they were familiar with and tended to exhibit initial response tendencies consistent with a disjunctive strategy. Faced with a difficult relationship, namely the conditional or biconditional rules which require the unfamiliar assignment of FF stimuli to the positive response category, the overall error patterns suggest that the subjects abandoned the disjunctive strategy in favour of conjunctive biased inference operations. Presumably though, disjunctive practice, in pointing out or reinforcing the possibility that TF and FT instances may belong in a different category than FF instances, aided the subjects' performance to the extent that other trends in the data were consistent with predictions i.e. the trend, following disjunctive practice, for the biconditional rule to be less difficult than the conditional rule; and the trend for disjunctive practice to be more beneficial than conjunctive practice in solving the biconditional RL problem.

Conjunctive practice: In contrast to the above, all pertinent aspects of the present data correspond to the suggestion that conjunctive-practiced subjects possessed a conjunctive solution bias. First, a majority of subjects who solved the conjunction rule in Problem 1, 78 percent over all conditions, demonstrated a conjunctive strategy during the initial stages of Problem 2. Further, as shown in Figures 4 and 5, virtually errorless performance was achieved by conjunctive-practiced subjects on the second conjunction RL problem. Finally, the error patterns exhibited by conjunctive-practiced subjects conformed to Inference model predictions for each of the four primary bidimensional rule conditions, as shown in Table 15. Taken together, the above findings suggest a solution bias for the conjunction rule, either as a consequence of one-problem practice and/or coupled with the fact that the subjects already possessed strong tendencies to respond in a conjunctive manner prior to entering the experimental situation (Bourne, 1974; Salatas and Bourne, 1974).

Limitations of Rule Practice. In spite of the above indications that one-problem practice was not sufficient to establish a solution bias for rules other than the conjunction, it was clearly evident that rule training was successful in altering, at least to some degree, the subjects' response tendencies. Further experiments along this line would entail increasing the number of RL problems based on the same rule prior to the transfer task, the intent of training being to strengthen response tendencies consistent with the practiced rule strategy while at the same time minimizing the likelihood that subjects revert to preexisting or more familiar inference operations. Alternatively, as suggested by Bourne (1974), subjects might receive training so as to enhance or change individual inference operations, rather than the procedure employed in the present study of training with entire rule strategies.

However, there may be limitations as to the effectiveness of the above methodologies in providing an adequate test of the modified Inference model. As explained at some length in an earlier chapter, extensive training, either with rules or with individual inference operations, might be expected to result in the development of 'open ended' inference operations (Bourne, 1974); or, phrased differently, subjects may become aware of all possible inference operations associated with the various rule strategies, to the degree that the rule learning task would simply be one of rule identification. Further, there may well be an interaction effect in the development of open ended inference operations. Training on difficult rules — rules which inform subjects as to unnatural or previously unknown inference operations, might accelerate the acquisition of open ended inferences in comparison to training on more simple rules.

Comparison of Modification Procedures. It will be recalled that the present findings regarding 'preexperimental rule bias' were not overly supportive of Reznick and Richman's (1976) contention that naive RL subjects may operate with rule biases other than the conjunctive. At the same time, the essential lack of differences in RL performance attributable to preexperimental bias also precluded a comparison of the manner in which Reznick and Richman suggested the Inference model should be modified to take into account various rule biases, versus the manner employed in the present experiment. It was felt that trends apparent in the data as a function of explicit rule training, were sufficient to permit a tentative comparison of the modification procedures.

The difference in interpretation lies with inference operation (C). As stated in an earlier chapter, inference (C) of the unmodified Inference model (Bourne, 1974) suggests that subjects make same/different judgements, with the category assignment of FF instances as the functional referent, to determine the response category to which they will assign stimuli lacking one or the other relevant attribute i.e. TF and FT instances. In the present experiment, modifications of inferences necessary to represent various rule biases were consistent with this assumption, as shown in Table 3.

On the other hand, Reznick and Richman's (1976) interpretation of inference (C) suggests that subjects assign TF and FT instances directly to response category, thereby ^ne^gating the relational aspect of TF and FT stimuli with the FF class. This difference in interpretation gives rise to different predictions when the model is modified with respect to various rule biases. With regard to the

Stage II rule conditions of the present study, the comparable differences in predictions are as follows. Reznick and Richman's interpretation predicts that: a) for conjunctive biased subjects, the biconditional rule should be less difficult than the conditional rule; b) disjunctive biased subjects should have greater difficulty with the biconditional rule than with the conditional rule; c) conjunctive biased subjects should have particular difficulty with the FT and FF stimulus classes in the conditional rule, and should have particular difficulty only with the FF class in the biconditional rule (although Reznick and Richman did not consider these predictions in their modification scheme); d) disjunctive biased subjects should have particular difficulty with the TF and FT classes in the conditional rule, and particular difficulty with the TF, FT, and FF classes in the biconditional rule (although again Reznick and Richman did not consider these features in their modification scheme); and e) conjunctive bias should be more beneficial than disjunctive bias in solving a biconditional RL problem.

Now, the only trend in the present data that supported Reznick and Richman's interpretation was for (d), the observed error patterns of disjunctive-practiced subjects in the conditional and biconditional rules (shown in Table 15). However, it has already been suggested that these error patterns simply reflect the methodological failure of one-problem practice to establish a solution bias for the inclusive disjunction rule. All in all, where points of comparison were possible, the present findings tend to support the modification procedure employed in the present experiment. That the Inference model may be modified to take into account various rule biases in a manner that assumes the same sort of inference operations proposed by Bourne (1974; Salatas and Bourne, 1974), as is tentatively suggested by the present findings, adds support to the view that the inference operations proposed by Bourne may actually reflect the ways in which subjects approach and attempt to solve a RL problem.

<u>Overall Problem 1 Rule Difficulty Order</u> It was mentioned in an earlier chapter that the typically reported hierarchy of rule difficulty in RL experiments, as measured by trials and errors to criterion, is conjunction, inclusive disjunction, conditional, and biconditional, in increasing order of difficulty. In the present study, however, the observed rule difficulty order was conjunction equal to inclusive disjunction easier than conditional equal to biconditional. The discrepancy between the present findings and those typically found in RL experiments may be accounted for by several factors.

Conjunction and inclusive disjunction RL difficulty: It will be recalled that a floor effect for both the conjunction and inclusive disjunction rules obscured any between-rule difficulty differences. That is, the majority of subjects in each rule condition were able to solve the problem with a minimum of difficulty, in spite of initial tendencies to respond in either a conjunctive, disjunctive, or affirmative fashion. Now, the position was offered that naive RL subjects are familiar with the above rule strategies, yet are constrained by the format or structure of typical RL experiments to predominantly adopt a conjunctive solution strategy. Am implication of this position is that it may be necessary to structure RL task conditions so as to promote the predominant utilization of a conjunctive strategy, and hence to produce rule difficulty differences for relationships with which subjects are familiar. Consequently, the observed lack of difficulty differences between the conjunction and inclusive disjunction rules in the present study, suggests that the subjects in these rule conditions were not constrained by the present experimental situation to primarily adopt a conjunctive strategy.

One way of increasing the likelihood that RL subjects will attempt to map a conjunctive solution, would seem to be in terms of the complexity or difficulty of the rule to be solved. As discussed earlier, the error patterns exhibited by subjects on the Problem 1 conditional and biconditional RL problems were consistent with those of a conjunctive bias, regardless of initial response patterns. Further, in spite of explicit training with the inclusive disjunction relationship, subjects exhibited error patterns on the Problem 2 conditional and biconditional RL problems which were also consistent with a conjunctive bias. These findings suggest that upon encountering a difficult or unknown relationship, subjects tend to revert to a conjunctive strategy in spite of familiarity with other relationships, either: a) because the conjunctive strategy is the one that is most familiar, or b) quite independent of the notion of relative familiarity, because a conjunctive strategy provides the most simple way of partitioning the stimulus population into positive and negative response categories. That is, subjects solving a conditional or biconditional RL problem quickly learn that the only aspect of the situation which is entirely consistent with prior expectations, is that TT instances belong in the positive category. Consequently, the adoption of conjunctive inference operations may simply provide the least confusing strategy with which to begin to learn the correct category assignment of TF, FT, and FF instances. Nonetheless, the suggestion is that the greater the task difficulty, the greater the likelihood that subjects will adopt a conjunctive strategy.

Another way of increasing task difficulty is in terms of complexity of the stimulus population. Beginning with the Haygood and Bourne (1965) study, the majority of RL experiments have employed stimuli varying on four tri-valued dimensions, with two relevant and two irrelevant dimensions.

However, it will be recalled that the stimuli in the present study varied on only three tri-valued dimensions, with two relevant and only one irrelevant dimension. Numerous researchers have shown that conceptual performance worsens with the number of irrelevant dimensions (eg. Battig and Bourne, 1961; Bourne and Bunderson, 1963; Bower and King, 1967; Overstreet and Dunham, 1969; Walker and Bourne, 1961). Therefore, use of the more complex stimulus population i.e. two irrelevant dimensions, might have raised the overall level of task difficulty in the present study to the point where naive subjects would have felt constrained to adopt a conjunctive strategy, thereby resulting in the typical rule difficulty differences between the conjunction and inclusive disjunction RL problems.

Another possibility is that the subjects in many RL experiments may be 'set' or constrained to respond conjunctively as a consequence of instructions given prior to the task proper. As will become apparent in a later section regarding conditional and biconditional rule difficulty, RL experiments sometimes vary considerably in terms of instructional content, while still adhering to the RL paradigm described by Haygood and Bourne (1965).

Conversely though, it is possible that some feature in the present instructions, for example the frequent use of <u>and,or</u> (see Appendix C), may have 'sensitized' subjects as to the possibility of strategies other than the conjunctive which would otherwise have remained either totally or relatively unavailable, thereby obscuring conjunction and inclusive disjunction rule difficulty differences. If so, it could be argued that the present experimental conditions did not permit a proper examination of the effects of preexperimental rule bias. That is, the same factors (i.e. instructions) that acted to negate difficulty differences between the Problem 1 conjunction and inclusive disjunction rules could have also acted to minimize pre-experimental rule bias effects. Now, the appropriate test of the above argument would involve structuring the RL task conditions so as to result in significant difficulty differences between the conjunction and disjunction rules, perhaps by the above suggestions of modifications to instructions and/or stimulus complexity. According to the Reznick and Richman (1976) position, that naive RL subjects may possess rule biases other than the conjunctive, within- and between-rule differences in solution difficulty as a function of preexperimental bias should persist, and further would be expected to be more apparent than in the present study. According to the present position, however, the same factors that produce rule difficulty differences between conjunction and inclusive disjunction RL problems should at the same time constrain the initial utilization of a conjunctive strategy, thereby minimizing or negating any preexperimental rule 'bias' effects.

Conditional and biconditional RL difficulty: Although no significant differences were found between the Problem 1 conditional and biconditional rules in terms of trials or errors to criterion, three times as many subjects failed to solve the biconditional as compared to the conditional rule. This finding clearly suggests that the biconditional was more difficult, or unnatural for subjects than the conditional relationship. Indirect support for this view was provided by the post-experiment verbalizations of the subjects (summarized in Table 16), where over all conditions, the conditional relationship was correctly verbalized approximately half of the times it was solved while the biconditional rule was correctly verbalized only a third of the time it was solved. Procedural differences between the present study and other RL experiments may account for the high number of nonsolvers, and hence for the lack of observed trials and errors differences between the conditional and biconditional RL problems.

Some RL studies report having provided truth table pretraining prior to the task proper (Bourne and Guy, 1968b; Guy, 1969; Neumann, 1974; Salatas and Bourne, 1974). Truth table pretraining, either by instructions to do so or by explicit tasks eg. card sorting, has been shown to facilitate RL performance (Dodd, Kinsman, Klipp, and Bourne, 1971; Lee, 1968). Some RL studies have also provided examples of simple class concepts, such as the affirmation or conjunction relationships, during instructions to subjects (Haygood and Bourne, 1965; Neumann, 1974; Salatas and Bourne, 1974). Giving specific rule examples might: a) strengthen or alter subjects' response tendencies, with subsequent confounding transfer effects upon RL performance; and/or b) provide, in effect, implicit truth table training prior to the task proper, thereby raising the overall level of performance. Consequently the above studies report few, if any, nonsolvers.

Obviously, the subjects in the present experiment received neither truth table training nor rule examples prior to the Stage I RL problem. Such procedures probably would have reduced the overall level of task difficulty to the extent that less efficient problem solvers became solvers, with comparatively higher trials and errors scores, thereby resulting in the usually observed difficulty order for conditional and biconditional relationships. In doing so, however, Stage I of the present study would no longer have permitted an examination of the behaviour of naive RL subjects.

At the same time, however, the above comments point to the major procedural flaw of the present experiment. In order to examine the effects of training with a particular rule upon subsequent RL performance, it was obviously necessary to replace those subjects who failed to solve the Problem 1 rule. In fact, replacement of nonsolvers is a common practice in RL experiments (eg. Haygood and Bourne, 1965; Neumann, 1974; Reznick and Richman, 1976; Salatas and Bourne, 1974). However, the unavoidable screening or selection of subjects on the basis of their ability to solve the Stage I RL problem has implications for the interpretation of the Stage II results. As a consequence of the screening procedure, it is likely that conditional and especially biconditional-practiced subjects were more uniform in terms of problem solving ability in comparison to conjunctive and disjunctive-practiced subjects, all of whom tended to solve the problem with relatively little difficulty. That is, the subject populations in the Stage II rule conditions were likely to be more heterogeneous in conceptual problem solving efficiency following conjunctive or disjunctive practice than following conditional or biconditional training.

The above difficulty was partially controlled for by the random assignment of subjects to treatment conditions. However, a more effective control procedure would have been, in conjunction with random assignment, to run the subjects individually rather than the present procedure of having subjects serve in groups of up to five per session. Alternatively, since running subjects in groups versus individually is considerably more economical in terms of time spent, it would have been possible to equate for the problem solving ability of subjects on the basis of measures with which this ability is likely highly correlated, such as intelligence test scores or Grade Point Average (Lee, 1968). Therefore, the use of more effective control procedures might have resulted in more conclusive or statistically reliable trend differences in Stage II of the present experiment.

Summary and Conclusions The present experiment was designed to test the predictive ability of the Inference model (Bourne, 1974; Salatas and Bourne, 1974) when modified to take into account rule biases other than the conjunctive. In order to test predictions derived from the modified model, it is necessary to arrange the experimental conditions such that the groups under consideration actually differ with regard to rule biases. However, the present findings indicate that neither of the two methods employed in the present study i.e. i) via inferred preexperimental rule bias, and ii) via rule training, was entirely successful in achieving this aim. Consequently, a definitive test of the modified Inference model was not possible, although the present findings did permit a tentative examination of issues important to the applicability of the Inference model — namely, a) the necessity of modifying the Inference model so as to better account for the RL behaviour of naive subjects, and b) the manner in which the model might be modified so as to optimize its predictive ability, given certain specifiable conditions.

The necessity of modifying the Inference model was addressed by the Stage I preexperimental bias procedure. Clearly, differentation between subjects on the basis of their initial response patterns did not provide an appropriate test of the modified Inference model. Although the present findings were consistent with those of other bias assessment procedures (Dominowski and Wetherick, 1976; Gates, 1978; Reznick and Richman, 1976) in that subjects tended to respond in either a conjunctive, disjunctive, or affirmative fashion, it was suggested that the few differences in RL performance could be reasonably accounted for as artifacts of a floor effect for the conjunction and inclusive disjunction RL problems. Thus, the present findings question the basis of Reznick and Richman's (1976) contention that initial response patterns exhibited by subjects reflect individual differences in rule bias, and by extension their contention that the predictive validity of the Inference model would be increased if these differences were taken into account. That the subjects in the present and Reznick and Richman (1976) study were able to solve the conjunction and inclusive disjunction RL problems with a minimum of difficulty, regardless of initial response pattern, does not seem to provide an argument in favour of various rule biases, certainly not in the sense of any persistent pattern of responding which might be expected with a bias. Rather, the present results may be better explained by positing that naive subjects are familiar with various rule strategies.

At the same time, the present findings question the validity of the central assumption underlying the Inference model, that naive RL subjects necessarily possess a conjunctive bias as a consequence of extra-experimental experience. Clearly, the Inference model cannot account for RL behaviour in those occasional situations where conjunction and inclusive disjunction RL problems are both readily solved, as in the present study and those of Gates (1978), Reznick and Richman (1976), and Reznick, Ketchum, and Bourne (1978). The suggestion is that the suitability of Inference model in accounting for the RL behaviour of naive subjects is situation-specific, depending upon such features as instructional 'set', rule difficulty, task complexity. An obvious implication for further research is that the various components of the RL task situation be systematically examined for their role in determining the behaviour patterns exhibited by naive RL subjects.

While the present preexperimental bias results did not support Reznick and Richman's (1976) contention that the Inference model must necessarily be modified to increase its predictive validity, the essential lack of RL differences attributable to preexperimental bias also prevented an examination of the manner in which the Inference model might best be modified so as to maximize its predictive validity in situations where subjects do differ in their rule biases. In this regard, the procedure of modifying response tendencies via rule training was moderately successful as a test of the modified model. A number of data trends were in the predicted direction, and were tentatively interpreted as indicating support for the view that the conjunctive biased inference operations of the Inference model (Bourne, 1974; Salatas and Bourne, 1974) may be readily modified or generalized to other rule biases in a manner that assumes the same sorts of mental operations. Actually, the present results were quite encouraging to this view, considering the procedural weaknesses of the present experimental design — namely, the methodological failure to establish solution-rule biases via one-problem training, as well as the failure to adequately control for problem solving ability of the subjects. The present findings suggest that improvements and extensions to the rule training procedure may offer a viable means of determining the limiting conditions of the modified Inference model.

In conclusion, although the present experiment did not permit definitive statements regarding the validity and utility of the Inference model as an explanation of the processes involved in conceptual rule learning, the research possibilities and issues considered in the present study clearly indicate that the area has by no means been fully explored.

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APPENDIX A

RELEVANT ATTRIBUTES AND STIMULUS SEQUENCES FOR THE 16 EXPERIMENTAL CONDITIONS

Conjunctive Rule(Problem 1) - Conjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (yellow, triangle)		Problem 2 (blue, star)		Problem 1 (blue, star)		Problem 2 (yellow, triangle)	
2	yellow stars	1	red circle	1	blue star	3	blue triangles
3	red triangles	2	red stars	1	yellow star	1	yellow triangle
3	yellow triangles	3	blue circles	3	red triangles	3	red stars
1	red circle	3	blue stars	2	blue circles	2	yellow circles
3	yellow circles	2	yellow circles	2	red circles	1	blue circle
2	red circles	2	blue triangles	1	yellow circle	1	red circle
3	blue circles	3	yellow triangles	3	blue triangles	1	yellow star
1	blue triangle	2	yellow stars	3	red stars	2	red stars
2	red stars	3	yellow circles	1	yellow triangle	2	red triangles
1	blue star	1	yellow star	2	blue triangles	2	blue circles
2	red triangles	1	yellow triangle	3	blue stars	3	red triangles
2	yellow circles	2	blue stars	2	red triangles	3	yellow triangles
1	yellow triangle	1	blue triangle	2	red stars	1	yellow circle
3	red stars	3	red stars	3	yellow circles	3	yellow stars
3	yellow stars	3	red circles	1	blue circle	3	red circles
1	blue circle	2	red triangles	1	red triangle	2	blue triangles
2	blue triangles	3	blue triangles	2	yellow triangles	2	blue stars
3	blue stars	3	red triangles	2	yellow stars	1	red star
3	blue triangles	1	blue star	2	yellow circles	2	yellow triangles
2	yellow triangles	1	red star	2	blue stars	3	yellow circles
1	red star	1	yellow circle	3	yellow stars	1	blue triangle
1	yellow circle	2	blue circles	3	blue circles	1	blue star
2	blue stars	2	red circles	1	red circle	3	blue stars
3	red circles	1	red triangle	1	red star	1	red triangle
1	yellow star	1	blue circle	3	yellow triangles	2	red circles
1	red triangle	2	yellow triangles	3	red circles	2	yellow stars
2	blue circles	3	yellow stars	1	blue triangle	3	blue circles

Conjunctive Rule(Problem 1) - Disjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (red, circle)		Problem 2 (blue, triangle)		Problem 1 (blue, triangle)		Problem 2 (red, circle)	
3	yellow circles	2	blue triangles	1	yellow circle	3	red circles
1	red circle	2	blue stars	1	blue star	1	red star
3	red triangles	1	yellow triangle	2	blue triangles	3	yellow triangles
2	blue stars	3	yellow circles	3	red triangles	2	yellow circles
2	blue circles	2	yellow circles	2	blue stars	3	yellow stars
2	yellow triangles	3	blue stars	2	yellow circles	2	yellow triangles
1	yellow star	2	yellow stars	3	yellow stars	2	blue circles
3	red stars	3	red triangles	1	yellow triangle	1	blue triangle
1	blue triangle	1	red star	2	red circles	3	red stars
3	red circles	1	blue circle	3	blue triangles	3	red triangles
1	yellow circle	1	blue triangle	2	blue circles	1	blue circle
3	yellow triangles	3	red stars	2	yellow triangles	1	red circle
1	red triangle	1	red triagle	2	yellow stars	2	blue triangles
2	yellow stars	3	red circles	3	red circles	1	yellow circle
1	yellow triangle	1	yellow circle	3	yellow triangles	3	blue stars
3	blue circles	2	yellow triangles	1	red star	1	yellow star
3	yellow stars	2	red circles	1	red circle	2	red triangles
1	red star	1	blue star	1	blue circle	1	blue star
2	red stars	3	blue triangles	1	red triangle	3	blue circles
3	blue triangles	3	yellow stars	3	yellow circles	2	red circles
2	red circles	2	red triangles	1	blue triangle	2	blue stars
1	blue circle	2	blue circles	3	blue stars	1	red triangle
2	blue triangles	3	yellow triangles	2	red triangles	2	yellow stars
2	yellow circles	1	red circle	3	red stars	2	red stars
3	blue stars	2	red stars	1	yellow star	3	blue triangles
2	red triangles	3	blue circles	3	blue circles	1	yellow triangle
1	blue star	1	yellow star	2	red stars	3	yellow circles

Conjunctive Rule(Problem 1) - Conditional Rule(Problem 2)

1/2 Subjects

	Problem 1 (blue, circle)		Problem 2 (red, triangle)
3	blue triangles	1	yellow triangle
2	red stars	2	yellow circles
2	blue circles	2	red triangles
1	red circle	3	red circles
1	yellow circle	1	blue circle
1	red triangle	3	blue stars
3	red triangles	3	blue triangles
2	blue stars	3	red stars
3	yellow triangles	1	yellow circle
2	yellow triangles	2	red stars
2	red circles	2	blue circles
2	blue triangles	1	red triangle
3	blue circles	3	yellow triangles
1	yellow star	2	blue triangles
3	blue stars	2	yellow stars
3	yellow stars	1	yellow star
2	red triangles	1	red circle
2	yellow circles	1	blue star
1	blue circle	2	yellow triangles
3	red stars	3	yellow stars
3	red circles	2	red circles
1	blue triangle	3	red triangles
1	yellow triangle	3	blue circles
1	blue star	1	blue triangle
2	yellow stars	3	yellow circles
1	red star	2	blue stars
3	yellow circles	1	red star

1/2 Subjects

	Problem 1 (red, triangle)		Problem 2 (blue, circle)
2	blue circles	3	red stars
2	red circles	3	blue circles
3	yellow triangles	2	blue triangles
1	red triangle	2	red circles
2	blue triangles	2	yellow stars
1	yellow circle	1	yellow triangle
3	blue stars	1	blue star
1	red star	3	red triangles
1	yellow star	3	red circles
3	red triangles	2	blue circles
2	yellow triangles	1	red star
2	red stars	3	yellow circles
1	blue star	1	blue triangle
3	yellow stars	3	blue triangles
1	yellow triangle	2	yellow triangles
3	blue circles	2	red stars
3	red circles	1	yellow circle
3	yellow circles	2	red triangles
2	blue stars	1	red triangle
2	red triangles	1	red circle
1	red circle	1	blue circle
3	blue triangles	3	blue stars
1	blue circle	3	yellow triangles
2	yellow circles	1	yellow star
3	red stars	2	yellow circles
2	yellow stars	3	yellow stars
1	blue triangle	2	blue stars

Conjunctive Rule(Problem 1) - Biconditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (red, star)		Problem 2 (yellow, circle)		Problem 1 (yellow, circle)		Problem 2 (red, star)	
1	yellow star	1	blue star	1	yellow circle	2	red triangles
3	red stars	2	red circles	3	red circles	1	red star
1	red circle	3	yellow circles	1	yellow star	3	yellow stars
2	blue triangles	3	yellow stars	2	blue stars	3	yellow circles
3	yellow circles	2	yellow triangles	2	red triangles	2	red circles
2	red triangles	1	red star	3	yellow triangles	1	yellow triangle
1	yellow triangle	1	red triangle	2	red stars	3	blue triangles
1	blue star	3	blue circles	2	blue triangles	2	yellow stars
3	blue circles	2	blue triangles	1	blue circle	2	blue circles
1	red star	2	yellow stars	3	yellow stars	3	red stars.
3	red circles	1	yellow circle	3	yellow circles	1	blue circle
2	blue stars	3	red stars	2	red circles	1	red circle
2	yellow triangles	1	blue circle	1	red star	2	blue stars
3	yellow stars	2	red stars	1	yellow triangle	3	red triangles
1	blue circle	1	blue triangle	3	blue stars	3	yellow triangles
1	red triangle	1	yellow triangle	2	blue circles	1	yellow circle
3	yellow triangles	3	red triangles	3	red triangles	1	yellow star
2	yellow circles	3	red circles	1	blue triangle	2	blue triangles
2	yellow stars	2	blue circles	3	blue circles	2	yellow triangles
1	yellow circle	3	blue stars	1	blue star	2	red stars
2	red stars	1	yellow star	2	yellow circles	1	blue star
3	red triangles	2	yellow circles	2	yellow triangles	3	red circles
2	red circles	3	yellow triangles	2	yellow stars	1	blue triangle
3	blue triangles	2	blue stars	3	blue triangles	3	blue stars
2	blue circles	2	red triangles	3	red stars	2	yellow circles
3	blue stars	1	red circle	1	red circle	3	blue circles
1	blue triangle	3	blue triangles	1	red triangle	1	red triangle

Disjunctive Rule(Problem 1) - Conjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (red, star)		Problem 2 (yellow, triangle)		Problem 1 (yellow, triangle)		Problem 2 (red, star)	
1	red star	2	red circles	2	yellow triangles	3	yellow triangles
3	yellow stars	3	red triangles	2	yellow circles	2	blue stars
3	red circles	3	yellow stars	3	red circles	2	red stars
2	blue triangles	2	yellow triangles	1	blue triangle	1	red triangle
1	yellow triangle	2	blue triangles	1	red star	3	red circles
3	red triangles	1	blue circle	2	yellow stars	1	blue triangle
2	yellow circles	1	blue star	2	blue stars	2	yellow circles
1	blue star	3	yellow circles	1	red triangle	1	yellow star
1	blue circle	3	red stars	3	blue circles	3	blue circles
2	red circles	2	yellow stars	2	red triangles	3	red stars
2	red stars	1	blue triangle	3	red stars	1	yellow triangle
3	blue triangles	1	yellow triangle	3	yellow triangles	2	red triangles
2	yellow stars	1	red star	1	yellow star	3	yellow stars
1	red triangle	3	blue circles	3	yellow circles	1	blue circle
2	yellow triangles	1	red triangle	2	red circles	2	blue triangles
3	blue circles	2	blue stars	1	blue circle	1	red circle
3	blue stars	3	red circles	2	blue triangles	3	yellow circles
3	yellow triangles	2	yellow circles	1	blue star	1	blue star
2	blue circles	1	yellow star	3	blue triangles	2	red circles
1	yellow star	3	blue triangles	2	red stars	3	blue stars
3	red stars	3	yellow triangles	3	yellow stars	1	yellow circle
2	red triangles	2	red stars	1	yellow triangle	1	red star
1	red circle	1	yellow circle	1	red circle	2	yellow stars
1	blue triangle	3	blue stars	3	blue stars	2	blue circles
1	yellow circle	1	red circle	1	yellow circle	3	blue triangles
2	blue stars	2	red triangles	2	blue circles	3	red triangles
3	yellow circles	2	blue circles	3	red triangles	2	yellow triangles

Disjunctive Rule(Problem 1) - Disjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (blue, circle)		Problem 2 (yellow, star)		Problem 1 (yellow, star)		Problem 2 (blue, circle)	
3	red stars	2	yellow triangles	3	yellow stars	1	red star
2	yellow circles	1	yellow star	1	red star	3	blue stars
1	blue triangle	3	red circles	2	red circles	3	blue circles
1	blue circle	2	red stars	2	yellow circles	2	red circles
2	red triangles	2	blue circles	3	blue circles	3	yellow circles
3	yellow stars	3	yellow circles	1	yellow triangle	1	red triangle
1	red circle	1	red circle	3	red triangles	3	blue triangles
2	blue triangles	3	blue triangles	1	blue star	2	yellow triangles
1	yellow star	2	blue stars	1	blue triangle	2	yellow stars
3	blue circles	3	yellow stars	2	blue circles	1	blue circle
1	red triangle	1	blue triangle	1	yellow circle	1	blue star
3	yellow circles	1	yellow triangle	2	yellow stars	2	yellow circles
3	blue stars	1	blue star	3	red stars	3	red stars
3	red triangles	3	red triangles	3	yellow triangles	1	yellow star
2	blue stars	2	yellow circles	1	blue circle	1	blue triangle
2	red circles	2	red triangles	1	red triangle	3	yellow triangles
1	red star	3	red stars	2	blue stars	1	yellow triangle
3	yellow triangles	2	red circles	2	blue triangles	1	red circle
1	blue star	3	blue circles	2	yellow triangles	2	red triangles
2	red stars	1	yellow circle	1	red circle	2	blue circles
1	yellow circle	3	blue stars	1	yellow star	3	red circles
2	blue circles	2	yellow stars	3	blue stars	2	blue triangles
2	yellow triangles	1	red triangle	3	red circles	2	red stars
3	blue triangles	2	blue triangles	2	red triangles	3	red triangles
2	yellow stars	3	yellow triangles	3	yellow circles	2	blue stars
1	yellow triangle	1	red star	2	red stars	3	yellow stars
3	red circles	1	blue circle	3	blue triangles	1	yellow circle

Disjunctive Rule(Problem 1) - Conditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (yellow, star)		Problem 2 (red, circle)		Problem 1 (red, circle)		Problem 2 (yellow, star)	
3	red stars	3	blue stars	3	red stars	1	red star
2	blue triangles	2	red stars	3	red circles	1	yellow star
1	yellow circle	2	red circles	2	yellow circles	2	yellow circles
2	yellow stars	2	blue circles	1	blue star	1	red triangle
3	yellow circles	1	blue triangle	3	blue triangles	3	blue triangles
1	blue circle	2	red triangles	1	blue circle	1	yellow triangle
2	red circles	1	yellow circle	3	red triangles	2	blue circles
3	blue stars	3	yellow stars	2	yellow stars	2	blue stars
2	red triangles	1	yellow triangle	2	yellow triangles	3	red triangles
2	yellow triangles	1	red circle	2	blue circles	2	red triangles
1	red star	3	red triangles	1	red star	3	yellow circles
3	yellow stars	2	yellow triangles	3	blue stars	2	yellow stars
3	blue circles	3	blue circles	2	red circles	3	blue stars
3	red triangles	1	blue star	2	red triangles	2	red stars
2	blue stars	2	yellow stars	3	yellow triangles	1	red circle
2	blue circles	2	yellow circles	1	yellow star	2	yellow triangles
3	red circles	3	blue triangles	1	yellow circle	1	blue circle
3	yellow triangles	3	red stars	3	yellow stars	2	blue triangles
1	red triangle	3	yellow triangles	1	red circle	3	yellow stars
1	blue star	3	red circles	1	blue triangle	3	yellow triangles
1	yellow star	1	red triangle	1	red triangle	1	blue star
2	yellow circles	3	yellow circles	3	yellow circles	3	red circles
1	red circle	2	blue stars	2	blue triangles	2	red circles
2	red stars	1	yellow star	2	blue stars	1	yellow circle
3	blue triangles	1	red star	2	red stars	3	blue circles
1	blue triangle	2	blue triangles	1	yellow triangle	3	red stars
1	yellow triangle	1	blue circle	3	blue circles	1	blue triangle

Disjunctive Rule(Problem 1) - Biconditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
	Problem 1 (red, circle)		Problem 2 (blue, star)		Problem 1 (blue, star)		Problem 2 (red, circle)
1	red circle	2	red stars	2	blue stars	1	red star
3	blue circles	3	blue circles	1	blue circle	3	yellow circles
2	blue stars	1	blue star	3	red circles	1	blue star
3	red stars	2	red circles	1	red star	3	red circles
1	yellow star	2	blue triangles	1	blue triangle	2	yellow stars
1	red triangle	1	red triangle	2	red triangles	3	red triangles
2	blue triangles	1	yellow star	3	red triangles	1	blue circle
3	blue triangles	2	yellow circles	3	yellow stars	3	blue triangles
2	yellow circles	3	yellow triangles	2	yellow triangles	3	yellow triangles
1	blue circle	2	blue stars	1	yellow triangle	1	yellow circle
3	red triangles	3	red stars	1	blue star	1	red circle
3	yellow stars	2	yellow triangles	1	yellow star	1	blue triangle
2	red circles	1	blue triangle	3	blue circles	2	red triangles
1	yellow circle	3	red circles	2	yellow circles	1	red triangle
3	yellow triangles	3	red triangles	2	blue triangles	2	blue stars
2	red stars	2	blue circles	1	red circle	2	yellow triangles
3	blue stars	1	yellow circle	3	yellow triangles	2	blue circles
1	blue star	3	yellow stars	2	red stars	1	yellow triangle
3	red circles	2	red triangles	3	blue stars	3	yellow stars
2	yellow stars	3	blue stars	2	red circles	3	blue circles
2	red triangles	3	blue triangles	2	blue circles	2	red circles
2	blue circles	1	red star	3	red stars	3	red stars
1	yellow triangle	1	red circle	1	yellow circle	2	yellow circles
3	yellow circles	2	yellow stars	1	red triangle	1	yellow star
1	red star	3	yellow circles	2	yellow stars	2	red stars
1	blue triangle	1	yellow triangle	3	blue triangles	3	blue stars
2	yellow triangles	1	blue circle	3	yellow circles	2	blue triangles

Conditional Rule(Problem 1) - Conjunctive Rule(Problem 2)

1/2 Subjects

	Problem 1 (red, triangle)		Problem 2 (blue, star)
3	blue circles	1	blue circle
2	yellow triangles	2	blue stars
1	red circle	2	yellow stars
3	red triangles	2	red circles
2	blue stars	3	yellow triangles
1	blue triangle	1	blue triangle
1	blue star	3	red triangles
3	yellow stars	1	red star
2	red stars	1	yellow circle
2	red circles	1	blue star
2	red triangles	3	blue triangles
1	blue circle	2	yellow triangles
3	blue triangles	1	yellow star
2	yellow stars	3	yellow circles
1	red star	2	blue circles
1	yellow triangle	2	yellow circles
3	blue stars	3	yellow stars
2	yellow circles	3	red circles
1	red triangle	1	yellow triangle
2	blue triangles	3	blue stars
3	red circles	3	blue circles
2	blue circles	2	red stars
3	red stars	3	red stars
1	yellow circle	2	red triangles
3	yellow circles	1	red triangle
3	yellow triangles	2	blue triangles
1	yellow star	1	red circle

1/2 Subjects

	Problem 1 (blue, star)		Problem 2 (red, triangle)
2	red stars	2	red triangles
1	red circle	3	red circles
1	blue circle	2	yellow circles
1	blue star	3	yellow triangles
3	blue triangles	2	blue triangles
2	yellow circles	2	yellow stars
3	yellow stars	3	yellow circles
2	yellow triangles	3	red stars
2	red triangles	2	blue circles
3	blue circles	1	red circle
2	blue stars	3	blue circles
2	red circles	1	red triangle
2	yellow stars	2	yellow triangles
1	yellow triangle	2	blue stars
2	blue triangles	3	yellow stars
3	red triangles	2	red circles
3	yellow triangles	1	yellow circle
1	red star	1	blue triangle
1	blue triangle	1	blue circle
3	red stars	3	red triangles
3	blue stars	2	red stars
3	red circles	3	blue triangles
1	yellow circle	1	blue star
2	blue circles	1	red star
1	yellow star	3	blue stars
1	red triangle	1	yellow triangle
3	yellow circles	1	yellow star

Conditional Rule(Problem 1) - Disjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (yellow, triangle)		Problem 2 (red, circle)		Problem 1 (red, circle)		Problem 2 (yellow, triangle)	
3	blue stars	2	red circles	3	blue circles	3	yellow circles
2	yellow triangles	2	yellow triangles	1	red circle	3	yellow triangles
2	blue triangles	1	yellow circle	2	red stars	1	blue circle
1	yellow circle	1	red star	1	yellow star	2	red triangles
1	red star	2	red triangles	1	blue circle	3	red circles
3	yellow stars	3	yellow stars	2	blue triangles	2	blue stars
1	blue star	1	blue triangle	2	blue stars	1	yellow star
1	red triangle	2	blue circles	1	red triangle	1	blue triangle
2	blue circles	3	blue stars	3	yellow triangles	3	blue stars
1	blue triangle	1	red triangle	2	yellow triangles	2	yellow triangles
2	yellow stars	2	yellow stars	3	red circles	1	red circle
3	yellow triangles	2	yellow circles	2	yellow circles	1	yellow circle
3	red stars	3	red circles	3	red stars	3	red triangles
2	red circles	2	blue triangles	2	red triangles	2	yellow circles
3	yellow circles	2	blue stars	1	blue star	1	red star
3	blue circles	2	red stars	3	yellow stars	3	blue triangles
2	red stars	3	blue circles	3	yellow circles	2	blue circles
3	blue triangles	1	yellow triangle	1	blue triangle	2	red stars
1	yellow triangle	3	yellow triangles	3	red triangles	3	yellow stars
[illegible]	red circles	3	red stars	2	red circles	3	red stars
3	red triangles	1	red circle	3	blue stars	1	yellow triangle
2	yellow circles	3	yellow circles	1	yellow circle	1	red triangle
2	blue stars	1	blue circle	2	yellow stars	2	yellow stars
1	blue circle	3	blue triangles	3	blue triangles	2	red circles
2	red triangles	1	yellow star	2	blue circles	3	blue circles
1	red circle	3	red triangles	1	yellow triangle	2	blue triangles
1	yellow star	1	blue star	1	red star	1	blue star

Conditional Rule(Problem 1) - Conditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (yellow, star)		Problem 2 (blue, triangle)		Problem 1 (blue, triangle)		Problem 2 (yellow, star)	
3	blue circles	1	yellow triangle	2	blue triangles	2	yellow triangles
3	yellow stars	3	red circles	3	blue stars	2	red stars
3	blue stars	3	blue triangles	1	red triangle	2	yellow stars
1	yellow circle	2	blue stars	2	yellow circles	3	blue circles
2	blue triangles	1	blue circle	1	blue star	1	red circle
1	yellow triangle	3	yellow stars	2	red circles	2	red triangles
2	red stars	2	red circles	3	yellow triangles	1	yellow triangle
2	red triangles	3	red triangles	3	red stars	3	blue triangles
1	blue circle	1	red star	1	yellow star	3	blue stars
1	yellow star	1	yellow circle	1	yellow triangle	2	blue stars
1	blue star	1	blue triangle	3	blue triangles	3	yellow stars
2	red circles	3	blue stars	2	blue stars	3	red circles
2	yellow circles	2	yellow triangles	1	red circle	3	yellow circles
3	red stars	2	red stars	2	yellow stars	2	blue circles
1	blue triangle	1	red triangle	2	red triangles	1	red star
3	red circles	2	yellow circles	3	yellow circles	2	blue triangles
3	yellow triangles	2	blue circles	3	blue circles	3	yellow triangles
3	blue triangles	3	red stars	1	red star	1	blue circle
3	yellow circles	2	blue triangles	1	blue circle	3	red triangles
1	red circle	1	yellow star	2	yellow triangles	1	blue star
2	yellow stars	1	blue star	3	red circles	2	yellow circles
1	red star	3	yellow triangles	1	blue triangle	1	yellow star
2	blue circles	1	red circle	2	red stars	1	blue triangle
2	yellow triangles	3	blue circles	2	blue circles	1	yellow circle
3	red triangles	2	red triangles	1	yellow circle	2	red circles
1	red triangle	2	yellow stars	3	red triangles	3	red stars
2	blue stars	3	yellow circles	3	yellow stars	1	red triangle

Conditional Rule(Problem 1) - Biconditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (blue, star)		Problem 2 (yellow, circle)		Problem 1 (yellow, circle)		Problem 2 (blue, star)	
1	red circle	1	yellow circle	2	yellow stars	3	red circles
3	blue stars	1	blue circle	2	yellow circles	3	blue circles
2	blue circles	3	red triangles	1	blue triangle	2	blue stars
3	red stars	2	yellow stars	3	red circles	1	red star
2	red triangles	3	red circles	3	red stars	1	red triangle
2	yellow triangles	1	red star	1	blue star	1	yellow star
1	blue triangle	3	blue stars	2	yellow triangles	1	yellow circle
1	yellow triangle	1	yellow triangle	3	blue circles	3	blue triangles
2	yellow stars	2	blue triangles	2	red triangles	1	yellow triangle
3	blue triangles	3	red stars	1	red circle	3	yellow circles
3	yellow circles	2	blue circles	1	red star	3	blue stars
1	red star	2	yellow triangles	3	yellow circles	3	red stars
1	blue star	2	yellow circles	3	yellow stars	1	blue circle
1	red triangle	1	blue triangle	2	blue circles	2	red triangles
3	yellow stars	3	yellow stars	3	blue stars	2	blue circles
2	red circles	1	blue star	1	red triangle	1	red circle
3	blue circles	2	red triangles	3	yellow triangles	2	yellow stars
2	yellow circles	3	blue circles	2	blue triangles	3	yellow triangles
1	blue circle	3	yellow triangles	1	yellow circle	1	blue star
2	blue stars	1	red circle	1	blue circle	2	red stars
3	red circles	3	yellow circles	2	blue stars	2	red circles
2	red stars	2	blue stars	1	yellow star	2	blue triangles
3	red triangles	1	red triangle	3	blue triangles	3	red triangles
1	yellow circle	1	yellow star	3	red triangles	3	yellow stars
2	blue triangles	2	red stars	2	red circles	2	yellow circles
3	yellow triangles	2	red circles	2	red stars	1	blue triangle
1	yellow star	3	blue triangles	1	yellow triangle	2	yellow triangles

Biconditional Rule(Problem 1) - Conjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (blue, circle)		Problem 2 (red, star)		Problem 1 (red, star)		Problem 2 (blue, circle)	
1	blue triangle	1	yellow circle	2	red stars	3	red circles
2	yellow triangles	2	yellow stars	3	blue stars	2	blue circles
1	blue circle	2	red triangles	3	red circles	3	red stars
3	yellow circles	3	red stars	1	blue triangle	1	blue star
2	red triangles	1	blue star	1	red triangle	3	yellow triangles
3	blue stars	3	blue triangles	2	yellow circles	2	red triangles
1	red star	1	yellow triangle	2	blue circles	2	blue stars
1	red circle	1	red circle	3	yellow stars	1	yellow star
3	yellow stars	2	blue circles	2	yellow triangles	2	yellow circles
2	blue stars	3	yellow triangles	3	blue triangles	1	blue circle
2	blue circles	1	red star	1	red star	3	blue triangles
3	red circles	3	red triangles	1	blue star	3	yellow stars
2	yellow stars	3	yellow stars	3	red triangles	1	yellow circle
1	red triangle	2	blue triangles	1	yellow circle	1	red circle
2	red circles	3	blue stars	2	blue triangles	1	yellow triangle
1	yellow triangle	2	yellow circles	2	yellow stars	2	red stars
3	red stars	3	red circles	1	red circle	2	blue triangles
1	blue star	1	blue circle	3	blue circles	3	red triangles
2	red stars	2	red stars	2	blue stars	3	blue circles
2	yellow circles	2	blue stars	2	red circles	1	blue triangle
2	blue triangles	1	blue triangle	3	red stars	3	yellow circles
3	blue circles	2	red circles	1	yellow triangle	2	yellow stars
3	blue triangles	1	yellow star	1	blue circle	1	red triangle
3	red triangles	3	blue circles	1	yellow star	3	blue stars
1	yellow star	2	yellow triangles	2	red triangles	2	yellow triangles
1	yellow circle	1	red triangle	3	yellow triangles	2	red circles
3	yellow triangles	3	yellow circles	3	yellow circles	1	red star

Biconditional Rule(Problem 1) - Disjunctive Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (yellow, circle)		Problem 2 (red, triangle)		Problem 1 (red, triangle)		Problem 2 (yellow, circle)	
3	yellow stars	1	blue star	1	red triangle	1	red circle
1	red circle	2	red stars	1	blue triangle	2	yellow circles
1	blue triangle	3	red triangles	1	red star	2	red stars
3	yellow circles	1	yellow triangle	3	blue circles	3	yellow triangles
2	blue stars	2	yellow stars	1	blue circle	3	blue stars
3	blue triangles	3	yellow circles	2	red circles	2	blue circles
2	red circles	2	blue triangles	3	yellow stars	1	blue triangle
1	yellow triangle	1	red circle	3	blue triangles	1	yellow star
1	red star	2	blue stars	1	yellow star	1	red triangle
2	blue circles	2	red triangles	3	red stars	3	red stars
3	yellow triangles	1	blue circle	2	blue triangles	1	yellow circle
2	yellow circles	3	blue triangles	2	blue stars	2	yellow triangles
1	red triangle	3	red circles	3	red triangles	1	blue circle
2	blue triangles	1	red star	2	yellow circles	2	red circles
1	yellow star	3	blue stars	2	blue circles	3	red triangles
3	red triangles	1	yellow circle	3	yellow triangles	3	blue triangles
1	blue star	2	yellow triangles	2	red stars	2	yellow stars
3	blue circles	1	yellow star	3	yellow circles	1	red star
1	yellow circle	3	yellow triangles	1	blue star	3	blue circles
2	red triangles	2	red circles	2	red triangles	1	yellow triangle
2	yellow triangles	2	yellow circles	2	yellow triangles	2	blue triangles
1	blue circle	1	red triangle	1	red circle	3	yellow circles
2	yellow stars	3	red stars	2	yellow stars	3	red circles
3	blue stars	2	blue circles	3	red circles	2	blue stars
3	red stars	3	yellow stars	1	yellow triangle	2	red triangles
3	red circles	1	blue triangle	1	yellow circle	3	yellow stars
2	red stars	3	blue circles	3	blue stars	1	blue star

Biconditional Rule(Problem 1) - Conditional Rule(Problem 2)

1/2 Subjects				1/2 Subjects			
Problem 1 (red, triangle)		Problem 2 (yellow, star)		Problem 1 (yellow, star)		Problem 2 (red, triangle)	
3	yellow triangles	2	yellow triangles	1	yellow star	3	red circles
3	blue stars	1	blue star	1	red star	1	blue triangle
2	red triangles	2	yellow stars	3	red circles	1	red triangle
2	red circles	3	red circles	2	yellow circles	2	yellow stars
1	red star	1	red triangle	2	blue stars	3	yellow circles
2	blue circles	3	yellow triangles	2	blue circles	3	red stars
1	yellow star	1	blue triangle	3	yellow triangles	2	blue stars
2	yellow triangles	3	red stars	2	blue triangles	1	yellow triangle
3	yellow stars	3	red triangles	1	red circle	1	blue circle
2	yellow stars	1	yellow star	2	red stars	3	red triangles
3	red circles	2	red circles	1	red triangle	1	yellow star
1	red triangle	1	red star	2	yellow triangles	1	red circle
1	yellow triangle	1	yellow triangle	2	yellow stars	3	blue triangles
1	blue star	1	red circle	3	blue triangles	3	yellow stars
1	blue triangle	3	blue circles	1	blue circle	2	blue circles
1	yellow circle	2	blue stars	1	yellow circle	3	yellow triangles
3	blue circles	1	yellow circle	3	blue stars	3	blue stars
3	red stars	2	red triangles	2	red triangles	2	red stars
1	red circle	2	blue triangles	1	yellow triangle	1	blue star
3	red triangles	3	yellow circles	3	yellow stars	2	red circles
1	blue circle	3	yellow stars	3	red stars	2	yellow triangles
2	blue triangles	2	red stars	2	red circles	2	red triangles
3	yellow circles	2	yellow circles	1	blue triangle	1	red star
3	blue triangles	3	blue triangles	3	yellow circles	1	yellow circle
2	yellow circles	2	blue circles	3	red triangles	2	blue triangles
2	red stars	3	blue stars	1	blue star	3	blue circles
2	blue stars	1	blue circle	3	blue circles	2	yellow circles

Biconditional Rule(Problem 1) - Biconditional Rule(Problem 2)

1/2 Subjects

	Problem 1 (blue, triangle)		Problem 2 (yellow, circle)
1	red circle	2	blue circles
2	blue triangles	1	yellow triangle
3	yellow triangles	2	yellow circles
2	blue stars	1	blue star
2	yellow stars	3	red triangles
2	blue circles	1	yellow star
1	yellow circle	3	red stars
2	red triangles	2	red triangles
3	yellow circles	1	blue circle
1	blue triangle	3	blue stars
2	yellow triangles	1	yellow circle
3	yellow stars	3	red circles
1	blue star	3	yellow stars
3	red stars	1	red circle
3	red triangles	2	red stars
3	red circles	2	blue triangles
2	yellow circles	2	yellow triangles
1	blue circle	1	red triangle
1	red triangle	2	blue stars
1	red star	3	blue circles
3	blue triangles	3	yellow triangles
3	blue circles	3	yellow circles
1	yellow star	1	blue triangle
3	blue stars	1	red star
2	red stars	2	red circles
2	red circles	2	yellow stars
1	yellow triangle	3	blue triangles

1/2 Subjects

	Problem 1 (yellow, circle)		Problem 2 (blue, triangle)
2	blue stars	1	blue triangle
3	yellow circles	2	yellow triangles
3	yellow stars	1	blue star
1	red circle	3	red circles
3	blue triangles	1	yellow circle
2	yellow triangles	3	red triangles
1	red triangle	3	yellow stars
3	blue circles	3	blue circles
2	red stars	1	red circle
1	yellow triangle	2	red triangles
3	red stars	3	yellow circles
2	yellow circles	2	blue circles
2	blue circles	2	blue triangles
3	red circles	1	yellow star
1	blue triangle	2	red stars
3	red triangles	2	blue stars
1	yellow star	2	red circles
2	blue triangles	3	yellow triangles
2	red circles	1	red star
3	yellow triangles	3	blue triangles
2	red triangles	3	blue stars
1	yellow circle	1	red triangle
1	blue star	1	yellow triangle
3	blue stars	3	red stars
2	yellow stars	2	yellow stars
1	red star	1	blue circle
1	blue circle	2	yellow circles

APPENDIX B

INTERPOLATED TASK MATERIALS

THE FOLLOWING SHEETS CONTAIN SEVERAL 'CONNECT-THE-NUMBERS' GAMES. REMEMBER, THESE ARE ONLY GAMES, SO WORK AT A RELAXED PACE. PLEASE WORK QUIETLY SO AS NOT TO DISTURB THE OTHER MEMBERS WHO ARE STILL SOLVING THE CONCEPT PROBLEM.

FIND WHERE NUMBER 1 IS LOCATED ON THE PAGE. BEGINNING WITH NUMBER 1, FIND AND DRAW A LINE CONNECTING EACH NUMBER IN ORDER, ENDING WITH 225.

59	195	14	105	69	81	143	20	160	2	114	200	74	213	48
86	171	4	131	194	57	182	113	43	161	75	104	31	140	11
30	159	85	139	9	103	152	80	149	212	68	202	162	123	219
102	201	138	42	151	93	35	130	8	51	132	181	24	203	90
49	3	170	112	218	32	33	129	172	60	29	148	115	56	220
62	211	25	158	67	19	122	163	73	199	128	17	84	224	40
22	83	189	39	121	183	55	13	164	47	188	109	214	180	133
210	37	106	92	50	204	87	169	61	173	89	44	184	39	1
91	179	146	12	165	137	52	107	94	215	26	101	150	34	116
41	347	58	108	174	10	142	66	153	82	185	63	100	206	21
15	190	205	72	156	99	88	198	117	5	134	221	76	187	225
143	120	157	45	175	127	28	168	77	193	64	207	124	18	186
78	145	23	178	98	191	118	38	209	135	7	154	70	111	223
119	222	65	217	16	155	110	196	54	176	125	46	167	96	71
6	208	53	197	126	177	36	192	136	95	166	27	144	216	97

APPENDIX C

INSTRUCTIONS TO SUBJECTS

"This is an experiment on concept attainment. You will be seeing a series of stimuli, one at a time, which are geometric designs containing the three dimensions of colour, shape, and number of figures. As you can see from these examples (experimenter pointed to a card showing several stimuli), each dimension of the geometric designs can have several possible values or attributes. That is, the stimuli can be either red, yellow, or blue, they can be either circles, triangles, or stars, and there can be either 1, 2, or 3 figures.

In the type of concept you will be learning, every stimulus can be sorted into one of two classes or categories. If you look at the panel in front of you, there are two buttons, one labelled "POSITIVE" and the other "NEGATIVE". If you think that a stimulus is an example of the concept, you are to firmly press the "POSITIVE" button. If you think that the stimulus does not represent the concept, you are to firmly press the button labelled "NEGATIVE".

Now, turn over the white card on your panel. On it are printed the names of the two stimulus attributes which are relevant or necessary to solution of the concept. As you can see, the relevant attributes are ____, ____ (experimenter named the relevant attributes). Your task will be to discover the relationship between these two attributes which determines whether a stimulus is an example or is not an example of the concept. Whether a stimulus belongs to the concept depends in some way upon whether it is or whether it is not ____ (experimenter named the first attribute) and on whether it is or whether it is not a ____ (experimenter named the second attribute).

When each stimulus appears on the screen here (experimenter pointed to the translucent window), the blue light in the top centre of your panel will come on. You will have a few seconds to look at the stimulus and decide what your response will be. When the blue light goes off, make your response. Once you have made your response, another slide will appear, telling you what the correct response was. This slide will stay on briefly, and after a few seconds another stimulus will be presented which again you will have to classify into either the positive or negative category by pressing the appropriate button. Do you have any questions at this point? (Questions were answered by paraphrasing relevant portions of the above instructions).

You will each be solving two concept problems. Some of you may solve the first problem before others do. If that happens, I will signal this to you by flashing the green light on your panel, on and off for a few seconds, at which point you must stop responding to the stimuli presented on the screen. While the others are continuing to work on the first problem you should turn to a different task until everyone in the group has solved the first problem, and that's the booklet and pencil beside your panel. So, if you see the green light flash on and off for a few seconds, this will be your signal to stop responding to the stimuli presented on the screen and to quietly begin working on the materials beside your panel. Are there any questions? (Questions were answered by paraphrasing relevant portions of the above instructions).

I will be in the next room during the experiment, and will return before you begin the second problem. Please do not talk to each other during the experiment". At this point the experimenter left the room.

At the conclusion of the first problem, the experimenter entered the room and said, "Please close the booklet and place it down beside your panel, along with the pencil (experimenter checked to make sure each subject did so). You will now solve the second concept problem. In this problem a different pair of attributes from the first problem will be relevant to solution of the concept. Here is a card naming the two relevant attributes (experimenter placed a card on each subject's panel, at the same time removing the card used in the first problem). As you can see, the relevant attributes are ____, ____ (experimenter named the attributes). As in the first problem, your task will be to discover the relationship between these two attributes which determines whether a stimulus belongs to either the positive or negative category. The relationship between the attributes that you will learn, may or may not be the same as that which you learned in the first problem. Again, some of you may solve the problem before others do. If that happens, I will signal this to you by flashing the green light on your panel, on and off for a few seconds, at which point you must stop responding to the stimuli presented on the screen, and quietly begin working on the materials beside your panel. Are there any questions? (Questions were answered by paraphrasing relevant portions of the above instructions).

I will be in the next room during the experiment. Please do not talk to each other during the experiment." At this point the experimenter left the room.

At the conclusion of the second problem, the experimenter entered the room, distributed a piece of paper to each subject, and said, "The relevant attributes for (either the first or second) problem were ____, ____. On the piece of paper briefly try to put into words how you were deciding whether a stimulus was positive or negative. That is, what was the relationship between the two relevant attributes ____, ____, that determined whether a stimulus was positive or negative in the (either first or second) problem"?. The experimenter waited until all subjects had finished writing, and then said, "The relevant attributes for (either the first or second)problem were ____, ____. Briefly try to put into words how you were deciding whether a stimulus was positive or negative. That is, what was the relationship between the two relevant attributes ____, ____, that determined whether a stimulus was positive or negative in the (either first or second) problem"? The experimenter waited until all subjects had finished writing, checked each subject's responses, and where necessary encouraged the subject to write down what he or she believed the particular relationship to be.

At this time the subjects were told the purpose of the experiment, thanked for their participation, and asked not to reveal to their classmates any details regarding the nature or solution of the experiment.

APPENDIX D

UNTRANSFORMED TRIALS AND ERRORS SCORES FOR EACH SUBJECT ON PROBLEMS 1 AND 2

S	Problem 1 Rule		Problem 2 Rule	
	Conjunction		Conjunction	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
1	1	1	0	0
2	1	1	0	0
3	2	1	0	0
4	3	1	0	0
5	1	1	2	1
6	2	1	0	0
7	11	2	0	0
8	2	1	0	0
9	4	2	0	0
10	11	1	0	0
	Conjunction		Inclusive Disjunction	
11	1	1	3	2
12	11	2	57	22
13	8	3	3	2
14	3	2	10	4
15	0	0	3	2
16	19	7	2	1
17	2	1	4	2
18	0	0	4	2
19	2	1	59	16
20	14	7	2	1

S	Problem 1 Rule		Problem 2 Rule	
	Conjunction		Conditional	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
21	1	1	21	6
22	0	0	11	6
23	4	2	31	14
24	4	2	115	57
25	15	6	12	7
26	0	0	160	72
27	17	6	122	45
28	2	1	13	6
29	0	0	82	47
30	3	2	30	12
	Conjunction		Biconditional	
31	0	0	36	17
32	0	0	44	14
33	0	0	23	10
34	1	1	23	11
35	33	16	128	30
36	2	1	117	43
37	3	1	56	17
38	11	4	30	13
39	2	1	161	73
40	0	0	65	30

S	Problem 1 Rule		Problem 2 Rule	
	Inclusive Disjunction		Conjunction	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
41	3	1	4	2
42	13	2	4	2
43	4	2	2	1
44	10	4	22	4
45	4	2	4	1
46	3	1	5	3
47	2	1	3	2
48	5	3	8	4
49	8	2	11	4
50	2	1	10	4
	Inclusive Disjunction		Inclusive Disjunction	
51	0	0	0	0
52	3	1	0	0
53	0	0	0	0
54	3	1	0	0
55	3	1	0	0
56	9	1	0	0
57	4	3	0	0
58	4	1	0	0
59	8	2	0	0
60	4	2	0	0

S	Problem 1 Rule		Problem 2 Rule	
	Inclusive Disjunction		Conditional	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
61	1	1	161	113
62	10	4	141	57
63	2	1	103	27
64	2	1	6	5
65	1	1	25	6
66	3	1	12	7
67	3	1	24	7
68	3	1	41	18
69	30	9	33	13
70	1	1	38	11
	Inclusive Disjunction		Biconditional	
71	4	2	63	20
72	2	1	33	20
73	2	1	67	34
74	2	1	45	19
75	2	1	75	21
76	4	2	0	0
77	26	11	6	4
78	2	1	157	66
79	4	2	27	13
80	2	1	17	7

S	Problem 1 Rule		Problem 2 Rule	
	Conditional		Conjunction	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
81	38	13	34	6
82	139	53	13	8
83	100	48	4	3
84	140	66	8	6
85	144	81	22	7
86	58	25	10	4
87	107	29	18	10
88	69	29	8	3
89	32	13	9	5
90	72	30	16	7
	Conditional		Inclusive Disjunction	
91	60	25	9	6
92	19	10	4	2
93	27	8	0	0
94	53	28	4	1
95	27	11	4	1
96	23	11	8	4
97	108	60	36	9
98	72	19	45	15
99	61	29	4	1
100	62	27	0	0

S	Problem 1 Rule		Problem 2 Rule	
	Conditional		Conditional	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
101	68	33	11	2
102	46	13	17	2
103	43	19	6	1
104	52	16	20	13
105	33	12	4	2
106	71	19	0	0
107	133	56	4	3
108	44	16	1	1
109	56	16	3	2
110	17	11	3	1
	Conditional		Biconditional	
111	28	11	25	6
112	91	34	27	4
113	48	15	31	8
114	84	20	12	7
115	43	26	5	3
116	18	10	20	8
117	49	29	24	9
118	67	17	46	14
119	88	30	31	10
120	40	17	40	16

S	Problem 1 Rule		Problem 2 Rule	
	Biconditional		Conjunction	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
121	132	49	12	6
122	12	4	16	9
123	59	26	3	3
124	11	6	2	2
125	63	13	21	7
126	36	13	6	3
127	108	54	35	14
128	90	37	24	6
129	50	26	17	6
130	21	7	13	7
	Biconditional		Inclusive Disjunction	
131	76	23	4	1
132	11	3	8	2
133	62	19	9	6
134	4	3	4	3
135	44	12	20	12
136	96	32	14	5
137	65	21	3	2
138	107	25	68	32
139	138	57	12	4
140	25	9	0	0

S	Problem 1 Rule		Problem 2 Rule	
	Biconditional		Conditional	
	Trials to Criterion	Errors to Criterion	Trial of Last Error	Total Errors
141	38	16	16	6
142	65	26	50	8
143	105	35	102	37
144	42	10	31	5
145	17	6	30	8
146	6	4	8	3
147	119	59	12	5
148	76	32	5	3
149	109	36	28	13
150	120	51	50	17
	Biconditional		Biconditional	
151	69	29	2	1
152	87	27	48	16
153	85	39	62	26
154	38	17	0	0
155	21	8	0	0
156	21	13	4	2
157	71	42	8	4
158	112	50	32	12
159	70	27	18	2
160	47	22	0	0

APPENDIX E

SUMMARY OF STATISTICAL ANALYSES IN STAGE I OF THE EXPERIMENT

OVERALL PROBLEM 1 RULE DIFFICULTY

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data

Fmax = 3.13, df = 4,39, p < .01; C=.38, df = 4,39, p < .01.

Source	SS	df	MS	F	p
Total	69.18	159			
Rules	50.49	3	16.83	140.25	< .01
error	18.69	156	0.12		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Cj 21.87	Dj 25.93	Bd 67.68	Cd 69.75
Cj	—	4.06	45.81**	47.89**
Dj		—	41.75**	43.82**
Bd			—	2.07
Cd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data

$F_{max} = 3.79$, *df* = 4,39, $p < .01$; $C = .47$, *df* = 4,39, $p < .01$.

Source	SS	df	MS	F	p
Total	49.03	159			
Rules	35.40	3	11.80	135.63	< .01
error	13.63	156	0.087		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Cj 14.49	Dj 15.90	Bd 51.08	Cd 54.40
Cj	—	1.41	36.59**	39.91**
Dj		—	35.18**	38.50**
Bd			—	3.32
Cd				—

* $p < .05$

** $p < .01$

RULE DIFFICULTY ORDER AS A FUNCTION OF PREEXPERIMENTAL BIAS

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, for Cj Bias

$F_{max} = 1.64$, *df* = 3,9, $p > .05$; $C = .40$, *df* = 3,9, $p > .05$

Source	SS	df	MS	F	p
Total	11.59	25			
Rules	9.28	2	4.64	46.40	< .01
Rules (unweighted)	8.91	2	4.46	44.60	< .01
error	2.31	23	0.10		

Summary of Neuman-Keuls Comparisons Between Cell Means for Trials to Criterion Data

	Cj .108	Dj .834	Bd 1.550
Cj	—	.726**	1.442**
Dj		—	.716**
Bd			—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, for Dj Bias

Fmax = 10.30, df=4,18, $p < .01$; C = .59, df=4,18, $p < .01$.

Source	SS	df	MS	F	p
Total	11.91	43			
Rules	7.98	3	2.66	27.14	< .01
Rules (unweighted)	7.64	3	2.55	26.02	< .01
error	3.93	40	.098		

Summary of Neuman-Keuls Comparisons Between Cell Means for Trials to Criterion Data

	Dj .638	Cj .829	Bd 1.583	Cd 1.729
Dj	—	.191	.945**	1.091**
Cj		—	.754**	.900**
Bd			—	.146
Cd				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed

Trials to Criterion Data, for Af(1st) Bias

Fmax = 4.63, df = 4,12, $p > .05$; C = .43, df = 4,12, $p > .05$.

Source	SS	df	MS	F	p
Total	14.99	32			
Rules	12.63	3	4.21	52.63	< .01
Rules (unweighted)	10.76	3	3.59	44.32	< .01
error	2.36	29	.08		

Summary of Neuman-Keuls Comparisons Between

Cell Means for Trials to Criterion Data

	Cj .491	Dj .552	Bd 1.837	Cd 1.839
Cj	—	.061	1.346**	1.348**
Dj		—	1.285**	1.287**
Bd			—	.002
Cd				—

* $p < .05$

* $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, for Af(2nd) Bias

Fmax = 12.14, df=4,9, $p < .01$; C = .56, df=4,9, $.05 > p > .01$.

Source	SS	df	MS	F	p
Total	12.86	30			
Rules	10.48	3	3.49	38.78	< .01
Rules (Unweighted)	9.98	3	3.33	37.00	< .01
error	2.38	27	.09		

Summary of Neuman-Keuls Comparisons Between Cell Means for Trials to Criterion Data

	Dj .545	Cj .669	Cd 1.714	Bd 1.830
Dj	—	.124	1.169**	1.285**
Cj		—	1.045**	1.161**
Cd			—	.116
Bd				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, for Cj Bias

Fmax = 13.67, *df*=3,9, $p < .01$; C = .69, *df*= 3,9, $p < .01$.

Source	SS	df	MS	F	p
Total	6.84	25			
Rules	5.57	2	2.79	46.50	< .01
Rules (unweighted)	5.32	2	2.66	44.33	< .01
error	1.27	23	.06		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Cj .030	Dj .583	Bd 1.144
Cj	—	.553**	1.114**
Dj		—	.561**
Bd			—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, for Dj Bias

Fmax = 11.26, df=4,18, p < .01; C = .61, df=4,18, p < .01.

Source	SS	df	MS	F	p
Total	10.93	43			
Rules	6.61	3	2.20	20.00	< .01
Rules (unweighted)	6.42	3	2.14	19.46	< .01
error	4.32	40	.11		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Dj .296	Cj .575	Bd 1.164	Cd 1.358
Dj	—	.279	.868**	1.062**
Cj		—	.589**	.783**
Bd			—	.194
Cd				—

* p <.05

** p <.01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, for Af(1st) Bias

Fmax = 37.40, df=4,12, $p < .01$; C = .57, df=4,12, $p < .01$.

Source	SS	df	MS	F	p
Total	11.06	32			
Rules	9.64	3	3.21	64.20	< .01
Rules (unweighted)	7.95	3	2.65	53.00	< .01
error	1.42	29	.05		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Dj .328	Cj .361	Bd 1.453	Cd 1.500
Dj	—	.033	1.125**	1.172**
Cj		—	1.092**	1.139**
Bd			—	.047
Cd				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, for Af(2nd) Bias

C = .51, df = 4,9, .05 > p > .01.

Source	SS	df	MS	F	p
Total	8.91	30			
Rules	7.25	3	2.42	40.33	< .01
Rules (unweighted)	6.88	3	2.29	38.17	< .01
error	1.66	27	.06		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Dj .300	Cj .429	Cd 1.268	Bd 1.390
Dj	—	.129	.968**	1.090**
Cj		—	.839**	.961**
Cd			—	.122
Bd				—

* p < .05

** p < .01

PREEXPERIMENTAL BIAS DIFFICULTY ORDER WITHIN EACH RULE

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Cj Rule

Fmax = 2.83, df = 4,9, p > .05; C = .40, df = 4,9, p > .05.

Source	SS	df	MS	F	p
Total	6.36	36			
Biases	2.70	3	.90	8.18	< .01
Biases (unweighted)	2.64	3	.88	8.00	< .01
error	3.66	33	.11		

Summary of Neuman-Keuls Comparisons Between Cell Means for Trials to Criterion Data

	Cj .108	Af(1st) .491	Af(2nd) .669	Dj .829
Cj	—	.383*	.561**	.721**
Af(1st)		—	.178	.338
Af(2nd)			—	.160
Dj				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Dj Rule

Fmax = 34.00, df = 4,12, p < .01; C = .74, df=4,12, p < .01.

Source	SS	df	MS	F	p
Total	2.92	33			
Biases	.48	3	.16	2.00	> .10
Biases (unweighted)	.42	3	.14	1.75	> .10
error	2.44	30	.08		

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Cd Rule

Fmax = 4.23, df=3,18, .05 > p > .01; C = .68, df=3,18, p < .01.

Source	SS	df	MS	F	p
Total	1.68	31			
Biases	.09	2	.05	.83	> .25
Biases (unweighted)	.08	2	.04	.67	> .25
error	1.59	29	.06		

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Bd Rule

F_{max} = 2.11, df = 4,11, p > .05; C = .36, df = 4,11, p > .05.

Source	SS	df	MS	F	p
Total	3.78	30			
Biases	.49	3	.16	1.33	>.25
Biases (unweighted)	.44	3	.15	1.25	>.25
error	3.29	27	.12		

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Cj Rule

Fmax = 9.33, df=4,9, .05 > p > .01; C = .56, df=4,9, .05 > p > .01.

Source	SS	df	MS	F	p
Total	2.76	36			
Biases	1.49	3	.50	12.50	< .01
Biases (unweighted)	1.47	3	.49	12.25	< .01
error	1.27	33	.04		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Cj .030	Af(1st) .361	Af(2nd) .429	Dj .575
Cj	—	.331**	.339**	.545**
Af(1st)		—	.068	.214
Af(2nd)			—	.146
Dj				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Dj Rule

$C = .65$, $\underline{df} = 4,12$, $p < .01$.

Source	SS	df	MS	F	p
Total	1.20	33			
Biases	.45	3	.15	5.00	< .01
Biases (unweighted)	.43	3	.14	4.67	< .01
Error	.75	30	.03		

Summary of Neuman-Keuls Comparisons Between Cell Means for Errors to Criterion Data

	Dj .296	Af(2nd) .300	Af(1st) .328	Cj .583
Dj	—	.004	.032	.287**
Af(2nd)		—	.028	.283**
Af(1st)			—	.255**
Cj				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Cd Rule

Fmax = 3.71, df=3,18, .05 > p > .01; C = .57, df=3,18, .05 > p > .01.

Source	SS	df	MS	F	p
Total	1.97	31			
Biases	.19	2	.10	1.67	>.10
Biases (unweighted)	.22	2	.11	1.83	>.10
error	1.78	29	.06		

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Bd Rule

Fmax = 2.29, df = 4,11, p > .05; C = .38, df = 4,11, p > .05.

Source	SS	df	MS	F	p
Total	5.38	30			
Biases	.51	3	.17	.94	>.25
Biases (unweighted)	.44	3	.15	.83	>.25
error	4.87	27	.18		

APPENDIX F

SUMMARY OF STATISTICAL ANALYSES IN STAGE II OF THE EXPERIMENT

OVERALL PROBLEM 2 RULE DIFFICULTY

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data

$F_{max} = 1.38$, $df = 4,39$, $p > .05$; $C = .29$, $df = 4,39$, $p > .05$.

Source	SS	df	MS	F	p
Total	63.95	159			
Rules	16.02	3	5.34	17.40	< .01
Error	47.93	156	0.307		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Dj 26.128	Cj 31.045	Cd 53.224	Bd 54.087
Dj	—	4.917	27.096**	27.959**
Cj		—	22.179**	23.042**
Cd			—	0.863
Bd				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data

$F_{max} = 1.81$, *df* = 4,39, $p > .05$; $C = .32$, *df* = 4,39, $p > .05$.

Source	SS	df	MS	F	p
Total	38.88	159			
Rules	9.88	3	3.29	17.70	< .01
Error	29.00	156	0.186		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Dj 18.219	Cj 22.104	Cd 39.705	Bd 39.991
Dj	—	3.885	21.486**	21.772**
Cj		—	17.601**	17.887**
Cd			—	0.941
Bd				—

* p < .05

** p < .01

EFFECT OF SAME-RULE PRACTICE

Summary of 4(Rules) X 2(Problems) Analysis of Variance, With the Second Factor Repeated, on the log(x+1) Transformed Trials to Criterion Data

C = .50, df = 8,9, $p < .01$.

Source	SS	df	MS	F	p
Total	39.38	79			
Between Ss	23.93	39			
A (Rules)	18.33	3	6.11	38.19	<.01
Ss within gps.	5.60	36	0.16		
Within Ss	15.45	40			
B (Problems)	11.18	1	11.18	111.80	<.01
AB	0.73	3	0.24	2.40	>.05
B X subj. wthn. gps.	3.54	36	0.10		

Summary of 4(Rules) X 2(Problems) Analysis of Variance, With the Second Factor Repeated, on the log(x+1) Transformed Errors to Criterion Data

C = .55, df = 8,9, p < .01.

Source	SS	df	MS	F	p
Total	24.25	79			
Between Ss	14.88	39			
A (Rules)	11.74	3	3.91	43.44	< .01
Ss within gps.	3.14	36	0.09		
Within Ss	9.37	40			
B (Problems)	6.49	1	6.49	162.25	< .01
AB	1.39	3	0.46	11.50	< .01
B subj. wthn. gps.	1.49	36	0.04		

RULE DIFFICULTY ORDER AS A FUNCTION OF PRIOR RULE PRACTICE

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Following Cj Practice

Fmax = 10.89, *df* = 4,9, $p < .01$; C = .45, *df* = 4,9, $p > .05$.

Source	SS	df	MS	F	p
Total	23.14	39			
Rules	18.14	3	6.05	43.21	< .01
error	5.00	36	0.14		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Cj .477	Dj 8.741	Cd 15.958	Bd 17.441
Cj	—	8.264**	15.481**	16.964**
Dj		—	7.217**	8.699**
Cd			—	1.482
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Following Dj Practice

C = .60, df = 4,9, $p < .01$.

Source	SS	df	MS	F	p
Total	21.64	39			
Rules	15.69	3	5.23	30.77	< .01
error	5.95	36	0.17		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Dj 0	Cj 8.391	Bd 14.460	Cd 15.897
Dj	—	8.391**	14.460**	15.897**
Cj		—	6.069**	7.506**
Bd			—	1.436
Cd				—

* p <.05

** p <.01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Following Cd Practice

$F_{max} = 5.14$, $df = 4,9$, $p > .05$; $C = .51$, $df = 4,9$, $.05 > p > .01$.

Source	SS	df	MS	F	p
Total	8.02	39			
Rules	2.65	3	0.88	5.87	< .01
error	5.37	36	0.15		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Cd 7.405	Dj 7.981	Cj 11.210	Bd 13.770
Cd	—	0.576	3.805	6.365**
Dj		—	3.229	5.788**
Cj			—	2.560
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Following Bd Practice

Fmax = 4.16, *df* = 4,9, $p > .05$; C = .50, *df*=4,9, $.05 > p > .01$.

Source	SS	df	MS	F	p
Total	10.88	39			
Rules	1.76	3	0.59	2.36	>.05
error	9.12	36	0.25		

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Following Cj Practice

Fmax = 20.11, df = 4,9, $p < .01$; C = .45, df = 4,9, $p > .05$.

Source	SS	df	MS	F	p
Total	14.99	39			
Rules	11.39	3	3.80	38.00	< .01
error	3.60	36	0.10		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Cj .301	Dj 6.279	Cd 12.699	Bd 13.449
Cj	—	5.978**	12.398**	13.148**
Dj		—	6.421**	7.170**
Cd			—	.750
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Following Dj Practice

C = .56, df = 4,9, $.05 > p > .01$.

Source	SS	df	MS	F	p
Total	13.93	39			
Rules	9.77	3	3.26	27.17	< .01
error	4.16	36	0.12		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Dj 0	Cj 5.431	Bd 11.406	Cd 12.201
Dj	—	5.431**	11.406**	12.201**
Cj		—	5.975**	6.770**
Bd			—	.795
Cd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Following Cd Practice

Fmax = 7.68, df=4,9, .05 > p > .01; C = .54, df=4,9, .05 > p > .01.

Source	SS	df	MS	F	p
Total	4.48	39			
Rules	1.65	3	0.55	6.88	< .01
error	2.83	36	0.08		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Cd 4.560	Dj 5.128	Cj 8.173	Bd 9.406
Cd	—	.568	3.613*	4.846**
Dj		—	3.045*	4.278**
Cj			—	1.233
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Following Bd Practice

Fmax = 6.61, *df* = 4,9, $.05 > p > .01$; C = .47, *df*=4,9, $p > .05$.

Source	SS	df	MS	F	p
Total	6.22	39			
Rules	0.81	3	0.27	1.80	>.10
error	5.41	36	0.15		

WITHIN-RULE DIFFICULTY AS A FUNCTION OF PRIOR RULE PRACTICE

Summary of Analysis of Variance on log(x+1) Transformed
Trials to Criterion Data, Within Cj Rule

$F_{max} = 5.36$, $df = 4,9$, $p > .05$; $C = .45$, $df = 4,9$, $p > .05$.

Source	SS	df	MS	F	p
Total	10.03	39			
Rule Pr.	7.56	3	2.52	36.00	< .01
error	2.47	36	0.07		

Summary of Neuman-Keuls Comparisons Between
Cell Totals for Trials to Criterion Data

	Cj .477	Dj 8.391	Bd 10.967	Cd 11.210
Cj	—	7.914**	10.490**	10.733**
Dj		—	2.576	2.819
Bd			—	.243
Cd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Dj Rule

C = .38, df = 4,9, p > .05.

Source	SS	df	MS	F	p
Total	12.90	39			
Rule Pr.	5.79	3	1.93	9.65	< .01
error	7.11	36	0.20		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Dj 0	Cd 7.981	Cj 8.742	Bd 9.405
Dj	—	7.981**	8.742**	9.405**
Cd		—	.760	1.424
Cj			—	.664
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Cd Rule

$F_{max} = 1.35$, df = 4,9, $p > .05$; $C = .28$, df = 4,9, $p > .05$.

Source	SS	df	MS	F	p
Total	11.16	39			
Rule Pr.	4.90	3	1.63	9.59	< .01
error	6.26	36	0.17		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Cd 7.405	Bd 13.964	Dj 15.897	Cj 15.958
Cd	—	6.559**	8.492**	8.553**
Bd		—	1.933	1.994
Dj			—	.061
Cj				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Trials to Criterion Data, Within Bd Rule

Fmax = 7.47, df = 4,9, .05 > p > .01; C = .48, df=4,9, p > .05.

Source	SS	df	MS	F	p
Total	13.84	39			
Rule Pr.	4.24	3	1.41	5.22	< .01
error	9.60	36	0.27		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Trials to Criterion Data

	Bd 8.417	Cd 13.770	Dj 14.460	Cj 17.441
Bd	—	5.353*	6.043*	9.024**
Cd		—	.690	3.671
Dj			—	2.981
Cj				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Cj Rule

Fmax = 4.78, df = 4,9, $p > .05$; C = .43, df = 4,9, $p > .05$.

Source	SS	df	MS	F	p
Total	5.04	39			
Rule Pr.	4.15	3	1.38	55.20	< .01
error	0.89	36	0.025		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Cj .301	Dj 5.431	Cd 8.173	Bd 8.199
Cj	—	5.130**	7.872**	7.898**
Dj		—	2.742**	2.768**
Cd			—	.026
Bd				—

* $p < .05$

** $p < .01$

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Dj Rule

C = .37, df = 4,9, p > .05.

Source	SS	df	MS	F	p
Total	7.29	39			
Rule Pr.	2.91	3	0.97	8.08	< .01
error	4.38	36	0.12		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Dj 0	Cd 5.128	Cj 6.279	Bd 6.812
Dj	—	5.128**	6.279**	6.812**
Cd		—	1.151	1.684
Cj			—	.533
Bd				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Cd Rule

$F_{max} = 2.08$, $\underline{df} = 4,9$, $p > .05$; $C = .34$, $\underline{df} = 4,9$, $p > .05$.

Source	SS	df	MS	F	p
Total	9.03	39			
Rule Pr.	4.17	3	1.39	10.30	< .01
error	4.86	36	0.135		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Cd 4.560	Bd 9.495	Dj 12.201	Cj 12.699
Cd	—	4.935**	7.641**	8.139**
Bd		—	2.706	3.204
Dj			—	.498
Cj				—

* p < .05

** p < .01

Summary of Analysis of Variance on log(x+1) Transformed Errors to Criterion Data, Within Bd Rule

F_{max} = 7.68, df = 4,9, .05 > p > .01; C = .44, df=4,9, p > .05.

Source	SS	df	MS	F	p
Total	9.11	39			
Rule Pr.	3.25	3	1.08	6.75	< .01
error	5.86	36	0.16		

Summary of Neuman-Keuls Comparisons Between Cell Totals for Errors to Criterion Data

	Bd 5.730	Cd 9.406	Dj 11.406	Cj 13.449
Bd	—	3.676*	5.676**	7.719**
Cd		—	2.000	4.043
Dj			—	2.043
Cj				—

* p < .05

** p < .01

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1953 - Born in London, Ontario.

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