1978

Response category labels and conceptual rules as determinants of attention in conceptual rule learning.

Robert D. Gates
University of Windsor

RESPONSE CATEGORY LABELS AND CONCEPTUAL RULES AS DETERMINANTS OF ATTENTION IN CONCEPTUAL RULE LEARNING

by

Robert D. Gates

B.A. (hons), Carleton University, 1975

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

Windsor, Ontario, Canada

1977

ABSTRACT

Ninety-six volunteer subjects solved one of four conceptual rule problems (conjunction, disjunction, conditional, biconditional) under one of four response category labelling conditions (Positive-only, Negative-only, Connotative, Neutral) in an orthogonal design. Visual stimuli consisting of 27 geometrical designs varying on the three tri-level dimensions of colour, form and number were presented until a criterion of 16 consecutively correct responses or 162 trials were reached. In the Positive-only and Negative-only conditions subjects classified stimuli as either belonging or not belonging to a single category labelled "POSITIVE" or "NEGATIVE" respectively. In the Connotative and Neutral conditions subjects classified stimuli as belonging to one of the two categories labelled either "POSITIVE" and "NEGATIVE", or "VEC" and "XAD" respectively. Informative feedback immediately followed each classification response. At the end of the experiment a written statement was obtained from each subject describing how they had classified the stimuli. Subjects' preexperimental classification biases showed a preference for simple affirmation or negation of relevant attributes, as well as conjunctive and disjunctive biases. Evidence of attentional focus on single dimensions of stimuli during early

stages of learning was found through an analysis of error distributions across truth-table categories of stimuli. Comparisons of the difficulty of acquisition of rules were made with both number of classification errors to criterion and trial of last classification error data. In the Connotative labelling condition, the biconditional and conditional rules were found to be more difficult than the conjunctive and disjunctive rules. In the Positive-only and Negative-only conditions, biconditional rule learning was facilitated to the degree that only the conditional rule was more difficult than the conjunction and disjunction. Analysis of subjects' post acquisition verbal statements showed that within each rule condition, subjects in the different labelling conditions focused their attention on the same response category. Furthermore, the response category focused on for each rule is that which can be described with the least complex logical statement. The rule difficulty and category focus findings were interpreted as indicating that the logical structure of conceptual rules determines the direction of category focus during rule learning, and that differing types of response category labels will either inhibit or facilitate single category focusing strategies. These findings also provide support for the notion that the logical complexity of the response category focused on is a central determinant of the difficulty with which conceptual rules are learned.

ACKNOWLEDGEMENTS

I wish to thank the members of my examining committee, Dr. Jerry Cohen and Dr. Akira Kobasigawa of the Department of Psychology, and Dr. R. Pinto of the Department of Philosophy, for their critical reading and insightful questions.

It has been both a priveledge and a challenge to work under the careful supervision of Dr. Ged Namikas. I thank him for his guidance, support and most of all his patience with me and the mistakes that are a part of learning.

Finally, I wish to thank my fellow student friends, especially Val, who were sympathetic when things went wrong, and shared my excitement when things went right.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The purpose of the research reported here was to test an explanation of differences in the ease of conceptual rule learning. Early explanations of the rule difficulty effect were based either on notions of logical complexity (Neisser & Weene, 1962) or so-called 'focusing' solution strategies (Bourne & Guy, 1968b; Giambra, 1974; Peters & Denny, 1971; Seggie, 1969). Both the logical complexity and focusing hypotheses fail as complete accounts of the rule difficulty effect (Bourne, 1970).

An inference-violation model proposed by Bourne (Bourne, 1974; Salatas & Bourne, 1974) has as a central postulate that, due to cultural factors, subjects are more familiar with, or practiced in dealing with a very simple concept rule, the conjunction (Bruner, Goodnow & Austin, 1956). The model quantifies deviations of other rules from the conjunction, successfully predicting the rule difficulty hierarchy.

The model also makes the assumption that subjects attend equally to every stimulus. Research in this area has demonstrated, however, that the labels applied to categories of stimuli in rule learning experiments have an effect on whether the subjects will focus on the positive (exemplar), negative (non-exemplar), or both categories (Giambra, 1974; Gottwald, 1971b; Peters & Denny, 1971; Seggie, 1969). Furthermore, there is an inferential basis for postulating that the complexity of the stimulus category focused on, and therefore the subject-generated descriptive rule, contributes to rule difficulty (Haygood & Devine, 1967; Hovland & Weiss, 1953; Neisser & Weene, 1962).

The present study attempted to determine if focus on different categories does affect the difficulty of conceptual rules. The difficulty of each of four rules was expected to differ depending on which stimulus category was focussed on. In addition, the direction of focus was assessed by two independent techniques.

In this introductory chapter definitions and concepts unique to the study of conceptual rule learning will be presented along with an historical review of basic research findings in concept attainment. Explanations of the rule difficulty effect will be reviewed, including a detailed presentation of Bourne's inference-violation model. Research supporting an alternative explanation will be discussed, followed by a plan and rationale for an experiment designed to test hypotheses derived from this research.

The Experimental Study of Concepts

The majority of research on human conceptual behavior within the last two decades has concentrated on the analysis of the acquisition and utilization of class concepts. The popularity of this type of concept is no doubt largely due to its relatively simple structure, and high rate of occurence in everyday life.

A class concept partitions a stimulus universe on the basis of a rule and selected stimulus attributes. Although with very complex concepts many stimulus dimensions may be relevant, primarily only bidimensional class concepts have been used in research. As the term implies, only two stimulus dimensions, with one attribute from each dimension, are relevant, while any number of irrelevant dimensions may also be present in the stimulus set.

The most common and intuitively appropriate partitioning of class concepts is into the two categories of exemplars and non-exemplars (interchangeably termed positive and negative examples) of the concept. For example, given the concept of "red square", a stimulus universe may be divided into two categories comprised by red square objects, which are exemplars, and objects that are not red and square, which are non-exemplars. In this example, colour and form are the relevant dimensions, and red and square are the relevant attributes for those dimensions.

Neisser and Weene (1962) described eight possible bidimensional rules, four of which are logical complements of the others. An exemplar of one of the primary rules is a non-exemplar of its complement, and vice-versa. The four primary rules, their complements, and some illustrative examples are shown in Table 1.

In addition to the two response classes of exemplars and non-exemplars, Haygood and Bourne (1965) have described four other classes based upon presence (denoted by T) and absence (denoted by F) of the two relevant attributes. Thus the four classes are: TT, both attributes are present; TF and FT, only one attribute is present; FF, neither attribute is present. Depending on the rule, each one of these truth-table categories (as they were so termed by Haygood & Bourne) may map into either the positive or negative concept category, as is shown in Table 1.

Several aspects of conceptual behavior can be distinguished. Acquisition or attainment of a concept refers to learning or discovering the rule and the relevant attributes which together constitute the concept. Utilization of a concept refers to the classification of stimuli according to the rule and the relevant attributes. A generally accepted criterion for the acquisition of a

Table 1

The Eight Bidimensional

Conceptual Rules

Rule	Truth-table Categories TT	TF	FT	FF	Description
Primary Rules					
Conjunction	+	[illegible]	-	-	Red <u>and</u> square
Disjunction	+	+	+	-	Red <u>or</u> square
Conditional	+	-	+	+	<u>if</u> Red <u>then</u> square
Biconditional	+	-	-	+	Red <u>if</u> <u>and</u> <u>only</u> <u>if</u> square
Complementary Rules					
Alternative Denial	-	+	+	+	<u>not</u> Red <u>or</u> <u>not</u> square
Joint Denial	-	-	-	+	<u>not</u> Red <u>and</u> <u>not</u> square
Exclusion	-	+	-	-	<u>if</u> Red <u>then</u> <u>not</u> square
Exclusive Disjunctive	-	+	+	-	<u>not</u> Red <u>if</u> <u>and</u> <u>only</u> <u>if</u> <u>not</u> square

concept is the successful utilization of that concept for some minimum number of stimulus categorizations.

Three types of experimental tasks have been devised to investigate concept acquisition. These different tasks are distinguished by the aspects of the concept that are unknown to the subject.

In an attribute identification task (AI), the subject is told the rule, and must discover the relevant attributes. This task was widely used in early studies of concept behavior (Haygood & Bourne, 1965), which were concerned with the effects of variables such as the number of relevant and irrelevant stimulus dimensions (Walker & Bourne, 1961), the amount of intra- and interdimensional variability (Battig & Bourne, 1961), and redundancy between dimensions (Bourne & Haygood, 1959).

In a rule-learning task (RL) the subject is told which stimulus attributes are relevant, and must attempt to discover the rule. Haygood and Bourne (1965) were the first investigators to study the acquisition of different rules using this task.

A third task is complete learning (CL) in which neither the relevant attributes nor the rule is known to the subject, who must attempt to learn both. Some investigations of concept learning did not separate the AI and RL components of concept learning, and therefore fall into this general paradigm (e.g., Neisser & Weene, 1962).

With all of these tasks two methods of stimulus presentation have been used. These are called the selection and reception methods, referring to whether the subjects or the experimenter determine the order in which stimuli are selected and categorized.

Rule Learning

Haygood and Bourne (1965) have stated that an assumption underlying research on attribute identification is that the effects of the variables under study would be the same regardless of the rule in force. Some available experimental evidence suggested, however, that under certain conditions, different conceptual rules differed in difficulty (e.g., Conant & Trabasso, 1964; Neisser & Weene, 1962; Sheperd, Hovland & Jenkins, 1961).

For example, Neisser and Weene (1962) have shown that within a CL task concepts with the most complex rules, the biconditional and exclusive disjunction, were more difficult to learn than less complex rules such as conjunctions and disjunctions. Haygood and Bourne (1965) concluded on the basis of this preliminary evidence that type of rule *per se* was a variable worthy of interest.

Haygood and Bourne therefore conducted a study in which four groups of subjects each solved five successive RL problems with the same rule, but a different pair of relevant attributes for each problem. Each group was given a different rule; either the conjunctive, disjunctive, joint denial or conditional. The stimulus universe in this study, as in subsequent studies in this area, was composed of coloured geometric designs which varied on four, three-valued dimensions (shape, colour, number and size).

The results showed that the four rules differed in difficulty, in the order of conjunction < disjunction < joint denial = conditional, from least to most difficult, as measured by the total number of errors to solution.

Subsequent research by Bourne and other investigators has confirmed the existence of a rule difficulty effect in RL tasks, and has also established a stable hierarchy of difficulty. Bourne and Guy (1968a, 1968b) found the order of conjunction < disjunction < conditional < biconditional, from least to most difficult. Examples of replications of the order stated above are recent studies by Salatas and Bourne (1974) and Neuman (1974).

These initial findings of differential rule difficulty were all made using the reception method of stimulus presentation. Using the selection method, Giambra (1970) found that the conditional rule was more difficult than the biconditional, suggesting that the generality of the rule difficulty effect is limited. However, Sawyer and Johnson (1971) noted that Giambra's RL task differed from others in that an example of the rule to be learned was provided to the subjects before the task proper. They proposed that this departure from standard RL instructions could account for the discrepancy between previous findings and Giambra's. Sawyer and Johnson conducted a study in which standard RL instructions were given to subjects learning either the conditional or biconditional rule under either reception or selection conditions. They reported finding that the conditional was less difficult than the biconditional under both presentation conditions (Sawyer & Johnson, 1971).

Explanations of Rule Difficulty

Early formulations. An S-R explanation based on the premise that subjects learn associations between individual stimuli and the correct response category has been shown to be inadequate by Bourne (1970). Since subjects would have to make the same number of associations for each rule, when stimulus universes are the same size, the rules should be equivalent in difficulty, as shown in Table 2.

Neisser and Weene (1962) described rules as being

Table 2

Predicted and Actual Rule Difficulty

Basis of prediction	Predicted outcome
S - R	Cj = Dj = Cd = Bd
Structural complexity (Neisser & Weene, 1962)	Cj = Dj = Cd < Bd
Positive category focus	Cj < Dj = Bd < Cd
Smaller category focus	Cj < Cd < Dj = Bd
Inference-violation	Cj < Dj < Cd < Bd
Empirical order	Cj < Dj < Cd < Bd

ordered hierarchically in terms of increasingly complex logical structure. On the lowest level are unidimensional rules which specify merely the presence or absence of one criterial attribute. Such rules use the logical operators of affirmation and negation. Level two rules are bidimensional relations using one logical operator from the set and, or, if, in combination with the affirmation and negation operators. Level three rules are those with more than one relational operator.

Neisser and Weene predicted that as rule complexity increased, so would relative acquisition difficulty. This hypothesis did not predict, however, the observed differences in difficulty between the level two rules (Conjunction, Disjunction and Conditional) as shown in Table 2.

An alternate hypothesis is derived from work by Smoke (1933) and Bruner, Goodnow and Austin (1956). Subjects solving concept problems appear to attend to and learn more from positive instances of the concept. Neumann (1974) has commented that the response labels typically used in RL research (e.g., positive/negative, yes/no) have a strong natural ordering which may direct a subject's attention towards the positive category. The hypothesis proposes that subjects focus their attention on the positive category, formulate a classification rule descriptive of that category, and assign other stimuli to the negative category by default. Rules which have a smaller proportion of stimuli in the positive category, such as the conjunction, should be less difficult to learn than those with large positive categories. Ordering the four primary rules by size of the positive category yields the hierarchy shown in Table 2. Clearly, this model also cannot account for the empirical rule difficulty hierarchy.

Haygood and Bourne (1965), and Bourne and Guy (1968b) suggested that subjects may favor the smaller and more homogeneous category, whether positive or negative. They maintained, however, that a strong bias for positive focusing would predominate when differences in category size were small, as is the case for the disjunction. The order of rule difficulty predicted by the smaller-category focus model is also shown in Table 2, again being inconsistent with the empirical findings.

<u>The inference violation model</u>. In their lengthy analysis of concept learning, Bruner, Goodnow and Austin (1956) proposed that extra-experimental experience was a strong determinant of concept difficulty. They noted that, at least within Western culture, the predominant experience of individuals was with conjunctive relationships. They hypothesized that subjects would be relatively unfamiliar with other concepts, and would in fact initially

assume that a given problem would require a conjunctive solution. Bourne and Guy (1968b) proposed that this conjunctive bias in fact determined rule difficulty. In an analysis of error distributions across truth-table stimulus categories, they found that greater numbers of errors occured when conjunctive assumptions were contradicted by the correct assignment of a stimulus. Bourne and Guy described naive subjects as finding it most natural, or easiest, to categorize stimuli in the following manner: TT instances with the positive category, FF instances with the negative category, and TF and FT instances in the same category, with a preference for assigning them to the negative category. This characterization of naive subjects' preferences for categorizing stimuli amounts to the conjunctive rule.

Bourne has gone on to expand this reasoning into a model of bidimensional rule difficulty (Bourne, 1974; Salatas & Bourne, 1974). A previous model proposed by Sawyer (1972) is used by Salatas and Bourne (1974) as additional basis for the model. Salatas and Bourne have proposed that four generalized assumptions or inferences are held by naive subjects for the categorization of stimuli: (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's (D) TT and FF stimuli will be placed in different categories.

Salatas and Bourne described these assumptions as initial subject states or processes governing the response to any stimulus. In order to predict the difficulty of any rule, Salatas and Bourne proposed a calculational scheme in which each violation of any of the assumptions results in an increment in rule difficulty. They further proposed that the increment be equal to the number of unique stimuli whose correct category assignment violated any of the assumptions. They also assumed that a violation of (D) would increase the difficulty of a rule by an arbitrary factor of 2.

By this scheme, the difficulty value of the conjunctive rule is zero, as no assumptions are violated. For a four-dimensional stimulus universe, with three values per dimension, the difficulty of the conditional rule is 12, which is reached in the following manner: four stimuli violate assumption (B), in that FF instances are assigned to the positive category; two TF stimuli are assigned to the negative category, in violation of (C); and lastly, assumption (D) is violated by the assignment of FF stimuli to the positive category along with TT stimuli, resulting in a magnification of the difficulty value of 6 by the arbitrary factor of 2, yielding a total rule difficulty value of 12.

Difficulty values for all eight bidimensional rules were calculated, yielding the predicted order of difficulty of conjunction, disjunction, alternative denial, exclusion, joint denial, exclusive disjunction, conditional, and biconditional. Using a standard RL paradigm, Salatas and Bourne tested the difficulty of the eight rules, finding that the predicted order of difficulty was confirmed, except for a reversal of the order for the exclusion/alternative denial and joint denial/exclusive disjunction. Additional support for the model came from an analysis of errors when grouped by inference violations. Significantly more errors were made when an inference was violated than when not. Salatas and Bourne also found that for the conditional, biconditional and their complements, the exclusive and exclusive disjunction, those truth-table categories predicted by the model to be most difficult contained significantly more errors than those classes predicted to be easier.

Other support for the model comes from a study by Neuman (1974) who obtained precisely the order of rule difficulty predicted by Salatas and Bourne, but only after giving subjects truth-table pretraining designed to facilitate rule learning.

Analysis and Critique

The inference-violation model provides a scheme for assigning difficulty weights to truth-table classes of stimuli. This scheme rests, however, on three assumptions: first, that naive rule-learning subjects do attempt to map a conjunctive solution onto the problem they are trying to solve; second, that every stimulus is attended to equally; and third, that both relevant dimensions are attended to equally. Evidence against the first of the assumptions would be the least damaging to the model, since the set of inferences is easily modified to accomodate any solution bias. The latter two are however more crucial components of the model, predicting respectively that stimuli from both response classes can result in increments of rule difficulty, and that subjects are aware of the truth-value of both relevant attributes exhibited by a stimulus when assigning it to one or the other response category. If evidence against either or both of these assumptions can be found, a major revision of the model would be required.

The purpose of this section is to review research findings bearing on all three of the assumptions stated above. A revision of the pre-solution bias assumption of the model has been found to be necessary, and proposed by Reznick and Richman (1976). A substantial body of research supports the contention that category focusing does occur, although the factors governing and the effects resulting from focusing are unclear. Finally, unidimensional attention has been reported to be a major cause of errors in conceptual rule learning.

Presolution bias. Dominowski and Wetherick (1976) assessed the presolution bias of subjects by asking them to classify all stimuli generated by two tri-valued dimensions after being told the relevant attributes, but before any informative feedback had been given. They report that about 16 percent of subjects demonstrated a conjunctive bias, while 58 percent classified the stimuli according to a disjunctive rule. The remaining subjects used either an affirmative (6%) or non-systematic (20%) rule. Reznick and Richman (1976) confirmed that a substantial proportion of subjects demonstrate disjunctive bias. They proposed that inference C of Bourne's model, which reads "TF and FT instances will be placed in the same category as FF instances", be changed to "TF and FT instances will be placed in the positive category". Rule difficulty values can then be computed substituting this new inference, C'.

Successful use of the inference-violation model depends, therefore, on first determining the precise presolution bias held by naive learners, since no one bias is demonstrated to the exclusion of others.

Category focus. In an earlier section, category focus models of rule learning were found to be inadequate explanations of conceptual rule difficulty. However, a substantial body of research indicates that category focusing cannot be ignored as a relevant variable affecting rule learning. This literature can be divided into three parts, addressing the questions of 1) the relative informational value of different types of stimuli, 2) what variables determine focusing, and 3) the effects of focusing on subjects' final classification rules.

Stimulus informational value: Following Smoke's (1933) finding that an increased proportion of positive instances facilitated concept acquisition, Hovland and Weiss (1953) attempted to determine if the information concerning the concept transmitted by positive and negative instances is equally well assimilated or utilized by concept learners. When series of positive or negative stimuli were equated for informational value (each series contained the minimum information for solution of the concept), conjunctive problems were more easily solved with a positive series. A mixture of positive and negative stimuli was intermediate in difficulty between positive only and negative only series.

Haygood and Devine (1967) varied the proportion of positive [p(+)] and TT [p(TT)] stimuli with disjunctive and biconditional concepts in an RL paradigm, finding that increasing p(TT) facilitated learning of both concepts. Increasing p(+), however, had insignificant effects on the difficulty of the rules. Haygood and Devine stated that the finding made with increasing p(TT) was unexpected, since these stimuli embody both relevant stimuli which in the RL paradigm are named for the subjects. They speculated that increased exposure to TT stimuli might facilitate acquisition of a truth-table stimulus encoding strategy. An alternative explanation is that increasing p(TT) serves only to increase the total number of stimuli which a subject learns to classify correctly very early, thus reducing the total number of errors in an artifactual manner.

Bourne and Guy (1968b) presented subjects with series of positive-only, negative-only, or mixed positive and negative stimuli in an RL paradigm with the conjunctive, disjunctive and conditional rules. Bourne and Guy hypothesized that rules would be easiest to learn when stimuli from the smaller and more homogeneous category were presented. They found, however, that acquisition of all three rules was least difficult in the mixed positive/negative condition. Contrary to expectation, rules were next most difficult when stimuli from the larger and more homogeneous category were presented. For example, the conditional rule was least difficult to learn in the mixed positive/negative condition, followed by the negative-only condition and the positive-only condition in increasing order of difficulty, respectively. One possible conclusion to be drawn from these findings is that the relative utility of positive and negative stimuli is dependant on the rule being learned.

Bourne and Guy's results may also be an artifact of their testing procedure. Subjects were presented with cycles of training and test stimuli. Training stimuli were drawn from one or both categories, and were followed by informative feedback. Test stimuli were from both categories, and were not followed by feedback. Errors made in classifying test stimuli served as the dependant measure of rule difficulty. It is possible that test stimulus errors reflect unfamiliarity with stimuli not present in the training series. As there would be fewer of these novel stimuli in conditions where training series were composed of stimuli from the larger and more heterogeneous category, fewer errors would be committed. When training stimuli were from the smaller and more homogeneous category, a greater number of errors would be expected with test stimuli.

While research on stimulus informational value has not yielded any clear findings, it appears to be appropriate to suggest that the difficulty with which a single category is learned, as with conceptual rules, may be dependant on the complexity of the structure of that category. One way in which the complexity of the structure of a category can be operationally defined is in terms of the statement necessary to describe the category. One obvious component of the complexity of a logical statement is the number of terms it incorporates. "Term" in the sense it is used here may be thought of as an element, which in the present case would be an attribute name. A more parsimonious statement is less complex than a long, exhaustive list of category elements. Another component of complexity is the difficulty of the logical operators relating stimulus elements. Some operators, such as affirmation, may be less difficult to work with by virtue of greater familiarity than others, such as the conditional, <u>if</u>. Finally, a second aspect of parsimony, homogeneity, can differentiate logically equivalent statements. Those statements incorporating fewer different operators are less complex than less homogeneous statements.

Determinants of focusing: Several studies have examined the effect of response category labels on rule learning, suggesting that the positive/negative, yes/no type of labels that have typically been used have a strong natural ordering, or connotative meaning which directs subjects' attention towards one response category.

Seggie (1969) presented conjunctive and disjunctive problems in a CL paradigm with two-dimensional stimuli. While he replicated the well established finding that the conjunctive rule is less difficult than the disjunctive, with standard response labels, he found the two concepts to be equivalent in difficulty when neutral labels were used. Seggie proposed that subjects learning the conjunctive concept with connotative labels focused on the positive category, therefore not learning the complete structure of the concept. He found that these subjects were unaware of the complement of the conjunction, the alternative denial rule, whereas subjects learning the conjunctive with neutral labels were. Seggie assumed that neutral labels precluded focusing, thereby forcing subjects to learn about both categories. Another possibility is that neutral labels allow subjects to focus on the negative category, thereby learning about the structure of the complement rule.

Peters and Denny (1971) reasoned that the greater difficulty of the biconditional rule compared to the conditional was due to conditional rule learners focusing on the negative category. They compared the difficulty of these two rules under neutral labelling and connotative labelling conditions. They predicted that the neutral labelling condition would result in subjects focusing on the negative category of both rules, while subjects in the connotative labelling condition were expected to focus on the positive category. To encourage category focus, subjects were asked to write a solution hypothesis after each stimulus presentation. They found that with the strong connotative labelling condition, the conditional rule was more difficult than the biconditional. In the neutral labelling condition, the opposite order of difficulty was obtained. Subjects' criterion hypotheses in the connotative labelling groups were phrased in terms of the positive category. Subjects in the neutral labelling groups predominately stated hypotheses phrased in terms of both categories. Peters and Denny interpreted their findings as being supportive of a category focus hypothesis, concluding that under typical connotative labelling conditions subjects may choose to focus on either category, whichever is the least complex.

In a similar study, Gottwald (1971b) found that connotative labels facilitate biconditional rule learning compared to a neutral labelling condition, concluding as well that neutral labels force subjects to learn about both categories. Giambra (1974) replicated Seggie's study, using more complex stimulus dimensions. He found that neutral labels increased the difficulty of the conjunction, but not to the level of difficulty of the disjunction, as found by Seggie (1969). Giambra's findings are nonetheless consistent with Seggie's original inference of category focusing occuring with connotative labels.

Finally, Neumann (1974) studied rule learning with all eight conceptual rules, under neutral and connotative labelling conditions. He found rules learned with neutral labels to be intermediate in difficulty between the primary and complementary forms of the rule learned with connotative labels. Neumann's findings replicate those of Seggie (1969) and Giambra (1974), showing the conjunction to be more difficult with neutral labels. His findings are inconsistent with those of Peters and Denny (1971) and Gottwald (1971b) in that he found the biconditional to be less difficult under neutral labelling conditions than under connotative labelling conditions. It is difficult to judge the significance of this discrepancy, since Neumann provided some pretraining for his subjects not usually given in standard RL experiments.

In summary, research on the effects of category labels on rule difficulty provides support for the existence of category focusing strategies occuring with connotative labels.

Subject-generated rules: The final body of research to be discussed here consists of analyses of subjects' classification rules, when formulated under conditions favoring category focusing.

Recall that Peters and Denny (1971) found that the hypotheses of subjects in connotative labelling conditions were framed in terms of the positive category. For simple conjunctions and disjunctions, one would expect these hypotheses to consist of conjunctive and disjunctive statements, although Peters and Denny do not report on this. Gottwald (1971a) replicated Peters and Denny's findings concerning focus category, and also found that subject-generated rules, while correct, were descriptive of the focus category. Subjects learning the biconditional rule stated hypotheses which were either a conjunction of conjunctions (describing the positive category), or an exclusive disjunction (describing the negative category). In another study, Gottwald and Swaine (1974) tested the efficiency or ease with which subjects utilized subject-generated rules (double conjunction and exclusive disjunction) or an experimenter-generated rule (the biconditional), all of which result in the same stimulus universe partitioning, using an AI task. Subjects found the positive-category double disjunction significantly easier to work with than the other two rules.

In conclusion, it seems that a focusing strategy can result in efficient learning of a classification rule primarily descriptive of the focus category. The more complex that category is, the more difficult it will be for a subject to arrive at a correct rule.

<u>Unidimensional attention</u>. An experiment conducted by Sawyer (1972) provides evidence that in addition to focusing on one response category, subjects also focus on one stimulus dimension during the initial stages of concept learning. He presented a series of four stimuli varying on two dimensions of two values each, and reinforced only the first stimulus. Reinforcement was accomplished by telling subjects thatthe first stimulus was positive, making it the TT stimulus. The other three stimuli served as non-reinforced test stimuli, being termed TF, FT or FF depending on which attributes each had in common with the TT stimulus. By computing the probabilities of assignment of each of the test stimuli to either the same response category as the TT stimulus, or to the other response category, he was able to show that subjects compared each test stimulus with the TT stimulus on one dimension to determine the category assignment of the test stimulus. If the compared dimension exhibited the same value for both stimuli, then the test stimulus was assigned to the same category as the TT stimulus. If the two stimuli differed on the compared dimen-

mension, then the test stimulus was assigned to the other category. When two stimuli were reinforced for assignment to one category, or to different categories, the pattern of results becomes even more clear. For example, if TT and TF were assigned to category 1 by reinforcement, then 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.

Sawyer concluded that the primary source of errors in rule learning lies in subjects incorrectly placing stimuli having common values on one-dimension in the same response category.

The Present Study

In the preceeding review, studies were discussed which have shown that category focusing is related to the use of connotative category labels. The effect of connotative labels appears to be that of directing a subject's attention towards the positive category of stimuli.[1] Focusing

---

[1]As an exception, Peters and Denny have suggested that subjects learning the conditional rule with connotative labels focus on the negative category.

based explanations of the rule difficulty effect hypothesize that size of the focus category, as measured by the number of truth-table classes, or the number of stimuli in the focus category, affects rule difficulty.

The existence of focusing has been inferred in three different ways: from post-acquisition knowledge of complement rules (Seggie, 1969); changes in the difficulty of rules when neutral labels are used (Giambra, 1974; Gottwald, 1971b; Peters & Denny, 1971; Seggie, 1969) and from the category(ies) mentioned by subjects in post-acquisition verbal statements (Gottwald, 1971a; Peters & Denny, 1971). The effect of neutral labels has been assumed by various authors to be either that of forcing subjects to learn about both categories, or allowing them to focus on the smaller category. The most direct evidence bearing on this question comes from Peters and Denny (1971), indicating that subjects using neutral labels focus on both categories.

To date, no research has directly compared the effects of focus on either the positive or negative categories on the difficulty of the four primary rules. The present study attempted such a comparison in order to establish whether differences in the size or complexity of focus categories affect rule difficulty. In addition, an attempt was made to determine the extent and direction of focusing with connotative and neutral labels.

In an attempt to produce positive and negative category focusing, subjects were required to classify only positive or only negative exemplars of a concept. Subjects were provided with only one response category, while being presented with a series of stimuli for both categories. This technique avoids the error made by Bourne and Guy (1968b) who presented stimuli from only one category, thereby changing the nature of the task to the degree that generalizations to more typical RL studies become tenuous.

The two methods for inferring category focus planned for the present study were analyses of: 1) subjects' post-acquisition verbal statements, and 2) the relative number of errors made in the positive and negative categories. At the end of the experiment, subjects were to be asked to write down a rule describing how they had classified as expressing focus on that category. Those mentioning both or no categories would be classified as expressing no focus. For the second measure of focus, it was reasoned that subjects would make fewer errors in the focus category than in the non-focus category. The generalization can be made from Sawyer's (1972) findings that if subjects have focused on one response category, they will make errors by incorrectly assigning stimuli from the non-focus category to the focus category, when a non-focus stimulus shares a value in common with one of the focus category stimuli. In other words, most errors will be made with truth-table classes of stimuli from the non-focus category which share a value in common with any stimulus in the focus category. It should be possible, therefore, to determine which category a subject focused on by comparing the proportions of errors made in the two categories. The category with the smaller proportion of errors should be the focus category. For example, consider the conjunctive rule. If a subject focuses on the positive category, containing the TT stimulus class, errors should be made by misassigning TF and FT stimuli to the positive category, as each displays one attribute in common with the TT stimulus. By comparing the percentage of errors in each response category, the problem of unequal numbers of stimuli in each of the truth-table categories is overcome.

Hypotheses. It was predicted that subjects in the positive-only and negative-only conditions would focus on the positive and negative response categories, respectively. From the research showing that positive category focusing was related to the use of connotative labels, it was hypothesized that subjects learning rules in the connotative labelling condition would focus on the positive category, except for those learning the conditional rule. These latter subjects were expected to focus on the negative category, as found by Peters and Denny (1971). Also on the basis of findings made by Peters and Denny, it was predicted that subjects in the neutral labelling condition would focus on both categories.

On the basis of the supposition made by many authors that the size, or complexity of the focus category affects rule difficulty, it was hypothesized that in the present research rules would be less difficult to learn when the smaller and less complex category was focused on. While the two studies by Haygood and Devine (1967), and Bourne and Guy (1968b) reviewed earlier failed to support this hypothesis, it was felt that the design of the present research would constitute a more appropriate test of the hypothesis. In the present study, size and complexity of the focus category was determined by counting the number of stimuli, and the number of truth-table classes of stimuli in each category. For each rule, therefore, difficulty of acquisition was predicted to be related to labelling condition (positive-only, negative-only, connotative or neutral).

For the conjunctive rule, the positive-only and connotative labelling conditions should result in focus on the smaller and less complex positive category, and should therefore be less difficult than the negative-only condition, where focus on the larger and more complex category should occur. All three of these conditions should be less difficult than the neutral labelling condition, where subjects should focus on both categories. For the disjunctive rule, the negative category is the smaller and less complex, so the negative-only condition should be less difficult than the positive-only and connotative conditions, where subjects should focus on the positive category. Again the neutral condition was predicted to be the most difficult. For the conditional rule, the negative-only condition was predicted to be less difficult, as the negative category is the smaller and less complex. For this rule, connotative labels were predicted to be associated with negative category focusing, so the connotative labelling condition should be equivalent in difficulty to the negative-only condition. Next in predicted difficulty the positive-only condition, predicted to be associated with focus on the larger positive category, followed by the neutral condition. Finally for the biconditional rule, the negative-only condition was predicted to be the least difficult, followed by the positive-only and connotative conditions where positive focus was predicted to occur. Again, the neutral labelling condition was predicted to be most difficult. These predictions are summarized in Table 3.

Table 3

Predicted Order of Difficulty of Labelling Conditions[1] for the Four Rule Conditions

	Category Size[2]		
Rule	Positive	Negative	Order
Cj	4	27	Pos = Con < Neg < Neu
Dj	18	13	Neg < Pos = Con < Neu
Cd	24	7	Neg = Con < Pos < Neu
Bd	17	14	Neg < Pos = Con < Neu

[1]Labelling conditions are abbreviated as follows: Positive-only - Pos, Negative-only - Neg, Connotative - Con, Neutral - Neu.

[2]Category size values are the sum of the number of truth-table classes and the number of stimuli contained in each response category.

A final set of predictions made in the present research are derived from Sawyer's (1972) research. As described in the preceeding literature review, Sawyer concluded on the basis of his findings that subjects attend to only one stimulus dimension during early stages of rule learning, assigning stimuli to the positive or negative response categories on the basis of presence or absence of one criterial attribute on the attended-to deminsion. If it is assumed that subjects attend as well to only one response category, then it follows that this criterial attribute will be selected from those in the focus category. One source of imprecision in Sawyer's model is that on basis is provided for predicting which of the relevant dimensions will be attended to: it must therefore be assumed that dimensions are selected randomly, one-half of subjects attending to one, one-half attending to the other. On the basis of this extension of Sawyer's model it is possible to predict in which truth-table classes of stimuli the majority of classification errors will occur. These predictions are summarized in Table 4, and were reached in the following manner: for both positive and negative focusing strategies considered independantly, those stimuli in the non-focus category have a value in common with one of the attributes in the focus category, or those stimuli in the focus category not

Table 4

Predicted Relative Difficulty of

Truth-Table Categories

Positive Category Focus

Rule	TT	TF	FT	FF
Cj	+	-*	-*	-
Dj	+	+*	+*	-
Cd	+	-*	+*	+**
Bd	+	-*	-*	+**

Negative Category Focus

Rule	TT	TF	FT	FF
Cj	+	-*	-*	-
Dj	+	+*	+*	-
Cd	+*	-	+	+*
Bd	+*	-	-	+*

Note. Those categories marked with a double asterisk (**) are predicted to be twice as difficult as those marked with one (*).

sharing common values on one dimension were predicted to be those where most errors would occur. Those stimuli having two attributes meeting the criteria just described were predicted to be associated with twice as many errors as those stimuli with only one attribute meeting the error criteria.

CHAPTER 11

METHOD

Subjects

Subjects were 96 undergraduate students enrolled in psychology courses at the University of Windsor. Ten subjects were replaced for failure to understand the instructions (9) or equipment failure (1) for a total of 106. Supplementary course credits were awarded to each subject for participating in the experiment.

Apparatus

The Generalized Learning Apparatus (GLA) described by Cervin, Smith and Kabisch (1965) was used to control the presentation of stimuli and response recording. The GLA consists of six subject panels (48.26 cm x 35.56 cm) connected to timing and relay circuits in an adjacent room. The subject panels are inclined at an angle of about 30° towards the subject, and are separated by vertical wooden partitions making it difficult for any subject to observe the responses made by an other subject. The panels were arranged so that each was about 3 m away from the stimulus projection screen.

For the purpose of the present experiment, only a blue warning light (6.3 V, blue jewel) centered at the top of each panel, and two response buttons located near the bottom left and right-hand corners were used. All other buttons and lights as described by Cervin et al. (1965) were covered with black tape. Stimuli were rear-projected with a GAF Anscorama auto-focus slide projector on a translucent window separating the control room from the subject room. Both rooms were kept at a lowered level of illumination in order to ensure maximum visibility of the stimulus image.

Stimuli

The stimuli were geometric designs varying on three tri-level dimensions of colour (red, yellow and blue), form (star, triangle and circle), and number (1, 2 or 3 identical forms) prepared on 5 cm X 5 cm colour photographic slides. The 27 possible combinations of all nine attributes were used to construct 16 stimulus sequences. The stimulus sequence for each condition was constructed randomly subject to the constraint that TT, TF, FT and FF instances were represented in their natural proportions, a 1:2:2:4 ratio, respectively, within each subset of nine stimuli, and therefore over the complete set of 27 stimuli as well. Colour and form were the relevant dimensions for all problems, and relevant attributes were randomly distributed over the 16 problems with the constraint that each of the relevant attributes were represented at least once for each rule and labeling condition. The 16 stimulus sequences used are presented in Appendix A. Feedback slides were prepared by hand lettering with pencil on Kodak Ektagraphic write-on slides.

Procedure

The experimental design can be described as two separate 2 x 4 orthogonal designs. In the first, four rules (conjunction, disjunction, conditional and biconditional) were combined orthogonally with two single response category conditions (positive-only and negative-only). For these groups only one response button was exposed, and was labeled either "POSITIVE" or "NEGATIVE", corresponding to whether only positive or negative stimuli were to be responded to, respectively.

In the second, the same four rules were combined orthogonally with two double response category conditions (connotative and neutral response category labels). For these groups two buttons were exposed. In the connotative labels groups, the buttons were labeled "POSITIVE" and "NEGATIVE". In the neutral labels groups, the two buttons were labeled "VEC" and "XAD". According to Neumann (1974) these two trigrams have no connotative meaning which could direct subjects' attention to one response category or the other.

The position of the "POSITIVE" and "NEGATIVE" or "VEC" and "XAD" buttons was counterbalanced between the left and right-hand response buttons. For groups using neutral labels, exemplar stimuli were classified as "VEC" for half of the subjects and "XAD" for the other half, a control for any possible meaningfullness of these labels.

The experimental task required of all subjects conformed to the rule learning paradigm described by Haygood and Bourne (1965). For all conditions, the stimulus universe was described with the aid of a card showing three stimuli displaying in combination all nine attributes. Subjects were told their task would be to classify a series of stimuli according to an unknown conceptual relationship between two relevant attributes.

Subjects in the single response category conditions were told to press the button only when they detected a stimulus from the category named by a printed label below the button, and not to respond to other stimuli.

Subjects in the double response category conditions were told to classify each stimulus by pressing one of the two buttons available to them. Printed labels below the buttons indicated which button represented each category.

The experimenter then inquired of all groups if the instructions were understood, repeating the relevant portions if they had not. A file card with the names of the relevant attributes printed on it was then placed on each subject's panel, and the room lights were dimmed. Complete instructions to subjects are presented in Appendix B.

Each trial began with the presentation of a stimulus and the blue warning light. After 5 seconds the blue light went off, signalling the beginning of a 2 second response interval. Only those responses which occurred during this interval were scored as correct or incorrect. A failure to respond during this interval in the double response category conditions was scored as an incorrect response. At the end of the response interval, the stimulus was replaced by a feedback slide which named the correct response category. In the case of the single response category conditions, a blank slide followed a stimulus not belonging to the labeled category. The feedback interval lasted 5.5 seconds. Figure 1 illustrates the sequence of events in a trial.

Stimulus presentations continued until a criterion of 16 consecutively correct responses was reached by every subject participating in a session, or until 162 trials had occurred. At the end of the session subjects were asked to write down the rule they had used to classify the stimuli. The experimenter examined each statement to determine if both relevant attributes were mentioned. If a statement did not meet this criterion, that subject was

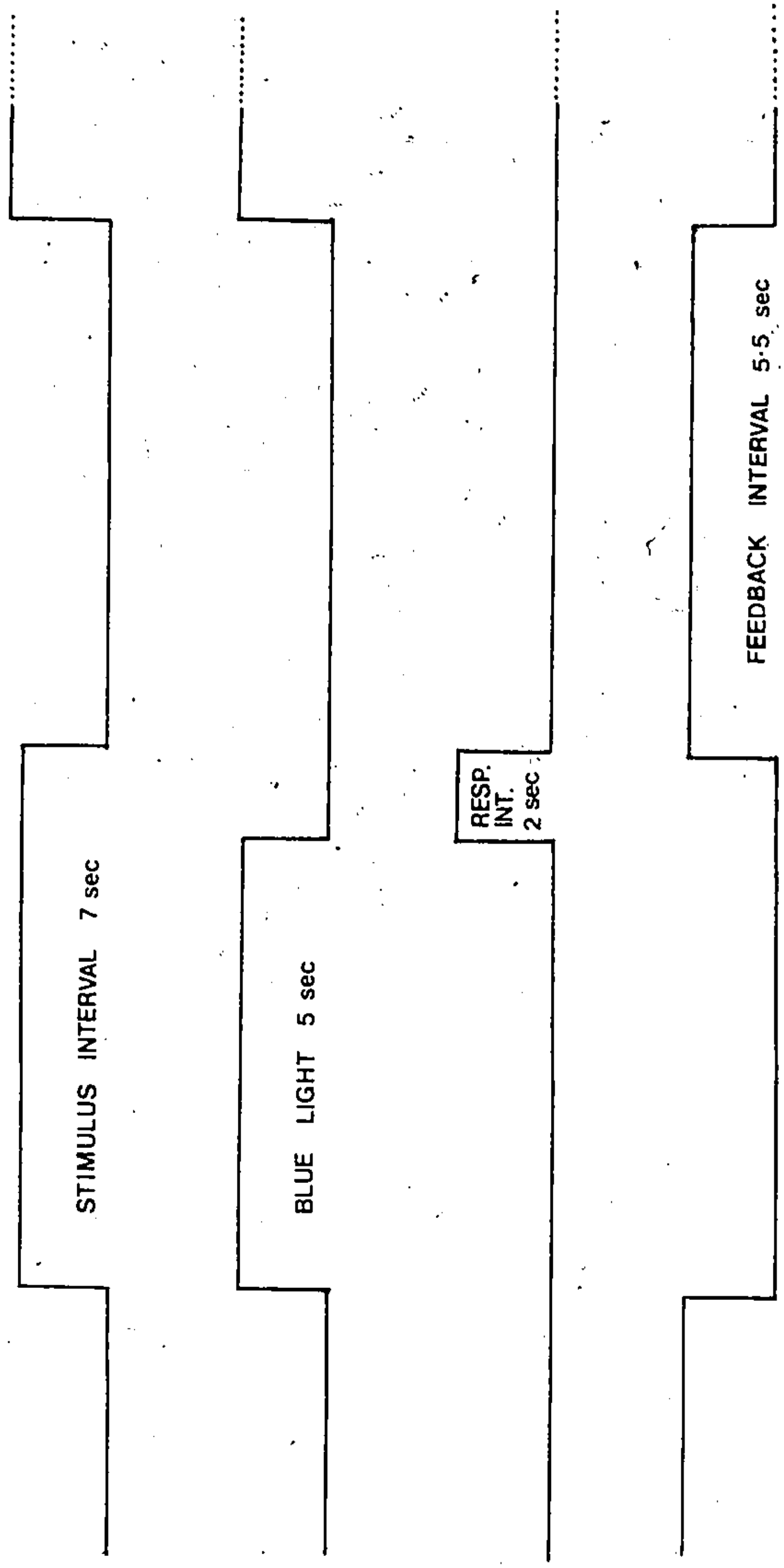

Figure 1. Sequence of Events in a Trial

asked to write another incorporating them. At this time, subjects were also asked if they had not been able to distinguish the colours of the stimuli, had ever taken a course in formal logic, or had ever been in a similar experiment. No subjects responded affirmatively to any of these questions.

Six subjects participated simultaneously in each experimental session. If fewer than six subjects appeared for a session, others were recruited to participate at another session, under the conditions specified for the deficient treatment group. The minimum number of subjects participating in any session was two, in order to maintain the group nature of the sessions. If more than a total of six subjects were needed to meet this requirement, the extra subjects were discarded at random. A total of ten subjects were discarded for this reason in the following conditions: positive-conjunction, 2; connotative-conjunction, 1; neutral-conjunction, 1; negative-disjunction, 1; positive-conditional, 1; connotative-conditional, 1; neutral-conditional, 1; positive-biconditional, 1; negative-biconditional, 1.

CHAPTER 111

RESULTS

The results of the present study are presented below in five major sections. In the first of these, an attempt was made to infer subjects' presolution biases from their initial classifications of stimuli. Next, the difficulty of acquisition of the four rules was determined, and comparisons of difficulty between rule and labelling conditions were made. In the third section, the presence and direction of category focussing was examined, and the two methods used for doing so were compared. In addition, a post-hoc test of the validity of the assumptions underlying the second of these methods was carried out. In the next section, the effects of rules and labels on the complexity of subjects hypothesis statements are described. In the final section, the distributions of classification errors within truth-table classes of stimuli were compared across rule and focusing conditions.

Initial Response Bias

In order to assess the preexperimental solution bias of each subject, the first categorization of each of the four truth-table classes of stimuli were classified by the expressed rule. For example, a subject categorizing these stimuli as: TT+, TF+, FT+, FF-, would be classified as expressing a disjunctive bias. However, this assessment of bias was confounded by the experience of the subject with other reinforced stimuli, although only a few (maximum of 8) reinforced trials would have occured. These data must therefore be interpreted with considerable caution.

Table 5 shows the frequency of each type of bias as a function of label and rule condition. A large number of subjects held affirmative biases, while a smaller number held either a conjunctive or a disjunctive bias. The apparently non-uniform distribution of these biases between rows shows that even at this early stage of learning, label and rule condition had already had some effect on subjects' hypotheses for solution.

Rule Difficulty

The number of classification errors made, and the trial of last error served as two measures of rule difficulty. Those subjects not meeting the learning criterion were not dropped from the analysis. The trial of last error for these subjects does not therefore represent trial of acquisition, but merely the trial on which they made their last classification error, allowing a possible maximum score of 162.

The mean scores for each group are shown in Figures 2

Table 5

Frequency of Initial Bias Types

as a Function of Label and Rule Condition

		Primary Biases					Complementary Biases					Other[1]
		Af	Cj	Dj	Cd	Bd	Ne	Ad	Jd	Ex	Ed	
Label	Pos	7	7	3	1	1	1	0	0	1	1	2
	Neg	2	4	6	0	0	2	1	2	1	1	5
	Con	9	7	4	0	0	2	1	2	1	1	2
	Neu	4	0	1	0	0	5	2	2	1	4	5
Percentage of Total		22.9	18.7	14.6	1.1	1.1	8.2	4.2	4.2	3.1	7.3	14.6
Rule	Cj	4	12	2	0	0	0	0	1	1	0	4
	Dj	7	2	7	0	0	1	2	1	1	2	1
	Cd	6	3	3	1	1	5	0	1	0	1	3
	Bd	5	1	2	0	0	2	2	1	1	4	6

[1]The 'Other' category represents unclassifiable rules.

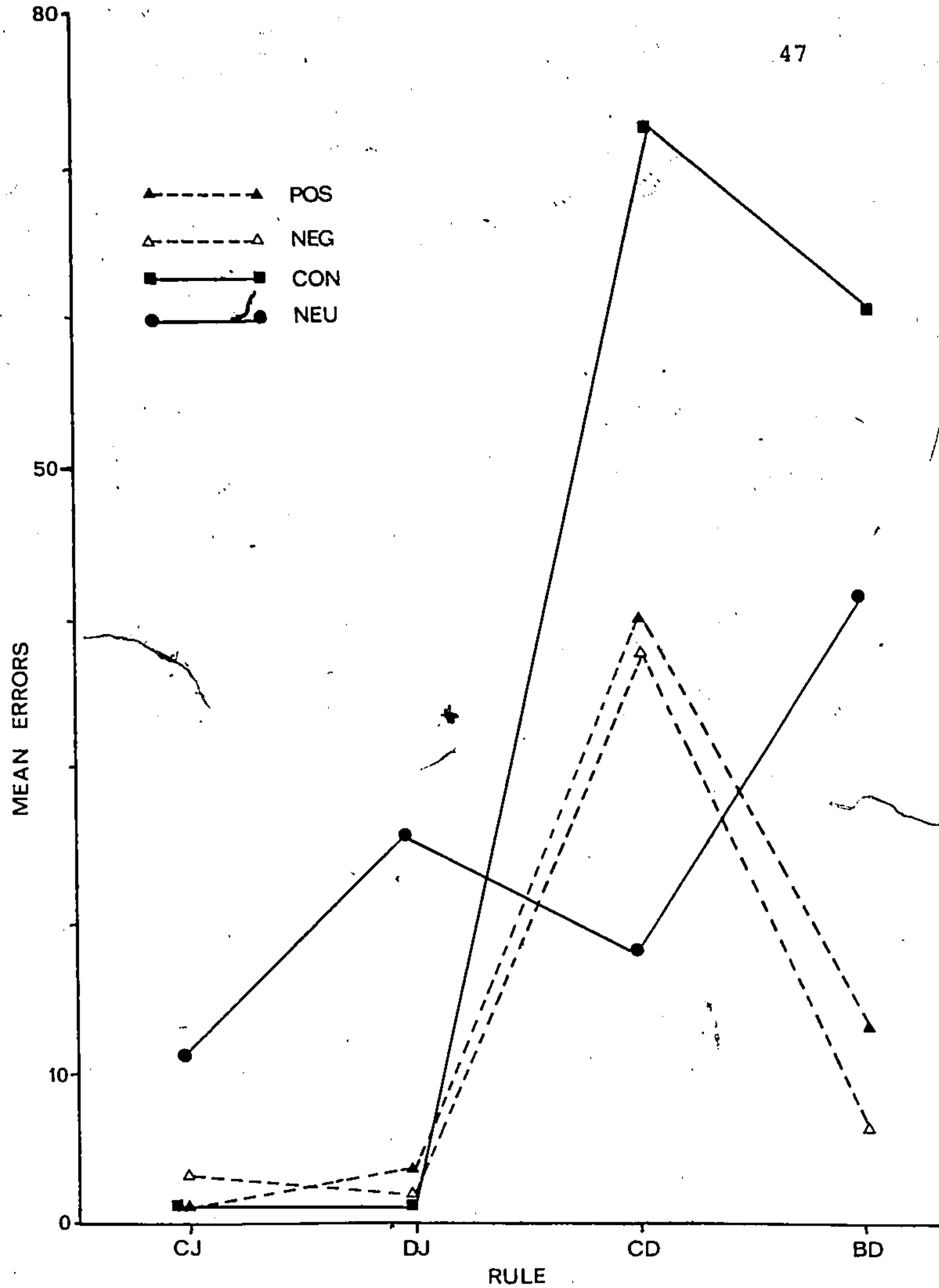

Figure 2. Mean Errors to Criterion for the Four Conceptual Rules as a Function of Labelling Condition.

and 3, illustrating the errors and trial of last error data respectively. Since the response requirements of the single and double response category tasks are not equivalent, subjects in these groups having either one or two buttons to push, two separate analyses of variance were done with each of the two dependant variables. Each of these four analyses took the form of a 2 (Label condition X 4 (Rule condition) independant groups factorial analysis of variance (Winer, 1971).

For the errors to criterion data, the analysis of the single category groups (Positive-only or Negative-only labels) showed only a significant effect of Rules (Table 6). For the double category groups (Connotative or Neutral labels) the analysis revealed a significant effect of Rules, and of the Label by Rule interaction (Table 7).

With the trial of last error data, analysis of the single category groups also showed only a significant effect of Rules (Table 8). For the double category groups, the findings were the same as those for the errors data. The effects of both Rules, and the Labels by Rules interaction were significant (Table 9).

Multiple comparisons between all totals were carried out using the Tukey "A" procedure (Winer, 1962). All of the differences reported below were found to be significant at the .01 confidence level. In the same manner as

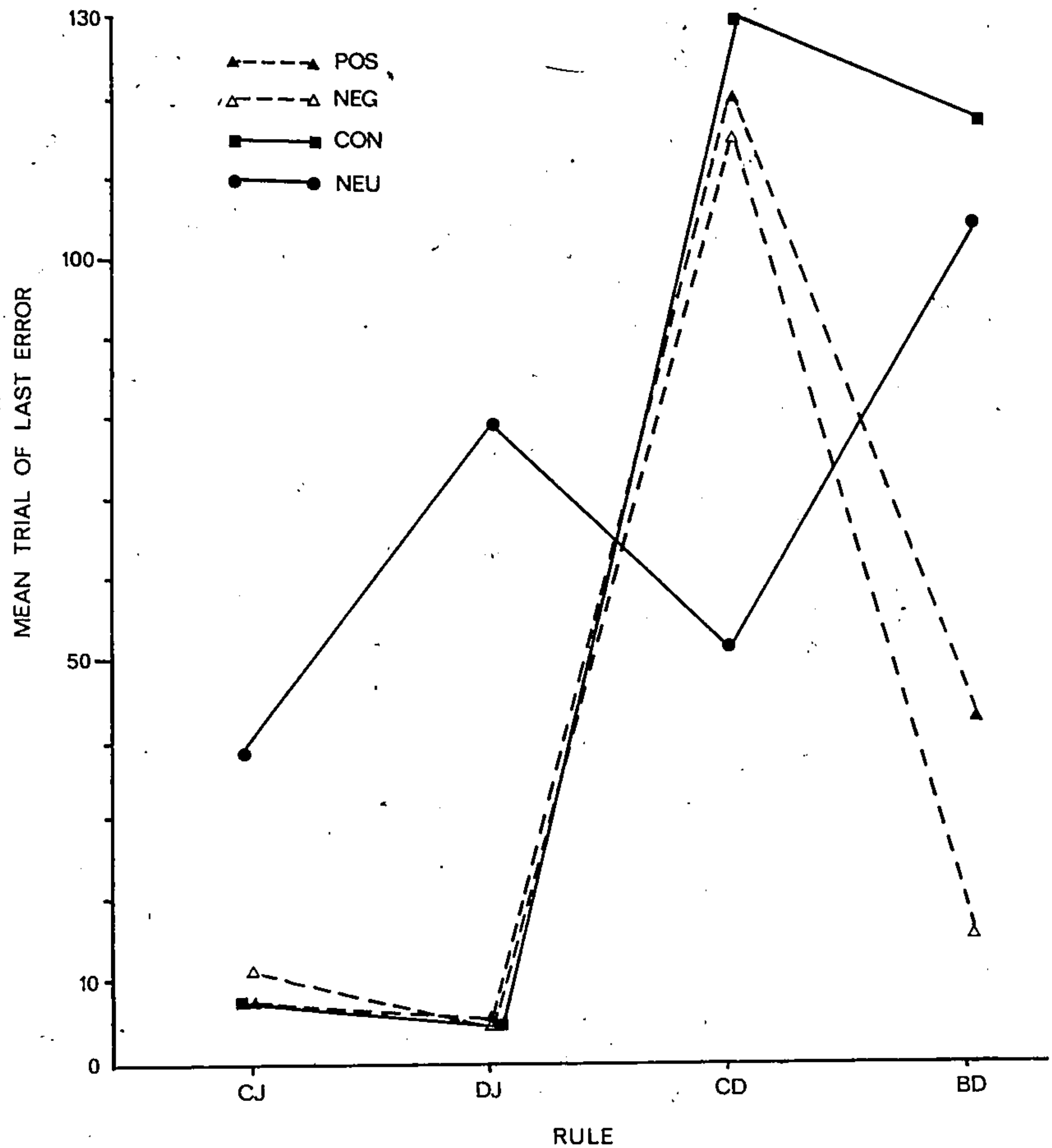

Figure 3. Mean Trial of Last Error for the Four Conceptual Rules as a Function of Labelling Condition.

Table 6

Summary of Analysis of Variance of
Errors to Criterion Data for the Single Category Groups

Source	SS	df	MS	F	P
Labels (Pos or Neg)	46.02	1	46.02	.44	> .10
Rules	11,295.56	3	3,765.19	35.98	< .01
Label X Rule	106.23	3	35.41	.34	> .10
error	4,186.17	40	104.65		
Total	15,633.98	47			

Table 7

Summary of Analysis of Variance of

Errors to Criterion Data for the Double Category Groups

Source	SS	df	MS	F	P
Labels (Con or Neu)	1,250.52	1	1,250.52	2.34	> .10
Rules	18,262.06	3	6,087.35	11.37	< .01
Labels X Rules	11,501.9	3	3,833.97	7.16	< .05
error	21,411.5	40	535.29		
Total	52,425.98	47			

Table 8

Summary of Analysis of Variance of

Trial of Last Error Data for the Single Category Groups

Source	SS	df	MS	F	P
Labels (Pos or Neg)	713.02	1	713.02	.86	> .10
Rules	101,058.73	3	33,686.24	40.51	< .01
Labels X Rules	1,572.9	3	524.3	.63	> .10
error	33,265.83	40	831.65		
Total	136,610.48	47			

Table 9

Summary of Analysis of Variance of

Trial of Last Error Data for the Double Category Groups

Source	SS	df	MS	F	P
Labels (Con or Neu)	243.0	1	243.0	.10	> .10
Rules	60,139.17	3	20,046.39	8.23	< .01
Labels X Rules	38,931.5	3	12,977.17	5.33	< .01
error	97,471.33	40	2,436.78		
Total	196,785.0	47			

the analyses of variance, independant sets of comparisons were made for the single category and double category groups. Where comparisons were made between the single category and double category groups, a pooled estimate of error variance was derived from the two relevant analyses of variance. Hartley's and Cochran's tests (Winer, 1971) showed that the assumption of homogeniety of variance was not violated. (For the errors to criterion data: $F_{max} = 3.35$, $k = 2$, $df = 5$, $p > .05$; $C = .77$, $b = 2$, $df = 5$, $p > .05$. For the trial of last error data: $F_{max} = 1.43$, $k = 2$, $df = 5$, $p > .05$, $C = .59$, $k = 2$, $df = 5$, $p > .05$.)

The findings of the multiple comparisons were not identical for the errors to criterion and trial of last error data, and so are reported separately below. Tables 10 and 11 summarize the findings made with the errors to criterion and trial of last error data, respectively. The complete set of comparisons may be found in Appendix D.

With the errors to criterion data, the neutral labelling condition differed in difficulty from the Connotative labelling condition only with the conditional rule, where Neutral labels were associated with significantly better concept attainment.

The Connotative, Positive-only and Negative-only labelling conditions differed in difficulty only with the

Table 10

Summary of Tukey "A" Comparisons[1]

Between Cell Totals for Errors to Criterion Data

Total Errors to Criterion	Label	Rule
443	CON	Cd
370	NEU	Bd
247	NEU	Bd
243	POS	Cd
235	NEG	Cd
159	NEU	Dj
109	NEU	Cd
82	POS	Bd
70	NEU	Cj
43	NEG	Bd
24	POS	Dj
18	NEG	Cj
13	NEG	Dj
9	CON	Dj
8	CON	Cj
7	POS	Cj

[1]Cell totals not connected by a common line are different with $p < .01$.

Table 11

Summary of Tukey "A" Comparisons[1]

Between Cell Totals for Trial of Last Error Data

Total Trial of Last Error	Label	Rule
781	CON	Cd
726	POS	Cd
710	CON	Bd
699	NEG	Cd
629	NEU	Bd
489	NEU	Dj
320	NEU	Cd
260	POS	Bd
233	NEU	Cj
98	NEG	Bd
65	NEG	Cj
49	CON	Cj
48	POS	Cj
40	POS	Dj
32	CON	Dj
27	NEG	Dj

biconditional rule, this rule being significantly less difficult to learn with the Positive-only and Negative-only labels. The Positive-only and Negative-only labelling conditions did not differ in difficulty within rules. In addition the Neutral labelling condition did not differ in difficulty from the Positive-only or Negative-only conditions with any rule.

As shown in Table 12, the conditional rule was more difficult than the conjunction, disjunction and biconditional rules in the single category conditions. In the Connotative condition, the biconditional was equivalent in difficulty to the conditional, both of these rules being more difficult than the conjunctive and disjunctive rules.

With the trial of last error data, no difference was found in the difficulty of the Connotative and Neutral labelling conditions with the conditional rule, as was found with the errors data. With the biconditional rule, only the Negative-only condition was significantly less difficult than the Connotative condition. As was found with the error data, the Positive-only and Negative-only condition did not differ from each other or the Connotative condition within any rule.

The hierarchies of rule difficulty obtained with the trial of last error data (Table 12) were the same as those

Table 12

Hierarchies of Rule Difficulty

Errors Data	
Labelling Condition	Order
Positive-only	Cj = Dj = Bd < Cd
Negative-only	Cj = Dj = Bd < Cd
Connotative	(Cj = Dj) < (Bd = Cd)
Neutral	Cj = Cd = Dj = Bd

Trial of Last Error	
Labelling Condition	Order
Positive-only	(Dj = Cj = Bd) < (Bd = Cd)
Negative-only	Dj = Cj = Bd < Cd
Connotative	(Dj = Cj) < (Bd = Cd)
Neutral	Cj = Cd = Dj = Bd

obtained with the errors data, except for the Positive-only condition. Here the conditional rule was more difficult than only the conjunction and disjunction.

The pattern of results evident in Figure 2 and 3 suggest that the two single category conditions and the Connotative labelling condition were related in their effects on rule difficulty. In support of this conclusion, Pearson Product-Moment correlations (Hays, 1963) were computed between each of the labelling conditions, for both the mean errors, and mean trial of last error data shown in Table 13. As shown in Table 14, strong correlations were found between the two single-category conditions, and the connotative condition. The somewhat lower coefficient of correlation between the Negative-only condition and the Connotative condition is probably due to the greatly reduced difficulty of the biconditional rule in the Negative-only condition compared to the Connotative condition. Essentially no relationship was found between the single-category conditions and the Neutral labelling condition, and only a weak relationship between the Connotative labelling and Neutral labelling condition was found.

Category Focus

Category focussing was determined by analysis of

Table 13

Mean Errors to Criterion and Trial of Last Error

for the Label and Rule Treatment Combinations

Mean Errors to Criterion

		Rule			
		Cj	Dj	Cd	Bd
Label	Pos	1.17	4.0	40.5	13.67
	Neg	3.0	2.17	39.17	7.17
	Con	1.33	1.5	73.83	61.67
	Neu	11.67	26.5	18.17	41.17

Mean Trial of Last Error

		Rule			
		Cj	Dj	Cd	Bd
Label	Pos	8.0	6.67	121.9	43.33
	Neg	10.83	4.5	116.5	16.33
	Con	8.17	5.33	130.17	118.33
	Neu	38.83	81.5	53.33	104.83

Table 14

Pearson Product-Moment Correlations

Between Labelling Conditions

Errors to Criterion

	Pos	Neg	Con	Neu
Pos		.98	.86	-.04
Neg			.76	-.23
Con				.38
Neu				

Mean Trial of Last Error

	Pos	Neg	Con	Neu
Pos		.97	.85	-.13
Neg			.69	-.34
Con				.31
Neu				

subjects' post-acquisition verbal statements, and the proportion of errors in the positive and negative response categories.

Subjects' verbal statements were classified as expressing focus on either the positive, negative or both categories, on the basis of which category(ies) a subject mentioned in his or her statement. For example, a statement mentioning only the positive category was classified as expressing focus on the positive category. Subjects mentioning both categories were classified as expressing focus on both categories. These few subjects who mentioned neither category were included in the "both" classification. Table 15 shows the number of subjects focusing on the positive, negative or both categories as a function of labelling condition. A Chi-square analysis of these frequencies shows that they differ significantly from chance expected values ($X^2 = 26.76$, df = 6, $p < .01$). This is due to a larger than expected number of subjects expressing focus on the positive category in the Positive-only and Connotative labelling conditions, and larger than expected number of subjects focusing on the negative category in the Negative-only conditions and both categories in the Neutral condition. Table 16 shows the same data partitioned by Rule condition. A Chi-square analysis of these frequencies shows that Rule was a determinant of focus category

Table 15

Number of Subjects in Each Labelling Condition

Focussing on the Positive, Negative or

Both Categories as Determined From Verbal Statements

		Focus Category		
		Positive	Negative	Both
Label	Pos	13	8	3
	Neg	8	14	2
	Con	18	4	2
	Neu	9	4	11

Table 16

Number of Subjects in Each Rule Condition Focusing on the Positive, Negative or Both Categories as Determined From Verbal Statements

		Focus Category		
		Positive	Negative	Both
Rule	Cj	21	2	1
	Dj	17	4	3
	Cd	5	14	5
	Bd	5	10	9

(X^2 = 36.91; df = 6; p < .01). More subjects than expected by chance focused on the positive category for the conjunctive and disjunctive rules, and on the negative category with the conditional rule. With the biconditional rule, greater than expected proportions of subjects focused on the negative category, and both categories. Inspection of the raw focus category data (Appendix C) shows that the majority of biconditional rule both-category focusers were in the neutral labelling condition, whereas the negative category focusers were most frequent in the two single-category conditions.

Focus category was also determined by comparing the proportions of each subject's errors made in the positive and negative categories of stimuli. The category where the smaller proportion of errors were committed was classified as the focus category. Where equal proportions of errors were made in both categories, that subject was classified as having focused on both categories. A number of subjects in the conjunctive and disjunctive rule conditions made no errors, and therefore were not included in this analysis.

Tables 17 and 18 show the numbers of subjects focusing on the positive, negative or both categories, as a function of Label and Rule condition respectively. Chi-square analyses of these frequencies dropping the "both"

Table 17

Number of Subjects in Each Labelling Condition Focussing on the Positive, Negative or Both Categories as Determined From Error Proportions

		Focus Category		
		Positive	Negative	Both
Label	Pos	8	11	1
	Neg	6	12	2
	Con	8	12	0
	Neu	9	12	3

Table 18

Number of Subjects in Each Rule Condition
Focussing on the Positive, Negative or Both Categories
as Determined From Error Proportions

		Focus Category		
		Positive	Negative	Both
Rule	Cj	14	1	1
	Dj	6	12	2
	Cd	3	20	1
	Bd	8	14	2

column shows that only Rule was a significant determinant of focus category ($X^2 = .44$, df = 3, $p > .90$) for Labels; $X^2 = 25.25$, df = 3, $p < .01$ for Rules). However, comparison of Tables 12 and 13, and 14 and 15 suggests that the two methods of determining category focus do not generate similar findings.

As a test of the agreement of the two methods, Gramer's ϕ (phi) was computed from a Chi-square analysis of the frequencies of agreement between the two methods (Table 19). Cramer's statistic is an index of the strength of association between two nominal variables (Hays, 1963), and is a good estimate of r. The value of ϕ obtained ($X^2 = 3.85$, df = 4, $p > .20$; $\phi = .15$) is far below the maximum possible value of 1.0, indicating that the two methods of determining category focus do not agree.

Complexity of Verbal Statements

In order to provide a basis for assessing the effects of Label condition on the form of subjects' postacquisition verbal statements, an attempt was made to quantify the complexity of these statements.

Subjects' verbal statements were reduced to symbolic logical statements. For example, if a subject said "a stimulus was positive if it was red or a triangle", the logical equivalent is the disjunction of red and triangle. The verbal statements given by subjects, and the logical

Table 19

Frequency of Agreement Between the

Two Focus Category Classification Methods

		Focus Category as Determined From Error Proportions		
		Positive	Negative	Both
Focus Category as Determined From Verbal Statements	Positive	18	16	3
	Negative	9	18	2
	Both	5	12	1

reductions of these statements are presented in Appendix E.[1] An ordinal value ranging from 1 to 7 was assigned to each logically reduced statement, representing the complexity of the statement. These values were determined by the number of elements in each statement, as shown in Table 20.

Table 21 shows the frequency of each level of statement complexity as a function of Rule condition.

For all rules except the conditional, the modal complexity of subjects' statements was 3, a low degree of complexity. The modal complexity value for the conditional rule was 7, indicating that these subjects formulated very complex statements. However, a Chi-square analysis of these frequencies, with complexity collapsed into the two categories of low (1 - 4) and high (5 - 7) complexity, indicates that rules were not differentially related to statement complexity ($X^2 = 7.54$, $df = 3$, $p > .05$).

Table 22 shows the frequency of each level of statement complexity as a function of labelling condition. For all labelling conditions, the modal statement com-

---

[1]Some subjects wrote statements which were either exhaustive lists of stimuli in one or two categories, or not based on stimulus attributes. These subjects were therefore not included in this analysis.

Table 20

Levels of Statement Complexity

Rule Form	Complexity Level	Verbal Descriptions
A	1	Red things
$\bar{A}$	2	not Red things
$A \vee B$ $A \wedge B$	3	Red and Square things Red or Square things
$A \vee \bar{B}$	4	Red and not Square things
$\overline{A \vee B}$ $\bar{A} \vee \bar{B}$	5	not (Red and Square) not Red and not Square
$(A \wedge B) \vee (\bar{C})$	6	Red or Square and not Green things
$(A \wedge B) \vee (C \wedge D)$	7	Red or Square and green or circular things

Table 21

Frequency of Levels of Statement Complexity Within Rule Conditions

		Statement Complexity						
		1	2	3	4	5	6	7
Rule	Cj	0	0	21	0	2	0	1
	Dj	1	0	17	0	3	1	1
	Cd	0	0	6	5	1	1	7
	Bd	0	0	9	1	9	3	4

Table 22

Frequency of Levels of Statement Complexity

Within Labelling Conditions

		Rule Complexity						
		1	2	3	4	5	6	7
Label	Pos			15		2	1	3
	Neg			13	3	2	2	2
	Con			16	2	1	2	1
	Neu	1		8	1	1		6

lexity was 3. Chi-square analysis of these frequencies, also with complexity collapsed into low (1 - 4) and high (5 - 7) groups, indicates that labels were not differential determinants of statement complexity ($X^2 = 2.52$, df = 3, $p > .5$).

In order to determine if the complexity of subjects' verbal statements was related to the difficulty of acquisition of the conceptual rules, Pearson product-moment correlations were computed between both the errors to criterion and trial of last error data, and the statement complexity values across all subjects with classifiable rules. As shown in Table 23, the coefficient of correlation between errors to criterion and complexity, and between trial of last error and complexity are very low, indicating a lack of any relationship between difficulty of acquisition and complexity of postacquisition verbal statements.

Difficulty of Truth-Table Classes

Tables 24, 25 and 26 show the mean percentage of errors made within each truth-table category for positive, negative and two-category focusers respectively. These values were computed in the following manner: for each subject, the percentage of his or her total errors occurring in each truth-table category was determined. Then, for each combination of Label, Rule and Focus condition,

Table 23

Pearson Product-Moment Correlations Between Errors, Trial of Last Error and Complexity of Postacquisition Verbal Statements

	Errors	Trial	Complexity
Errors		.90	.13
Trial			.10
Complexity			

Table 24

Mean Percentage of Errors Occuring in
Each Truth-Table Category:
Positive Category Focussing Subjects

Rule	Label	TT	TF	FT	FF	n
Cj	Pos	0	12.5	3.7	0	6
	Neg	10.0	7.5	1.2	3.0	5
	Con	10.7	0	11.0	1.0	5
	Neu	11.4	40.2	26.4	10.9	5
Dj	Pos	4.2	23.9	7.0	7.5	6
	Neg	0	30.0	0	0	2
	Con	0	10.8	15.6	1.5	6
	Neu	13.3	25.1	30.4	28.6	4
Cd	Pos	0	75.0	2.8	30.6	1
	Neg	–	–	–	–	0
	Con	5.6	38.2	57.6	83.7	4
	Neu	–	–	–	–	0
Bd	Pos	66.7	50.0	16.7	14.3	1
	Neg	33.3	25.0	18.2	50.0	1
	Con	29.9	60.7	65.4	42.9	3
	Neu	–	–	–	–	0

Note: column headings TT, TF, FT, FF are grouped under "Truth-table category".

Table 25

Mean Percentage of Errors Occuring in Each Truth-Table Category: Negative Category Focusing Subjects

Rule	Label	Truth-table category				n
		TT	TF	FT	FF	
Cj	Pos	-	-	-	-	0
	Neg	-	-	-	-	0
	Con	0	33.3	0	0	1
	Neu	60.0	10.0	18.2	12.2	1
Dj	Pos	-	-	-	-	0
	Neg	12.5	12.5	0	10.0	4
	Con	-	-	-	-	0
	Neu	-	-	-	-	0
Cd	Pos	9.0	41.5	8.5	35.5	4
	Neg	23.3	45.2	15.5	20.0	5
	Con	6.2	58.5	27.0	36.6	2
	Neu	38.9	24.4	20.0	9.1	3
Bd	Pos	18.1	22.5	22.13	21.8	4
	Neg	40.0	16.1	9.0	14.0	5
	Con	21.4	57.7	35.7	19.6	1
	Neu	-	-	-	-	0

Table 26

Mean Percentage of Errors Occuring in Each Truth-Table Category: Both Category Focussing Subjects

Rule	Label	Truth-table category				n
		TT	TF	FT	FF	
Cj	Neg	0	25.0	25.0	11.1	1
Dj	Neu	30.0	2.4	22.5	31.2	2
Cd	Pos	61.1	61.1	16.7	19.4	1
	Neg	5.6	58.3	22.2	62.5	1
	Con	-	-	-	-	0
	Neu	41.7	32.0	19.3	16.4	3
Bd	Pos	0	54.2	8.3	13.0	1
	Neg	-	-	-	-	0
	Con	29.4	51.4	52.8	42.3	2
	Neu	54.3	20.9	41.4	33.9	6

the percentages within each truth-table category were averaged to obtain the mean percentage of errors within that category.

These data were evaluated qualitatively by comparing the pattern of errors observed across the four truth-table categories within each rule and labelling condition with the pattern predicted for each rule (contained in Table 4).

For positive category focusing subjects (Table 24), the pattern of errors exhibited by subjects in the conjunctive rule Positive-only and Neutral labelling conditions was similar to the predicted configuration. These subjects made more errors in the TF and FT categories than in the TT and FF categories. Subjects in the Positive-only, Negative-only and Connotative labelling conditions within the disjunctive rule exhibited the same pattern of errors, similar to that predicted for this rule and focus condition. Subjects in the conditional rule Connotative labelling condition exhibited a pattern of errors in close agreement with the predicted configuration, making most of their errors in the FF category, fewer errors in the TF and FT categories, and the fewest errors in the TT category. Biconditional rule Connotative labelling subjects show a similar pattern of errors, with a reduced number of errors in the FF category.

With negative category focusing subjects (Table 25), only the one subject in the conjunctive rule neutral labelling condition, and subjects in the biconditional rule negative labelling condition exhibited patterns of errors in agreement with the predicted patterns.

CHAPTER IV

DISCUSSION

Category Complexity

The central hypothesis of the present study stated that the difficulty with which individual rules were learned would be related to the size and complexity of the response category focussed on. Specifically, it was predicted that rules would be easier to learn when the smaller and less complex category was focused on.

This research attempted to produce focus on the positive and negative response categories by requiring subjects to classify only positive or only negative stimuli. Before discussing the experimental findings relating to the above hypothesis, it is therefore necessary to examine first the effects of the four response category labelling conditions on category focusing.

Category focus. As shown in Table 15, Labels were related to category focus (as determined by verbal statements) in the predicted direction. Subjects in the Positive-only condition focused on the positive category, subjects in the Negative-only condition focused on the negative category. Subjects in the Connotative condition focused on the positive category, and subjects in the Neutral condition focused on both categories. On the basis of these findings it might be concluded that the 'methodological' aim of the study had been successfull, in that the two single-category conditions were associated with focus on the named category. Furthermore, these data appear to support the hypothesis made in the present research that connotative labels would be associated with positive category focus, and neutral labels with focus on both categories.

However, when direction of focus is broken down by Rule condition, as shown in Table 16, it can be seen quite clearly that the category a subject focused on was dependant on the rule being learned. Subjects learning the conjunctive and disjunctive rules focused on the positive category and subjects learning the conditional and biconditional rules focused on the negative category, although biconditional rule learners also showed a strong tendancy to focus on both categories. This unexpected finding makes evaluation of the category size/complexity difficulty hypothesis difficult, if not impossible, since within a given rule, subjects in all labelling conditions tended to focus on the same response category. Clearly, the attempt to produce <u>differential</u> focus within rules was unsuccessful, although category focusing did occur within each rule.

<u>Rule difficulty</u>. Within rules: As stated above, the

major hypothesis of this study was that the difficulty of individual rules would differ depending on the labelling condition. These predictions (Table 3) were not supported by the findings of the present research, as discussed below.

The Positive-only and Negative-only conditions did not differ within rules, as shown in Tables 10 and 11. Furthermore, the Connotative labelling condition, which was also predicted to be associated with category focus, differed from the Positive-only and Negative-only conditions only within the biconditional rule. Here the single-category conditions were associated with a significant facilitation of learning.

The Neutral labelling conditions were predicted to be the most difficult for all rules. As shown in Tables 10 and 11, this prediction was also not supported. The Neutral condition differed in difficulty from the Connotative condition only within the conditional rule, and only with the classification errors data, where the Neutral condition was associated with a significant facilitation of learning.

While these within-rule difficulty findings do not support the predictions made in the present research, it would be in error to reject the hypothesis that the size and complexity of the focus category determined rule difficulty, as a necessary condition for the test of this hypothesis was not met by the present research. Focus on the positive and negative categories within each rule was not achieved, as described above. Rather, subjects in differing labelling conditions within a given rule condition all tended to focus on the same category (Table 16).

The high correlations between the Positive-only, Negative-only and Connotative conditions (Table 14) suggest that subjects in these conditions solved rules in a similar manner. From the focus category data (Table 16) it can be seen that the category focused on is the one which may be described with the less complex rule. With reference to Table 1, showing the structures of the four rules, the positive categories of the conjunction and disjunction are easily described with a conjunctive and disjunctive statement, respectively. While the negative categories of these rules require similarly simple statements, there is an additional requirement of negating the relevant attributes. The negative category of the conditional rule can be described with the relatively simple statement "A and not B", which is a conjunction. The positive category, on the other hand, requires the more complex statement "A and B or not A". With the biconditional rule, the differences are less obvious, the positive category being described by "A and B or not A and not B", and the negative category being described by "A or B but not both". This latter statement, describing the negative category, is more parsimonious, and can therefore be considered to be the less complex.

The effect of the single-category and connotative labelling conditions appears to be that of having allowed subjects to focus on the least complex response category. With the biconditional rule, however, subjects in the Connotative labeling condition focused either on the positive or both response categories (see raw focus category data in Appendix C), while subjects in the single-category conditions focused on the negative response category. From these findings, the generalization may be made that Connotative labels are associated with focus on the less complex category only when the differences between the two categories are distinct; with the biconditional rule this is not the case. The effect of single-category labels appears to be that of facilitating focus on the less complex category when the two categories are not grossly different, possibly by making it more evident to subjects that knowledge of the defining characteristics of only one response category is sufficient for a solution.

The effects of neutral labels on rule learning in the present research are less clear-cut; the Neutral labelling condition did not differ from any other condition except within the conditional rule, where neutral labels were associated with a significant reduction in errors compared to the Connotative condition. As shown in Figures 2 and 3, there was a trend for the Neutral condition to be more difficult than the single-category and Connotative conditions in the conjunctive and disjunctive rules. With the conditional and biconditional rules, this trend was reversed, the Neutral labelling condition being less difficult than the Connotative condition. Subjects learning the conjunctive and disjunctive rules with neutral labels focused on the positive response category. One-half of those learning the conditional rule with neutral labels focused on the negative category and one-half on both categories. All subjects learning the biconditional rule with neutral labels focused on both categories. One possible interpretation of these findings is that focus on the less complex category does occur with neutral labels, but only with less difficult rules. As rules become more difficult, subjects may have increasing difficulty in associating non-meaningful category labels with categories of stimuli, resulting in confusing the two categories while attempting to learn the defining characteristics of one category.

Between rules: As noted in the presentation of the results, the present research found that with connotative labels the conjunctive and disjunctive rules were equivalent in difficulty, as were the conditional and biconditional rules (Table 12). The lack of a difference in difficulty between the conjunction and disjunction is apparently due to a floor effect; both rules were solved virtually without error. These rules may have been equally familiar to the subjects used in the present research, as suggested by the initial response bias data. A conjunctive bias was held by 18.7 percent of the subjects, and 14.6 percent held a disjunctive bias (Table 5). Dominowski and Wetherick (1976) found that more of their subjects held a disjunctive bias than a conjunctive bias. Reznick and Richmann (1976) found that with colour and form attributes, those used in the present research, a greater proportion of subjects expressed a disjunctive bias than a conjunctive bias.

The lack of a difference in difficulty between the conditional and biconditional rules in the Connotative condition may be due to the ceiling on the possible number of trials. Non-learners were not dropped from the present study, and made up approximately 50 percent of the subjects in these two groups. This artificially limits the total possible number of trials for differences in difficulty to become apparent.

Within the single-category conditions, there was a strong trend for the conditional rule to be more difficult than the conjunctive, disjunctive and biconditional rules (Figures 2 and 3). This trend was statistically significant only with the trial of last error data, where the conditional rule was more difficult than the conjunction and disjunction in the Positive-only labelling condition, and more difficult than the conjunction, disjunction and biconditional rules in the Negative-only condition (Table 12). One possible explanation of the increased difficulty of the conditional rule compared to the biconditional rule is that the category focused on by conditional rule learning subjects may be more complex than the category focused on by biconditional rule subjects. Conditional rule subjects focused on the negative category, described by "A and not B". Biconditional rule subjects focused on the negative category, described by "A or B but not both". Since the former statement incorporates one attribute negation, it may be more complex, and therefore more difficult to learn than the latter, which is a type of disjunction.

In summary, the rule difficulty findings, considered in light of the category focus findings, suggest that there are two important determinants of rule difficulty. These are: a) the ease with which subjects can focus on the less complex category; and b) the relative complexity of that category. The pattern of focus category findings necessary for a formal evaluation of these principles was not obtained. However, they seem to provide the most parsimonious _post hoc_ explanation of the rule difficulty findings.

Focus category difficulty. Analysis of the frequencies of the seven levels of postacquisition verbal statements within the four rule conditions (Table 21) showed that rules were not related to the complexity of the verbal statements, suggesting that the verbal statements did not reflect the difficulty of the category(ies) focused on within each rule. However, differences in statement complexity were probably obscured by the necessity of having to collapse statement complexity into high and low levels to increase cell frequencies.

The quantification of statement complexity may have in itself not sufficiently discriminated differences in the complexity of verbal statements, as suggested by the low correlations obtained between rule difficulty and statement complexity (Table 23).

Difficulty of Truth-Table Classes

A second set of hypotheses in the present research were derived from Sawyer's (1972) work, and predicted in which truth-table classes most errors would occur with each rule (Table 4). These predictions were based on the principle advanced by Sawyer that errors in concept learning stem from subjects incorrectly assigning stimuli sharing an attribute in common to the same response category. A comparison of these predictions (Table 4) with the percentages of errors occuring in each truth-table class (Tables 24 and 25) revealed a moderate degree of support for the predictions. In fact, the degree of concordance between the predictions and the results obtained are encouraging when methodological problems discussed below are considered. First, however, the findings will be discussed.

A greater degree of support is found overall with the data obtained from subjects focusing on the positive response category (Table 24). With the conjunctive rule, the pattern of errors in the Positive-only and Neutral labelling groups indicates that subjects made most errors in the TF and FT stimulus classes, as predicted. The greater proportion of errors occuring in the TF class compared to the FT class indicates that the first stimulus dimension was attended to, subjects therefore assigning TF stimuli to the positive category (TT stimuli).

A similar pattern of results is found with the Positive-only and Negative-only labelling conditions within the disjunctive rule. Again, a greater percentage of errors occured in the TF stimulus class than in the FT class, indicating attention to the first stimulus dimension. Connotative labelling subjects also show a greater percentage of errors in the TF and FT classes, as predicted. The approximately equal percentages of errors in these two classes indicates that attention to each of the relevant stimulus dimensions was equiprobable.

With the conditional rule, only the Connotative labelling condition contained a large number of positive-category focusers. Approximately twice as many errors occured in the FF class than in the TF and FT classes, which in turn were more difficult than the TT class. This pattern of results is in close agreement with the prediction made for this rule.

The pattern of results obtained from subjects learning the biconditional rule in the Connotative labelling condition only partially supports the prediction made for this rule. While large percentages of errors occured in the TF and FT categories, as predicted, a smaller than predicted percentage of errors occured in the FF class.

Very little support for the predictions made for negative category focus (Table 4) can be found in the data collected from subjects focusing on the negative category (Table 25). The one subject in the conjunctive rule connotative labelling condition shows clear evidence of having attended to the first stimulus dimension. In the biconditional rule Negative labelling condition, the pattern of results is suggestive of attention to the first stimulus dimension, most errors occuring in the TT class. By attending to the first dimension, subjects incorrectly placed TT stimuli in the same category as TF stimuli.

The overall lack of agreement of the findings made with negative category focusers with the predictions made for these groups can be accounted for in one of two ways. Sawyer's principle may only be applicable to situations where positive category focus occurs. Alternatively, subjects focusing on the negative category at solution may have initially attempted to use a positive focusing strategy at the outset, switching to a negative focusing strategy at a later time. This second explanation seems more appropriate, especially since no particular agreement can be advanced for supposing that Sawyer's model will not accomodate negative category focus.

As mentioned above, the degree of agreement between the predictions and the empirical findings is encouraging, as the data collected are in fact biased against the model. Sawyer's model is meant to account for classification errors made during initial stages of learning. Subjects obviously must eventually come to attend to more than one stimulus dimension since a solution would otherwise be impossible. The data presented in in Tables 24, 25 and 26 represent the complete process of acquisition for each subject. Thus, errors made at later stages of acquisition, or after changes in strategy as suggested above, are included in these summary data. The present findings extend the generality of Sawyer's model, since Sawyer used a stimulus universe less complex than that used in the present research. Sawyer's stimulus universe consisted of four stimuli, representing all possible combinations of two bi-valued dimensions. In the present research, the stimulus universe was composed of the 27 possible combinations of three tri-valued dimensions.

Initial Response Bias

Bourne's (1974) model of conceptual rule learning is based largely on the assumption that subjects hold a conjunctive solution bias. The findings of the present research show that while some subjects did hold a conjunctive bias, other solution biases were held as well. Table 5 shows that the most frequent bias was a unidimension affirmation. Interestingly, the most frequent complementary bias, the negation, is also unidimensional. Unidimensional biases suggest that subjects were attending to only one stimulus dimension, a finding that supports Sawyer's (1972) model.

The effect of informative feedback on shaping subjects' solution biases can be seen with the conjunctive and disjunctive bias frequencies, which were highest in the conjunctive and disjunctive rule conditions respectively. This finding illustrates the confounded nature of these data. Nonetheless, the high overall percentage occurence of the disjunctive bias is strong evidence against the central assumption of Bourne's (1974) model.

The frequency of complementary biases is a somewhat surprising finding, suggesting that focus on the negative category of a rule (which is the positive category of the complement of the primary rule) can occur at very early stages of learning. However, all types of complementary biases were most frequent in the Neutral labelling condition, suggesting that subjects were not actually focusing on a "negative" category, but had selected one of the neutral categories at random for focus.

Summary and Conclusions

The present research was designed to test the hypothesis that the size and complexity of the response category focused on during learning determines conceptual rule difficulty. In order to test this hypothesis, it is necessary to compare groups of subjects learning the same conceptual rule, but focusing on different response categories. This requirement was not met by the present research, since subjects in different response category labelling conditions all tended to focus on the same response category within their respective rules, contrary to expectation. A formal test of the category complexity hypothesis was therefore not possible.

The findings of the present study do suggest, however, that category focusing strategies may be facilitated or inhibited by the type of labels used for naming the response categories. Non-connotative, neutral labels are least conducive to category focusing, while connotative and single-category labels are associated with increasing facilitation of category focus.

Furthermore, the relative differences in the complexity of the two response categories also appears to affect category focus. Where differences in complexity are subtle, focus on either or both of the response categories may occur. When these differences are distinct, however, subjects will focus on the category which can be described with the least complex logical statement.

This latter finding provides an important clue for the analysis of differences in the difficulty of acquisition of conceptual rules. Previous authors have suggested that connotative response category labels direct subjects' attention to the positive category, and that variables related to the structure of that category affect rule difficulty (Giambra, 1974; Gottwald, 1971b; Neumann, 1974; Seggie, 1969). The findings of the present research suggest that one quality of the structure of the focus category affecting difficulty of acquisition may be the logical complexity of the statement necessary to describe the focus category. An attempt made in the present study to relate the complexity of subjects' verbal descriptions of the category they focused on to the difficulty with which they attained the concept was unsuccessful, probably because the quantification of statement complexity was insufficiently comprehensive or discriminative. This remains a potentially fruitful area for future research.

The present research has also provided considerable support for Sawyer's (1972) concept learning model, by showing that subjects make errors by incorrectly placing stimuli sharing values on one dimension in the same response category. More support for the model was found with data obtained from positive category focusing subjects than with those focusing on the negative category. The suggestion was made in the discussion of these findings that negative category focusing subjects may have switched from a positive to negative focus strategy at some point during acquisition, thereby obscuring earlier error patterns with errors made after a switch in strategy. In retrospect, a more precise test of Sawyer's model could be made by sampling subjects' errors within small blocks of trials at various intervals during learning.

Such a sample was made in the present study during the first eight trials, in order to assess subjects' initial classification bias. The findings made with these data support Sawyer's model by showing that a substantial proportion of subjects held biases suggesting attention to one stimulus dimension.

The impetus for the present research was a discrepancy between two assumptions implicit in Bourne's model of conceptual rule learning, and research findings contradicting these assumptions. Bourne's model assumes that subjects attend equally to both response categories, and both relevant stimulus dimensions. The present research has shown that subjects attend to only one stimulus dimension during early stages of learning, and that subjects focus their learning on one response category. Furthermore, the initial response bias findings of this study do not support another assumption of Bourne's model, by showing that a majority of subjects do not hold a conjunctive solution bias. While Bourne's model does accurately predict the difficulty of bidimensional conceptual rules, the findings of the present study suggest that the validity of the model as an explanation of processes involved in conceptual rule learning must be questioned.

APPENDICES

APPENDIX A

STIMULUS SEQUENCES AND RELEVANT ATTRIBUTES FOR THE 16 EXPERIMENTAL CONDITIONS

Conjunctive Rule

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

Conjunctive Rule

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

Disjunctive Rule

POS (red, circle)

1. red triangle
1. blue circle
3 yellow stars
2 red stars
3 blue triangles
3 blue stars
1 yellow star
3 red circles
3 yellow circles
1 red star
2 blue triangle
3 red triangles
3 blue circles
2 blue stars
1 yellow triangle
2 yellow stars
2 blue circles
1 red circle
1 yellow circle
2 red triangles
3 red stars
2 yellow triangles
3 yellow triangles
1 blue triangle
2 red circles
1 blue star
2 yellow circles

NEG (yellow, circle)

1 yellow star
1 blue circle
3 blue stars
2 yellow stars
3 blue triangles
3 red stars
1 red triangle
3 yellow circles
3 red circles
1 yellow triangle
2 blue stars
3 yellow triangles
3 blue circles
2 red stars
1 blue triangle
2 red triangles
2 blue circles
1 yellow circle
1 red circle
2 yellow triangles
3 yellow stars
2 blue triangles
3 red triangles
1 blue star
2 yellow circles
1 red star
2 red circles

Disjunctive Rule

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

Conditional Rule

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

Conditional Rule

CON (red, circle)

1 red star
3 blue triangles
3 blue stars
3 red circles
3 yellow circles
2 yellow stars
2 red triangles
2 yellow triangles
2 yellow circles
1 yellow star
1 blue triangle
3 red triangles
3 blue circles
2 red circles
2 red stars
3 yellow stars
1 blue circle
3 yellow triangles
1 blue star
1 red circle
2 blue stars
1 yellow triangle
3 red stars
1 yellow circle
1 red triangle
2 blue triangles
2 blue circles

NEU (blue, circle)

3 blue triangles
1 yellow star
1 red circle
1 blue circle
1 yellow circle
2 blue stars
3 red stars
3 yellow stars
1 yellow triangle
3 red circles
1 blue star
1 red star
3 red triangles
3 blue stars
2 yellow stars
3 yellow circles
2 blue circles
2 red triangles
2 yellow circles
1 red triangle
3 blue circles
1 blue triangle
3 yellow triangles
2 red stars
2 blue triangles
2 red circles
2 yellow triangles

Biconditional Rule

POS (blue, triangle)

1 yellow circle
3 red circles
2 red triangles
2 blue triangles
3 yellow triangles
2 blue circles
3 red stars
3 yellow circles
3 blue circles
3 red triangles
3 blue triangles
2 yellow triangles
2 blue stars
2 red circles
2 yellow circles
1 red star
3 blue stars
1 yellow star
1 blue triangle
1 red triangle
1 blue star
1 red circle
2 yellow stars
1 yellow triangle
1 blue circle
2 red stars
3 yellow stars

NEG (red, star)

3 blue triangles
1 yellow circle
1 red triangle
3 blue circles
2 red circles
2 red stars
2 yellow stars
1 blue star
3 yellow triangles
1 yellow star
2 yellow circles
3 red triangles
2 yellow triangles
1 red star
2 red triangles
1 yellow star
3 yellow circles
3 blue stars
1 blue circle
1 blue triangle
3 red circles
3 red stars
2 yellow stars
1 red circle
2 blue circles
2 blue triangles
2 blue stars

Biconditional Rule

CON (yellow, triangle)

2 red stars
1 red circle
1 blue triangle
3 red triangles
1 yellow star
3 blue stars
3 yellow triangles
3 yellow circles
3 blue circles
1 red triangle
2 blue stars
2 blue circles
2 yellow triangles
3 blue triangles
3 red circles
1 blue circle
1 yellow circle
2 yellow stars
2 red circles
3 red stars
1 blue star
2 red triangles
1 yellow triangle
2 yellow circles
1 red star
2 blue triangles
3 yellow stars

NEU (yellow, star)

1 red circle
1 red star
3 blue triangles
1 yellow star
1 red triangle
2 yellow circles
3 red stars
2 yellow triangles
1 blue circle
3 blue circles
3 red circles
2 red stars
2 yellow stars
1 blue triangle
2 blue circles
2 blue triangles
3 yellow circles
3 yellow triangles
2 red triangles
2 red circles
3 yellow stars
3 blue stars
3 red triangles
1 blue star
1 yellow triangle
2 blue triangles
1 yellow circle

APPENDIX B

INSTRUCTIONS TO SUBJECTS

"This is an experiment on concept attainment. You will be seeing a series of geometric designs which contain the three dimensions of colour, shape, and number of figures. As you can see from these examples, (Experimenter points to a card showing several stimuli) there can be either 1, 2 or 3 figures, which may be either red yellow or blue, and will be either circles, triangles or stars. In the type of concept you will be learning, every stimulus belongs to one of two classes or categories. In a moment I will tell you a pair of stimulus attributes which are relevant to the solution of the concept. Your task will be to discover the relationship between those two attributes, which determines whether a stimulus belongs to one or the other category."

Connotative labelling groups. "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 press the POSITIVE button. If you think that the stimulus does not represent the concept, you are to press the button labelled NEGATIVE."

Neutral labelling groups. "If you look at the panel in front of you, there are two buttons, one labelled 'VEC' and the other 'XAD'. If you think that a stimulus belongs to the category of VEC, you are to press that button. If you think that a stimulus belongs to the category of XAD, then press that button."

Positive-only labelling groups. "If you look at the panel in front of you, there is a button labelled 'POSITIVE'. If you think that a stimulus is an example of the concept, then you are to press the button. If you think that a stimulus is not an example, then do nothing; you are to indicate only those stimuli you believe to be examples of the concept."

Negative-only labelling groups. "If you look at the panel in front of you, there is a button labelled 'NEGATIVE'. If you think that a stimulus is not an example of the concept, then you are to press the button. If you think that a stimulus is an example of the concept, then do nothing; you are to indicate only those stimuli you believe not to be examples of the concept."

All groups. "When each stimulus appears on the screen here (Experimenter points to the opaque window), the blue light in the centre of the top of your panel will come on. You will have a few seconds to look at the stimulus, and decide which your response will be. Do not make your response until the blue light goes off. Once you have made your response, another slide will come up telling you what the correct response was." (At this point, for the two single-category conditions, the experimenter said, "if you should have pressed the button, the slide will show the name of the button. If you should have done nothing, the slide will be blank.") "This slide will stay on for a few seconds, and then the whole sequence of events will be repeated. Do you have any questions?" (Relevant portions of the instructions were paraphrased in response to questions.) "Now turn over the white card on your panel. On it are the names of the two relevant attributes. I will be in the next room for the duration of 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 experiment, the experimenter entered the room and said "On this piece of paper (distributes note paper) I want you to write down the rule, or method, or scheme you used to classify the stimuli." When all subjects had finished writing, the experimenter said "Check to see if you have mentioned both of the two relevant attributes. If not, please write a new rule incorporating them." Subjects were then told the purpose of the experiment, and thanked for their participation.

APPENDIX C

FOCUS CATEGORY FOR EACH SUBJECT AS DETERMINED FROM VERBAL STATEMENTS AND PROPORTIONS OF ERRORS IN THE POSITIVE AND NEGATIVE CATEGORIES

Rule

Label	S#	Cj Verb	Cj Err	Dj Verb	Dj Err	Cd Verb	Cd Err	Bd Verb	Bd Err
	1	P		P		N	N	N	N
	2	P	P	P	P	N	N	N	N
	3	P	P	P	B	B	N	N	P
Pos	4	P	P	P	N	N	N	N	N
	5	P		P	N	P	P	B	P
	6	P		B	N	N	N	P	P
	1	P		N		N	N	N	P
	2	P		N	P	N	P	N	B
	3	P	P	P	N	N	N	P	N
Neg	4	B	P	P	N	N	N	N	N
	5	P	B	N	P	N	N	N	N
	6	P		N	N	B	N	N	N
	1	P	N	P		P	N	P	P
	2	P		P	N	P	N	B	P
	3	P	P	P	N	N	N	B	N
Con	4	N	P	P		P	N	N	P
	5	P		P	N	P	N	P	N
	6	P	P	P	N	N	P	P	P

Rule

Label	S#	Cj Verb	Cj Err	Dj Verb	Dj Err	Cd Verb	Cd Err	Bd Verb	Bd Err
	1	P	P	P	B	N	N	B	N
	2	P	P	B	P	B	N	B	N
	3	P	P	P	N	B	N	B	N
Neu	4	P	P	P	N	B	N	B	N
	5	P	P	B	P	N	N	B	B
	6	N	P	P	P	N	B	B	N

Note. 1) Table entry P = Positive focus, N = negative focus, B = both focus.

2) Missing entries under error proportion headings are those subjects who made no errors.

APPENDIX D

TUKEY "A" MULTIPLE COMPARISONS OF CELL TOTALS FOR ERRORS TO CRITERION AND TRIAL OF LAST ERROR DATA

Errors to Criterion

Single Category Conditions
(critical value = 135.06; $p < .01$)

Total	Label	Rule
243	Pos	Cd
235	Neg	Cd
82	Pos	Bd
43	Neg	Bd
24	Pos	Dj
18	Neg	Cj
13	Neg	Dj
7	Pos	Cj

Double Category Condition
(critical value = 305.46; $p < .01$)

Total	Label	Rule
443	Con	Cd
370	Con	Bd
247	Neu	Bd
159	Neu	Dj
109	Neu	Cd
70	Neu	Cj
9	Con	Dj
8	Con	Cj

Pooled Single and Double Conditions
(critical value = 255.88; p < .01)

Total	Label	Rule
443	Con	Cd
370	Con	Bd
247	Neu	Bd
243	Pos	Cd
235	Neg	Cd
159	Neu	Dj
109	Neu	Cd
82	Pos	Bd
70	Neu	Cj
43	Neg	Bd
24	Pos	Dj
18	Neg	Cj
13	Neg	Dj
9	Con	Dj
8	Con	Cj
7	Pos	Cj

Trial of Last Error

Single-Category Condition
(critical value = 380.75; $p < .01$)

Total	Label	Rule
726	Pos	Cd
699	Neg	Cd
260	Pos	Bd
98	Neg	Bd
65	Neg	Cj
48	Pos	Cj
40	Pos	Dj
27	Neg	Dj

Double Category Conditions
(critical value = 651.74; $p < .01$)

Total	Label	Rule
781	Con	Cd
710	Con	Bd
629	Neu	Bd
489	Neu	Dj
320	Neu	Cd
233	Neu	Cj
49	Con	Cj
32	Con	Dj

Pooled Single and Double Conditions
(critical value = 578.29; $p < .01$)

Total	Label	Rule
781	Con	Cd
726	Pos	Cd
710	Con	Bd
699	Neg	Cd
629	Neu	Bd
489	Neu	Dj
320	Neu	Cd
260	Pos	Bd
233	Neu	Cj
98	Neg	Bd
65	Neg	Cj
49	Con	Cj
48	Pos	Cj
40	Pos	Dj
32	Con	Dj
27	Neg	Dj

APPENDIX E

SUBJECTS' VERBATIM AND TRANSFORMED

POSTACQUISITION VERBAL STATEMENTS

Positive-only Conjunction

S1 "Whenever a yellow triangle appeared I pressed the (positive) button."

Yellow and Triangle

S2 "It must be either 1, 2, or 3 yellow triangles."

Yellow and Triangle

S3 "All yellow triangles are positive, because the card corresponded to what was shown as positive on the screen."

Yellow and Triangle

S4 "I first found out which shape would give a positive result - I then learned not only which shape, but also which colour would result in a positive result.

Triangle and Yellow

S5 "Push pos. button if I saw either 1, 2, or 3 yellow triangles."

Yellow and Triangle

S6 "The rule I arrived at for classifying a stimulus was that there not be a triangle, either 1, 2, or 3 triangles but they must be yellow triangles."

Yellow and Triangle

Negative-only Conjunction

S1 "I was always looking for a blue star, if I saw anything else other than a blue star I pressed the negative button."

Blue and Star

S2 "The card said there must be 'star - blue'. I wasn't sure if both star and blue were necessary at first. I guessed correctly the first time, which clarified that both were necessary, by seeing if the correct answer was neg. or blank."

Blue and Star

S3 1) "at first related picture to correct answer"

2) "then found direct correlation between card -- saying "BLUE STAR" with correct response. - all blue stars needed no response."

Blue and Star

S4 " - if colour blue
- if object star — positive
- if colour yellow, red
- if object circle, triangle — negative

Pos - Blue and Star

Neg - Yellow or Red, and Circle or Triangle

S5 "Stimuli classified bu cue card. However, it was not until the first slide that it actually sunk in."

Blue and Star

S6 "Rule to use:

Whenever blue star came on, this was the same as my card (non-negative response). Therefore I did not push the negative button. However if an image came on which was unlike my specific card (star, blue), I waited for the light to go off, then I pushed the "negative" button."

Blue and Star

<u>Connotative Conjunction</u>

<u>S</u>1 "Memorized the card 'circle red' when one circle red appeared, I pushed positive; but first time I saw 2 circle reds; I pushed negative; but then I learned it was positive. So whenever I saw a red circle, no matter how many circles, I pushed positive."

Circle and Red

<u>S</u>2 "All red circles were positive the rest negative."

Red and Circle

<u>S</u>3 "If it was a red circle it was positive. Anything else was negative. 2 or more red circles was also positive."

Red and Circle

<u>S</u>4 "If the stimulus wasn't a red circle or circles it was negative."

Not Red and Circle.

<u>S</u>5 First criteria was the shape of the stimulus. If circular, then the criteria of colour was used.

If red and circular, then the stimulus fit the category - Positive."

Red and Circle

S6 "It had to be red and a circle."

"I don't know how it was neg. or positive once it was a circle and red. I saw no correlation except guessing."

"Became too boring and I could not concentrate."

Red and Circle

Neutral Conjunction

S1 "Any time that red triangle(s) appeared (in any proximity to each other), I classified them VEC.

Red and Triangle

S2 "Only red triangles, number not important placement not important, must be triangles, only red."

Red and Triangle

S3 " - 1st

- triangle Red - any position and any amount. XAD."

Triangle and Red

S4 "After making mistakes 2x I realized that only red triangle which corresponded with the card was XAD, everything else was VEC."

Red and Triangle

S5 "Red triangles indicated VEC no reference to position or number"

Red and Triangle

S6 "At first I was guessing and not really paying much attention, then the card you gave me was drawn to my attention and I pressed XAD for everything but red triangles."

(VEC -)

Not Red and Triangle

Positive-only Disjunction

S1 "If something was red then it was (pos) regardless of shape.

If something was circle then it was (pos) regardless of colour.".

Red or Circle

S2 "Choose anything that was red and all circles no matter what colour and no matter where were positioned and how many."

Red or Circle

S3 "The positive stimuli was everything that was either red or circles. i.e. circles of any colour or red figures of any shape."

Red or Circle

S4 "If the picture shown was either 1) red, any shape, 2) circle, any colour, 3) both, circle and red - then positive."

Red or Circle

S5 "Whenever I see red colour or circle shape I will consider it as a (positive) stimulus."

Red or Circle

S6 "Positive stimulus: any shape that made me think of either Red or Circle.

Negative stimulus: any shape that was not a circle

any colour that was not red."

Pos - Red or Circle

Neg - Not Red or not Circle

Negative-only Disjunction

S1 "If the stimulus wasn't a circle, or if it was a colour other than yellow, it was negative."

Not circle or not yellow

S2 1) "Blue/Red colours with shapes that have edges."

2) "Anything that was yellow, or was in the shape of a circle was not the stimulus. The stimulus had to be blue or red with edges."

Yellow or Circle

S3 1) "According to colour and shape. With yes no reaction to test."

2) "Remember yellow and circle."

Yellow and Circle

S4 "Any design that had a circle (regardless of colour) or the colour yellow in it, I chose as positive."

Circle or Yellow

S5 1) "Thought the stimulus was negative for anything blue or red and not a circle. At beginning of expt I was confused re what was wanted - I guess I sort of used process of elimination and tried to find out which attributes were negative and match them.

2) "Yellow and circle was positive."

Blue or red and not Circle

S6 "If the stimulus wasn't yellow or a circle, pressed button."

Not Yellow or not Circle

Connotative Disjunction

S1 "Shape and colour determined response. To pick of a shape that was a star and a colour that was red."

Star and Red

S2 "If something red was flashed I would press the (pos) button and if some star or stars were flashed I would press (pos) button."

Red or Star

S3 "Look for red colour of any design star of any colour."

Red or Star

S4 "If stimulus was red or star, it was positive otherwise negative."

Red or Star

S5 1) "colour and shape."

2) "red colour and/or the star dimension if either one showed up on the screen."

Red or Star

S6 "any dimension that was red or a star."

Red or Star

Neutral Disjunction

S1 "Anything that was blue, any shape, or a triangle, any colour, or both, was XAD.
Anything else was VEC."

Blue or Triangle

S2 "Single obj - VEC
blue triangle - XAD
sharp pointed obj - XAD
smooth edge - VEC."

no rule

S3 "If it was blue no matter what the shape or a triangle no matter what the colour it was XAD."

Blue or Triangle

S4 "If anything that came up blue, regardless of shape, or any triangle, regardless of colour was VEC. Any other stimulus, neither blue or a triangle, was XAD. Number of stimuli present made no difference."

Blue or Triangle

S5 All blues no matter what shape or number is VEC. All reds and yellows no matter what shape or number XAD with the exception of red and yellow triangles no matter how many were VEC."

Blue or (Red or Yellow and Triangle)

S6 "When the triangle appeared I pressed XAD at first but then concentrated on when it appeared, no other colour bothered me except the red star."

Triangle

Positive-only Conditional

S1 "Everything was positive except yellow triangles and circles no matter how many there were or their position on the slide."

Yellow and Triangle and Yellow and Circle

S2 "Yellow circles and yellow triangles had blank responses all the rest were positive."

Yellow and Circle and Yellow and Triangle

S3 "Yellow stars."

Yellow and Star

S4 1) "Checked colour, number and shape to judge if they were acceptable. Any number of yellow triangles or circles were not acceptable. It seemed that everything else was.

2) "Yellow and star were on the card. Yellow stars are positive while yellow triangles and yellow circles are not."

Yellow and Triangle and Yellow and Circle

S5 "Responses were made with stars present
responses were made with colour yellow present
responses were made when 3 items were present
other positive responses were made at random
the button was not suppressed when a single yellow circle was shown."

Star or Yellow on three

S6 1) "I can't really say I figured it out. It seemed that you could not positively relate stars and circles basically in certain numbers and colours.

2) "If there were three in the yellow in an other shape it was not positive."

Negative-only Conditional

S1 "Red, non-triangles were negative."

Red and not Triangle

S2 1) "Red balls, red stars, any combined pattern."

2) "No blue triangles."

Red and Circle, and Red and Star

S3 "all colours excepting red - no response.
all colours that were red but not a triangle -

negative.

when <u>one</u> triangle out of order - nothing no response they were triangles."

Red and not Triangle

<u>S4</u> 1) "There were never 2 negatives in a row. Every 6th, 4th, 2nd, 4th, 6th time was negative, maybe.

2) "The red triangle was never followed by a negative."

No rule

<u>S5</u> "All the red were negative except for one triangle alone or if they were or

Red and not alone and Triangle

<u>S6</u> "Red - triangles - single objects."

No rule

<u>Connotative Conditional</u>

<u>S1</u> "I only pushed positive button for slides showing red circle, which was on card in front of me. I did not use both attributes from card in front of me - red and circle."

Red and Circle

<u>S2</u> "If I saw a red circle - positive or if I saw a stimulus that was a circle or that was red was also positive.

"Stimulus that were shapes and colours other than circles and red were negative. Used both attributes given."

Red or Circle

S3 "Red was negative unless it was in the form of a circle. Any other colour and shape, including circles, was positive.

The number of objects didn't matter."

Red and not Circle

S4 "If stimulus did not meet criterion given, red circle, I classified it as positive - all else negative.

I ignored all 'right' answers given following each example.

The words red circle kept staring me in the face."

Red and Circle

S5 "Sets of three mostly positive, especially red circle.

Sets of two mostly positive.

Sets of 1 mostly positive with exceptions of the red triangles.

All red circles were positively reinforced."

Three or two or one and not (Red and Triangle)

S6 "Every colour or shape except red star the correct answer on board appeared positive.

Always positive.

Not (red and Star)

Neutral Conditional

S1 "Circles were never under XAD, only blue stars and triangles. Anything else, no matter how many or where appeared on slide, went under VEC category. These could be any amount of blue stars or blue triangles in the slide but still under XAD."

Blue and Star, or Blue and Triangle

S2 "All red and yellow geometric figures plus the blue circles were VEC. The blue triangles and stars were XAD."

Pos - Blue and Star, or Blue and Triangle

Neg - Red or Yellow or Blue and Circle

S3 "The stimuli ran in a basic pattern. VEC would always appear consecutively, more than once in a row. XAD only would appear once, then VEC would appear. XAD would never appear more than once in a row. I tried using this sequence, starting whenever a blue circle would appear. It seemed that this worked occasionally but I was frequently mixed up.

No rule

S4 "XAD. yellow, red stars and triangles circles, even blue to the left, or uneven in placement. Red circle.

VEC. blue, triangle, star in middle bottom or even in placement. Circle as well, yellow."

No rule

S5 1) "For everything but blue stars & blue triangles I pushed XAD button - for blue triangles and blue stars I pushed VEC button."

2) "For blue circles I pushed XAD button."

Blue and Triangle or Blue and Star

S6 "Blue triangles and stars or blue and non-circle."

Blue and not Circle

Positive-only Bi-conditional

S1 "Anything blue, other than a blue triangle - no response. A triangle, unless blue - no response."

Blue or Triangle (exclusively).

S2 "If it was blue or a triangle, did not press button, any other shape and/or colour - press. If it was blue and triangle - press button."

Blue and Triangle and not (Blue or Triangle)

S3 "All blue was negative except when they were triangles. All other colours were positive except when they were triangles."

Blue or Traingle (exclusively)

S4 "All of them except for triangle any colour or shape, is positive. Any blue colour except triangle is neg."

Blue or Traingle (exclusively)

S5 "All blue triangles - Pos
Red orange triangles - Neg
Blue stars - Neg
Red or orange stars - Pos
Orange and blue circles - Pos
Red circles - Neg."

No rule

S6 "It was a positive stimulus if it did not have any blue colour. It was a positive stimulus if it was not triangular in shape. It was positive if it was both blue and a triangle."

Not blue or not Triangle and Blue and Triangle

Negative-only Biconditional

S1 "Negatives - anything red but stars
- anything star shaped but not the red ones."

Red or Star (exclusively

S2 "I had red star so whenever the picture was a red object or a blue or orange star I pressed the negative button. Anything else I did not press the negative button. At first, I pressed negative for a red star but that is wrong."

Red or Star (exclusively)

S3 "The red star or any other image that isn't red is positive."

Red and Star, or not Red

S4 "Anything that was red and not a star was negative. A star that wasn't red was negative. Number made no difference."

S5 "Any red, any star, except red star, required negative response."

Red or Star (exclusively)

S6 "Push the button for any figure flashed on the screen that was red, but not a star; or for a figure that was star-shaped, but not red in colour."

Red or Star (exclusively)

Connotative Biconditional

S1 1) " - First impression - whatever seems right
- when tried to figure out relationship just became more confusing."

2) " - When something position wise could be shaped as a triangle positive.
- When other colours than yellow positive.

Triangle and not Yellow

S2 "I suddenly realized that the card you placed on my machine indicated the positive stimuli. All yellow triangles were positive. Everything else that had yellow was negative. All other colours besides yellow were positive."

Yellow and Triangle or not Yellow

S3 1) " - By colour - by number - by shape - by position

- by correlation of any above combinations - by elimination - by sequence of any above."

2) "by identifying number or sequence of yellow triangles."

No rule

S4 "Rules - all yellow stars and circles negative regardless of the number on the slide.
- all red and blue triangles negative regardless of the number on the slide presented.
- card with words yellow and triangle used at first but then discarded as irrelevant.
- number of imageson slide discarded as irrelevant."

Yellow and (Star or Circle), and Triangle and (Red or Blue)

S5 "The yellow triangle was always positive, but any other shape in yellow was negative. The other colours were all positive except the triangle shapes in those colours."

(Yellow and Triangle) or (not Yellow and not Triangle)

S6 "If another single shape appeared that was not a triangle and not yellow it was positive. Still was working on the sets of two's and three's."

One and (not Yellow and not Triangle)

Neutral Biconditional

S1 "For every yellow object or star shaped object you pushed XAD except in the case of any yellow stars where you pushed VEC along with any other objects which were neither yellow or stars."

Neg - Yellow or Star (exclusively)

Pos - Yellow and Star) and (not yellow and not Star)

S2 "XAD - All things yellow

- All things stars except yellow stars of any number

VEC - yellow stars of any number

- all things not yellow

- all things not stars except for previously mentioned yellow stars."

Neg - Yellow or Star (exclusively)

Pos - Yellow and Star and not Yellow and not Star

S3 1) "Colour, shape, placement. using no.

1 XAD button

2 or 3 VEC button."

2) "Yellow star was control, figure, symbol."

No rule

S4 "3 yellow stars were XAD, other stars were VEC, red, group of 2 or just 1 star. Yellow circles

VEC. Squares or triangles on left side of screen

XAD. Most figures were XAD.

No rule

S5 1) "Yellow circle - left

Red, blue circles - right"

2) "Yellow - left

Red and blue - right (Negative on left for this S)

No rule

S6 1) "3 of each VEC & XAD and then how long holding each button."

2) "thought there might be a change of button when a yellow star appeared."

No rule

APPENDIX F

ERRORS TO CRITERION AND TRIAL OF LAST ERROR FOR EACH SUBJECT AS A FUNCTION OF RULE AND LABELLING CONDITION

Rule

Label	S#	Cj Errors	Cj Trials	Dj Errors	Dj Trials	Cd Errors	Cd Trials	Bd Errors	Bd Trials
	1	0	0	0	0	24	68	21	39
	2	1	9	14	27	35	82	6	24
	3	3	15	6	7	53	162	14	52
Pos	4	3	24	1	1	30	95	13	42
	5	0	0	1	1	50	158	21	90
	6	0	0	2	4	51	161	7	13
	1	0	0	0	0	5	9	8	18
	2	0	0	4	7	28	120	8	14
	3	13	58	1	4	40	142	19	37
Neg	4	3	3	2	4	50	151	4	6
	5	2	4	5	8	37	115	3	22
	6	0	0	1	4	75	162	1	1

Rule

Label	S#	Cj Errors	Cj Trials	Dj Errors	Dj Trials	Cd Errors	Cd Trials	Bd Errors	Bd Trials
	1	1	15	0	0	108	162	80	161
	2	0	0	2	11	108	161	18	12
	3	1	3	2	8	46	86	84	162
Con	4	1	1	0	0	108	162	39	108
	5	0	0	3	9	59	158	47	105
	6	5	30	2	4	14	52	102	162
	1	6	9	44	84	8	17	10	40
	2	7	17	4	6	3	17	18	28
	3	8	17	46	150	66	159	66	157
Neu	4	2	4	3	17	21	85	59	160
	5	30	109	24	75	7	36	60	159
	6	17	77	38	157	4	6	34	85

REFERENCES

Battig, W. F., & Bourne, L. E. Jr. Concept identification as a function of intra- and interdimensional variation. Journal of Experimental Psychology, 1961, 61, 329-333.

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

Bourne, L. E. Jr. An inference model for conceptual rule learning. In Salso, R. L. (Ed.), Theories in Cognitive Psychology: The Loyola Symposium. Toronto: John Wiley & Sons, 1974.

Bourne, L. E. Jr., & Guy, D. E. Learning conceptual rules: 1. Some interrule transfer effects. Journal of Experimental Psychology, 1968a, 76, 423-429.

Bourne, L. E. Jr., & Guy, D. E. Learning conceptual rules: 11. The role of positive and negative instances. Journal of Experimental Psychology, 1968b, 77, 488-494.

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

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

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

Conant, M. B., & Trabasso, T. Conjunctive and disjunctive concept formation under equal information conditions. Journal of Experimental Psychology, 1964, 67, 250-255.

Dominowski, R. L., & Wetherick, N. E. Inference processes in conceptual rule learning. Journal of Experimental Psychology: Human Learning and Memory, 1976, 2, 1-10.

Giambra, L. M. Conditional and biconditional rule difficulty with attribute identification, rule learning, and complete learning task. Journal of Experimental Psychology, 1970, 86, 250-254.

Giambra, L. M. Labels for response categories: Do neutral labels make conjunctive and inclusive disjunctive concepts equally difficult. Psychological Reports, 1974, 35, 1155-1159.

Gottwald, R. L. Attribute-response correlations in concept attainment. American Journal of Psychology, 1971a, 84, 425-436.

Gottwald, R. L. Effects of response labels in concept attainment. Journal of Experimental Psychology, 1971b, 91, 30-33.

Gottwald, R. L., & Swaine, M. R. The relative difficulty of a subject-generated rule in an attribute identification task. Bulletin of the Psychonomic Society, 1974, 3, 21-22.

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

Haygood, R. C., & Devine, J. Effects of composition of the positive category on concept learning. Journal of Experimental Psychology, 1967, 74, 230-235.

Hays, W. L. Statistics. New York: Holt, Rinehart & Winston, 1963.

Hovland, C. I., & Weiss, W. I. Transmission of information concerning concepts through positive and negative instances. Journal of Experimental Psychology, 1953, 45, 175-182.

Neisser, U., & Weene, P. Hierarchies in concept attainment. Journal of Experimental Psychology, 1962, 64, 640-645.

Neumann, P. G. Effects of directional and neutral category labels in bidimensional rule-learning problems. Memory & Cognition, 1974, 2, 695-699.

Peters, K. G., & Denny, J. P. Labelling and memory effects on categorizing and hypothesizing behavior for biconditional and conditional conceptual rules. Journal of Experimental Psychology, 1971, 87, 229-233.

Reznick, J. S., & Richmann, C. L. Effects of class complexity, class frequency, and preexperimental bias on rule learning. Journal of Experimental Psychology: Human Learning and Memory, 1976, 2, 744-782.

Salatas, H., & Bourne, L. E. Learning conceptual rules: III. Processes contributing to rule difficulty. Memory & Cognition, 1974, 2, 549-553.

Sawyer, C. R. A Concept Learning Model. Unpublished doctoral dissertation, University of New Mexico, 1972.

Sawyer, C. R., & Johnson, P. Conditional and biconditional rule difficulty under selection and reception conditions. Journal of Experimental Psychology, 1971, 89, 424-426.

Seggie, J. L. Levels of learning involved in conjunctive and disjunctive concepts. Australian Journal of Psychology, 1969, 21, 325-333.

Sheperd, R. N., Hovland, C. I., & Jenkins, H. N. Learning and memorization of classification. Psychological Monographs, 1961, 75 (13, Whole No. 517).

Smoke, K. L. Negative instances in concept formation. Journal of Experimental Psychology, 1933, 16, 583-588.

Walker, C. M., & Bourne, L. E. Jr. Concept identification as a function of amounts of relevant and irrelevant information. American Journal of Psychology, 1961, 74, 410-417.

Winer, B. J. Statistical Principles in Experimental Design, New York: McGraw-Hill, 1962.

Winer, B. J. Statistical Principles in Experimental Design (2nd Ed.). New York: McGraw-Hill, 1971.

VITA AUCTORIS

Robert David Gates

1953 -	Born in Halifax, Nova Scotia to Archibald and Patricia Gates
1958 - 1971	Attended elementary and secondary schools in Halifax and Dartmouth, Nova Scotia
1975 -	Granted degree of Bachelor of Arts with Honours in Psychology from Carleton University, Ottawa, Ontario
1975 -	Registered as a full-time graduate student in Psychology, at the University of Windsor