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AN ABSTRACT OF THE THESIS OF Teresa Farley Kao for the Master of Science
in Psychology presented July 18, 1984.

Title: The Effect of Problem Complexity on the Efficiency of Intuitive
and Analytic Processes.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Dr. Barry F. Anderson, Chairman

Dr. Adriane M. Gaffuri

Dr. John A. Walker

Some investigators have suggested that when material becomes more
complex, an individual is forced to use an intuitive process, while
others suggest that increasing complexity forces analysis. This study

was an attempt to resolve this question by manipulating rate of presentation and instructions. No effect was found due to these manipulations or due to complexity. The reason is not clear, but may be due to a combination of factors which inclined the experiment in the direction of the intuitive process.

THE EFFECT OF PROBLEM COMPLEXITY ON THE EFFICIENCY OF
INTUITIVE AND ANALYTIC PROCESSES

by

TERESA FARLEY KAO

A thesis submitted in partial fulfillment of the
requirements for the degree of

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TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

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CHAPTER I

INTRODUCTION

DISTINCTION BETWEEN INTUITIVE AND ANALYTIC PROCESSES

Intuition is widely claimed to be an important mode of knowing. Discussions of intuition usually contrast it with analysis.

Bruner (1960) characterized intuitive thinking as not advancing in well-defined steps but tending to involve maneuvers based on an implicit perception of the total problem and arriving at the answer with little awareness of the process. Analytic thinking, in contrast, proceeds a step at a time and with relatively full awareness. Heidbreder (1946) described behavior which she calls "spectator behavior." In spectator behavior, a subject does not deal with individual attributes but develops an impression of what a positive instance looks like without stating a rule. This she contrasts with "participant" behavior, in which a subject guesses which are the correct attributes and tests the guesses against experience, with a strong tendency to believe there is an underlying rule.

Neisser (1963) compared holistic (intuitive) with sequential

(analytic) processes in the context of differences between human thought and artificial intelligence. Multiple (holistic) processing, found in humans but not characteristic of computers, asks all the questions at once. According to Neisser, it is effective in the face of ambiguous cues and is not seriously affected by internal errors. A sequential process, on the other hand, goes consecutively from one decision to another. It can go astray if a wrong decision is made and so is less effective in the face of error, as this increases the chances of a wrong decision. Hammond (1981) similarly described the intuitive process as responsive to many contemporaneous cues, working rapidly and unconsciously, substituting cues and strategies to produce solutions at least approximately correct. It is more likely to be employed when the cues are perceptual. Analytic task strategies are consciously executed and evaluated. Analysis is likely to occur when the cues are not perceptual, but symbolic (Hammond, 1981). Peters, Hammond, and Summers (1974) found that intuitive processes are likely to lead to small errors, while analytic processes are likely to lead either to no errors or to very large errors.

Hammond's (1981) analysis of intuition-inducing and analysis-inducing task conditions indicates that intuition is induced by tasks which are continuous rather than discrete, and where the subject measures the cue levels (as opposed to having the cue levels measured for him/her). In these terms, intuition is induced by complexity. Intuition is also induced by speeded tasks. This introduces a temporal measure of complexity.

PROBLEM COMPLEXITY AND PROCESSING MODE

This paper is concerned with a major disagreement in theory and data about the relative efficiency and effectiveness of the two processes. According to one point of view, when material is complicated and difficult to deal with, an individual is forced to proceed intuitively. According to the other, under these same circumstances, an individual must proceed analytically to make progress. Theories differ regarding what conditions lead to intuition or analysis, and under what circumstances intuitive or analytical processes are more effective.

A number of thinkers and investigators have suggested that when the material under consideration becomes very difficult to process, an individual turns to intuition. Reed (1946) found that when subjects attempted to learn a concept for classifying nonsense words, they reverted to rote memory in highly complex situations. Katona (1967) asserted that memorizing is resorted to under circumstances which are not suitable to understanding and in which organization reaches its limit. (There is presumably some overlap between rote memory and intuition, although the degree of this overlap is not established.)

Peterson and Beach (1967), in a review of literature comparing the performance of "intuitive man" with "statistical man," discuss evidence from different types of experiments where greater task complexity (more cues available) appears to lead to more nearly optimal performance by subjects. These are judgments of covariation between multivalent, as opposed to bivalent, variables and with multiple, as opposed to single, predictors.

According to de Groot (1965), chess masters simultaneously consider many facts, making continuous re-evaluations at greater depth in a given situation. They depend heavily on their own intuition to deal with the very complex situations in competition play or in playing many games simultaneously (Hearst, 1969). Newell and Simon's (1972) chess experts solved chess problems in much the same way. A "large number of patterns serve as an index to guide the expert in a fraction of a second to relevant parts of the knowledge store" (Larkin, McDermott, Simon and Simon, 1980).

Osler and Trautman (1961) found that in learning a simple concept (the number two), irrelevant stimulus dimensions such as color, shape, and other physical characteristics had no effect on the learning of subjects assumed to be using associative (intuitive) learning.

A second group of researchers has argued that, as the material under consideration becomes very difficult to process, an individual is forced to turn to analysis.

Rees and Israel (1935) found that only in short anagrams were subjects able to solve the anagrams all at once (holistically or intuitively). In longer anagrams, they were forced to analyze.

The very point of judgment and decision analysis is to improve performance by applying analysis to problems too complex for intuition.

The spirit of decomposition is to divide and conquer; decompose a complex problem into simpler problems, get one's thinking straight in these simpler problems [and] paste these analyses together with a logical glue. (Raiffa, 1968)

Some research indicates that decomposition does, indeed, improve judgment (Armstrong, Denniston, and Gordon, 1975; Gettys, Michel, Steiger, Kelley, and Petersen, 1973; Edwards, Phillips, Hays, and Goodman, 1968; Kaplan and Newman, 1966; Schum, Southard, and Wombolt, 1969).

Because the individuals on the two sides of this question were looking at very different materials and defining various aspects of their work in different ways, it is difficult to know how to bring their findings to bear on the question of whether intuition or analysis is better suited to processing very complex material, or what circumstances lead to using intuition or analysis successfully. An understanding of which process is more appropriate could lead to more effective performance in many areas.

"Complexity" has been variously defined in terms of (a) the number of variables, (b) the number of relevant variables, or (c) complexity of the logical statement relating the relevant variables. Many investigators mentioned that they look at the effects of various numbers of variables, but do not always distinguish whether they are relevant or irrelevant, or even specify the number of variables considered. One exception to this policy may be seen in the cases of Hull (1920) and Osler and Trautman (1961). Both studies considered complexity in terms of number of irrelevant variables. Hull (1920) found that the simpler stimuli (characters similar to Chinese ideographs), involving fewer irrelevant cues, produced much more efficient concept development than the complex ones, which contained more irrelevant material. Osler and

Trautman (1961), on the other hand found that irrelevant stimulus dimensions had no effect on those subjects assumed to be using associative learning.

The apparent contradiction between the findings of Hull (1920) and those of Osler and Trautman (1961) provides a convenient place to begin a comparison of intuitive and analytic processes: How does the number of irrelevant variables affect efficiency or effectiveness of learning in intuitive and analytic modes of processing?

This question will be explored in a comparison of the two processes, using visual stimuli. An attempt will be made to manipulate intuition and analysis by varying (a) rate of presentation (rapid vs. self-paced) and (b) instructions (learn to classify stimuli vs. discover a rule for classifying stimuli). This assumes that intuition is rapid (Hammond, 1981; de Groot, 1965; Larkin, McDermott, Simon and Simon, 1980; Neisser, 1963) without the need to learn a rule (Hammond, 1981; Heidbreder, 1946; Bruner, 1960) and that analysis is allowed when time and instructions allow for finding a rule (Peters, Hammond, and Summers, 1974; Hammond, 1981; Heidbreder, 1946; Neisser, 1963; Bruner, 1960). This would allow the same stimuli to be used in both processes, so that process effectiveness and efficiency might be accurately compared.

As a basis for this comparison, performance will be measured by the number of responses required to reach a predetermined criterion on learning. The criterion will be based on the ability to transfer learning to newly-presented stimuli.

In addition, the subject's confidence in each response will be

recorded. Bartlett (1958) suggests that subjects show overconfidence in intuition and underconfidence in analysis, while Hammond (1981) suggests that subjects show greater confidence in the process of analysis but greater confidence in the product of intuition. This measure reflects the subject's confidence in the product--his decision.

The subject's ability to verbalize the rule used to identify stimuli will also be recorded. Hammond (1981) asserts that verbal reports are accurate only when the task materials are consciously manipulated (as in analysis) and that otherwise, there is no structure for recall and the verbal report is less accurate. Asking subjects to verbalize their processes at different points also provides some information regarding their confidence in the process.

This study should provide answers to two questions:

1. Is it possible to produce intuitive and analytic learning by these procedures?
2. Assuming there is a difference between the intuitive condition and the analytic condition, what kind of effect does complexity, as defined here, have on intuitive and analytic learning processes?

CHAPTER II

METHODOLOGY

SUBJECTS

Subjects were 72 students, consisting of 39 females and 33 males, recruited from Introductory Psychology classes and offered course credit for participation.

DESIGN

Subjects were assigned randomly to two groups, 36 to an Analytic Learning condition (A) and 36 to an Intuitive Learning condition (I). Each group of 36 was randomly divided into three subgroups (12 per group). The three subgroups were presented with stimuli differing in the number of irrelevant variables. These stimuli were bar graphs with varying numbers of bars. The term "irrelevant variables" refers only to those bars irrelevant to the classification of the stimulus, not to other factors the subject might have considered in examining the stimuli. Each subject learned one of three possible tasks: one task (RI) consisted of learning stimuli with 1 relevant (first bar) and 1

irrelevant variable; one task (RII) consisted of learning stimuli with 1 relevant (middle bar) and 2 irrelevant variables; and one task (RIII) consisted of learning stimuli with 1 relevant (fourth bar) and 3 irrelevant variables.

The differences between the intuitive condition and the analytic condition were: (a) speed of presentation--Intuitive subjects had brief exposure to stimuli, while exposure to stimuli for Analytic subjects was self-paced; and (b) instructions--Intuitive subjects were asked to learn to classify stimuli, while Analytic subjects were asked to find a rule to classify stimuli.

Measures of interest were: (a) the learning curve as reflected by the proportion of correct responses, the number of different stimuli seen by the subject, and the total number of responses made; (b) confidence ratings, which reflected awareness of the correctness or incorrectness of the answer; and (c) the ability to verbalize the rule used to classify stimuli.

APPARATUS

An Ohio Scientific Challenger 2P computer and a monochrome CRT display were used to present stimuli. The program, written in BASIC, selected, randomized, and presented stimuli, in addition to keeping records of numbers of correct and incorrect responses and mean confidences for each.

Stimuli were formed from numbers representing the values 0, 1, 2, 3, and 4 for each variable, with all possible combinations present in a

set from which stimuli were randomly selected for presentation to the subject. Numbers from the set were converted into bar heights on a bar graph. A stimulus was classified by the program as low ("L") or high ("H") according to a specific rule: "L" was a value of 2 or less for the relevant variable (less than half the total possible height for a bar), and "H" was a value of 3 or more for the relevant variable (more than half the total possible height for a bar). Stimuli were centered on a CRT 7-1/2 inches high and 9-3/4 inches wide. Presented in a frame, two-bar graphs were 3-1/2 inches high and 1-7/8 inches wide; three-bar graphs were 3-1/2 inches high and 2-1/2 inches wide; and four-bar graphs were 3-1/2 inches high and 3-1/8 inches wide. Bars within the graph were 1/2 inch wide with heights varying from 1/4 inch to 2 inches, with an increment of 1/4 inch between the lowest and the next to lowest height, followed by increments of 1/2 inch. Each subject was seated approximately 22 inches from the display. Each subject's answer, confidence rating, and the correct answer were displayed, when appropriate, on the bottom four lines of the screen.

PROCEDURE

The experiment took place in a room with only the experimenter and the subject present. The computer keyboard and the display were on separate tables, with the experimenter seated in front of the computer keyboard and the subject seated in front of the display. The subject was given instructions appropriate for his/her learning mode, I or A. The experimenter entered the subject's assigned ID number, which enabled

the computer to identify the appropriate presentation procedure to follow for that subject.

Instructions for the Analytic subject:

This is a learning experiment. You will be looking at pictures that resemble bar graphs. Each picture is called Low or High. Your task is to learn what each picture is called. As you learn, new examples will be added to the ones you have already learned.

There is a rule which determines in which category, Low or High, a picture belongs. In order to make learning easier, try to determine the rule which will enable you to place pictures in their correct category. Each picture will remain on the screen for as long as you wish--that is until you give your answer.

I'll give you two hints to help you. (1) If all the bars are high, the stimulus is a "High," and if all the bars are low, the stimulus is a "Low." (2) The order or sequence in which the stimuli appear is unimportant.

Instructions for the Intuitive subject:

This is a learning experiment. You will be looking at pictures that resemble bar graphs. Each picture is called Low or High. Your task is to learn what each picture is called. As you learn, new examples will be added to the ones you have

already learned.

Each picture will be shown for a brief period of time before the screen clears. You will then be asked what that picture is called (Low or High).

I'll give you two hints to help you. (1) If all the bars are high, the stimulus is a "High," and if all the bars are low, the stimulus is a "Low." (2) The order or sequence in which the stimuli appear is unimportant.

Subjects first learned a practice set of one-bar stimuli consisting of two runs through all five possible graphs in the same preselected order for all subjects (total: 10 stimuli). These stimuli were called "L" and "H" according to the same rule used in the main task. These subjects also gave confidence ratings so that they became comfortable with the procedure. These subjects were then shown two samples of the graphs they would be learning (depending on which task condition they were randomly assigned to: RI, RII, or RIII). Each sample remained on the screen until the experimenter said the correct answer. At this point, the subject was not required to make any response. The two samples were preselected and presented in the same order for all subjects in that task condition. One consisted of all low bars, and the other of all high bars.

Each subject, whether I or A, was read the following instructions after his/her first classification response:

Now, I would like you to tell me how likely you think it is

that your answer is correct. What I would like you to give me is an answer between 50% and 100%. If you were just guessing, you should say "50%," because you can be right half the time by guessing. If you were sure you were right, you should say "100%." If your confidence is somewhere between these two extremes, you should give an intermediate percentage. I will be asking you for such a confidence rating after each response.

The intuitive subject saw a stimulus for .75 second. The screen cleared, and the subject was asked to state an answer ("H" or "L") and a confidence rating. The correct answer was then displayed below the subject's responses on an otherwise blank screen. For the Analytic subject, each stimulus remained on the screen until the subject gave his/her answer and confidence rating. For all subjects (I and A), the correct answer remained for 1 second before the screen cleared. At regular points in the stimulus sequence, the subject was asked "What can you tell me about 'High' and 'Low'?" The question was indicated on the display by the words "High and Low?" The subject's responses were recorded by the experimenter for later examination. These explanations provided the data to determine whether a subject realized at any point which bars were relevant and irrelevant, and to what extent the subject was testing different rules to learn, to what point the rules (if any) were correct, whether the subject was describing visual relationships between bars or between bars and the frame, or whether the subject said he/she was guessing.

In RI, RII, and RIII groups, both I and A subjects learned stimuli in a part-list/whole-list alternation. At first, three stimuli were learned to a criterion of one correct response for each. Then five new stimuli were learned to the same criterion. Next, all eight stimuli were re-presented until a criterion of one correct response each had been reached. Following that, five new stimuli were learned to criterion. Finally, all thirteen stimuli were re-presented until criterion had been reached. This alternation of five new stimuli and review of the whole list of stimuli seen so far continued until (a) the subject correctly identified five stimuli the first time they were seen, at which point the words "Learning Completed" appeared on the screen, or (b) 15 minutes had elapsed, at which point the experiment was arbitrarily terminated.

The subject was then thanked for participation and was free to leave. The maximum time for a subject was 30 minutes.

CHAPTER III

RESULTS

PRACTICE TASK

On the 10 stimuli in the practice task, performance was uniformly high. Twenty-eight subjects gave 0 incorrect responses, 28 subjects gave 1 incorrect response, and 16 subjects gave 2 incorrect responses.

Confidence ratings in the practice runs were generally high for correct and low for incorrect responses. Two subjects gave ratings in the 50% to 75% range, and 70 subjects gave ratings in the 76% to 100% range for correct answers. Thirty-six subjects gave ratings in the 50% to 75% range, and 8 subjects gave ratings in the 75% to 100% range for incorrect responses. This excludes those 28 subjects who made no incorrect responses.

MAIN TASK

Three sets of analyses were performed on the data from the main task. The first set considered performance. An analysis of variance (ANOVA) was performed on the proportion of correct responses, the

dependent variable of principal interest. In addition, a multivariate analysis of variance (MANOVA) was performed on the proportion of correct responses, the number of different stimuli learned, and the total number of responses. Each of these analyses was performed separately on (a) all subjects and (b) those subjects who reached criterion. Table I shows the mean proportion of correct responses for all subjects, and Table II shows the ANOVA of these data. Tables III and IV show the mean number of different stimuli learned for each group and the mean total responses of subjects in each group, respectively. Table V shows the numbers of subjects reaching criterion, and Tables VI and VII show the mean proportion of correct responses for subjects reaching criterion and the ANOVA of these data.

The second set of analyses considered confidence ratings. A MANOVA was performed on overall confidence and confidence on correct minus confidence on incorrect responses. Table VIII shows confidence ratings on correct and incorrect responses.

The third set of analyses considered strategy. Each subject was classified in terms of (a) ability to verbalize the correct rule (Table IX) and (b) extent of hypothesis testing (Table X). Finally, the covariation between ability to verbalize the correct rule and extent of hypothesis testing was assessed.

Analysis of Performance

Analysis of the data from the main task was performed by means of MANOVA's (Statistical Package for the Social Sciences, Release 7-9, Hull and Nie, 1981). According to Cochran's and Bartlett's tests, there was

no significant departure from homogeneity of variance in these data. Inspection of normal and detrended normal plots of the data showed no departure from reality.

TABLE I
MEAN PROPORTION OF CORRECT RESPONSES (WITH STANDARD DEVIATIONS)
FOR ALL SUBJECTS

	2 variables	3 variables	4 variables
Intuitive	.81 (.10)	.74 (.16)	.78 (.10)
Analytic	.80 (.14)	.76 (.11)	.75 (.10)

overall mean = .77, SD = .03

The accompanying ANOVA shows no significant main effect of intuitive and analytic conditions or of number of irrelevant variables, or any interaction between intuitive and analytic conditions and the number of irrelevant variables.

TABLE II
ANOVA ON PROPORTION OF CORRECT RESPONSES
FOR ALL SUBJECTS

Source	SS	<u>df</u>	<u>ms</u>	<u>F</u>	<u>p</u>
Total	1.028	71			
Within Cells	.976	66	.015		
Intuitive/Analytic	.001	1	.001	.045	.83
No. Variables, 1st Deriv	.020	1	.020	1.352	.25
No. Variables, 2nd Deriv	.020	1	.020	1.352	.25
I/A x Var, 1st Deriv	.002	1	.002	.143	.71
I/A x Var, 2nd Deriv	.009	1	.009	.577	.45

TABLE III
MEAN NUMBER OF DIFFERENT STIMULI LEARNED

	2 variables	3 variables	4 variables
Intuitive	17	13	13
Analytic	13	13	11

TABLE IV
MEAN NUMBER OF RESPONSES

	2 variables	3 variables	4 variables
Intuitive	52	40	39
Analytic	38	38	29

A MANOVA considering all subjects, their proportion of correct responses, number of stimuli learned, and number of responses using Pillais', Hotellings', Wilks', and Roys' tests (Hull and Nie, 1981, pp. 32-33) produced no significant main effect due to intuitive and analytic conditions, due to number of irrelevant variables, or due to any interaction between intuitive and analytic conditions and number of irrelevant variables.

Fifty-six percent of the total subjects reached the learning criterion.

TABLE V
NUMBERS OF SUBJECTS REACHING CRITERION

	2 variables	3 variables	4 variables
Intuitive	7	7	6
Analytic	7	7	6

TABLE VI
MEAN PROPORTION OF CORRECT RESPONSES (WITH STANDARD DEVIATIONS)
FOR SUBJECTS REACHING CRITERION

	2 variables	3 variables	4 variables
Intuitive	.85 (.08)	.84 (.09)	.83 (.11)
Analytic	.87 (.14)	.80 (.11)	.80 (.12)

The weighted mean across levels of complexity for learning of those subjects who reached criterion (excluding the 5 correct criterion responses) is 71% for Intuitives and 68% for Analytics.

The accompanying ANOVA, limited to subjects reaching criterion, shows no significant main effect of intuitive and analytic conditions, or of number of irrelevant variables, or of any interaction between intuitive and analytic conditions and the number of irrelevant variables.

TABLE VII
ANOVA ON PROPORTION OF CORRECT RESPONSES
FOR SUBJECTS REACHING CRITERION

Source	SS	<u>df</u>	<u>ms</u>	<u>F</u>	<u>p</u>
Total	.455	39			
Within Cells	.428	34	.013		
Intuitive/Analytic	.003	1	.003	.209	.65
No. Variables, 1st Deriv	.016	1	.016	1.239	.27
No. Variables, 2nd Deriv	.002	1	.002	.150	.70
I/A x Var, 1st Deriv	.003	1	.003	.223	.64
I/A x Var, 2nd Deriv	.003	1	.003	.198	.66

A MANOVA of the same measures as the earlier MANOVA, but limited to subjects reaching criterion, produced no significant main effects due to intuitive and analytic conditions, or due to number of irrelevant variables, or to any interaction between intuitive and analytic

conditions and the number of irrelevant variables (using the tests of Pillais, et al).

Analysis of Confidence

Confidence ratings produced an overall mean of 78%, SD = 12%. Confidence in correct answers showed a mean difference of only 11% from confidence in incorrect responses, with SD = 9%. This was calculated excluding the 6 cases where no incorrect responses were made (no confidence rating given) and 1 case where the correct confidence rating was lost due to experimenter error. For subjects reaching criterion only, mean confidence for correct responses was 86% for Intuitives and 82% for Analytics, with incorrect responses generating mean confidences of 72% for Intuitives and 75% for Analytics. The following table shows ranges of confidence expressed by subjects.

TABLE VIII
DISTRIBUTION OF CONFIDENCE RATINGS

	Intuitive	Analytic
Correct Responses		
50% - 75% rating	4	10
76% - 100% rating	31	26
Incorrect Responses		
50% - 75% rating	16	20
76% - 100% rating	17	13

A MANOVA was performed on (a) overall confidence and (b) confidence on correct minus confidence on incorrect responses for all subjects in all conditions to see whether differences were present in this measure, as no differences were found between the groups with other response measures. Tests by Pillais, et al produced no significant differences between intuitive and analytic confidence ratings due to the number of irrelevant variables or due to any interactions between intuitive and analytic conditions and the number of irrelevant variables.

Analysis of Strategy

When subjects were asked to articulate what they knew about the stimuli, to identify the rule, or to verbalize the rule, an accurate response was considered to be a correct specification of the relevant and irrelevant variables of the stimuli. Twenty-four percent of the subjects correctly identified the rule. An additional 11% identified a locally correct rule which specified the relevance or irrelevance of each variable which was consistent with the feedback they received before reaching criterion, but which was not general enough to cover all possible stimuli. This was verified by checking their rule with the stimuli they identified to reach the learning criterion. Thirty-five percent of the subjects identified a correct or locally correct rule.

Approximately twice as many subjects (47) are clearly nonverbalizers (did not identify a workable rule) as are verbalizers (25 identified a generally correct or locally correct rule). Of the subjects who reached criterion, 60% of the Intuitive and 45% of the Analytic subjects identified a generally or locally correct rule. The

weighted mean across levels of complexity for the proportion of those subjects who reached criterion and were able to correctly identify the rule is 70% for Intuitives and 55% for Analytics.

TABLE IX
ABILITY TO VERBALIZE A CORRECT RULE

	2 variables	3 variables	4 variables
Intuitive			
Correct Rule	5	1	4
Locally Correct Rule	1	2	1
Analytic			
Correct Rule	3	3	1
Locally Correct Rule	2	0	2

Hypothesis testing was performed by most subjects, regardless of group. A subject was judged to be testing hypotheses if more than one rule was used while learning. All subjects could be divided into four groups in this regard: subjects who tested more than one hypothesis (abandoning an incorrect rule and testing a different one); subjects who used one basic rule but made adjustments to it so it would "work" with the stimuli; subjects who reached criterion with one rule only (made no mention of using any other); and subjects who retained one rule even though it was recognized as incorrect or who had no rule and "guessed."

Subjects who reached criterion with one hypothesis cannot be clearly determined to have tested hypotheses. Approximately three times

as many subjects are clearly hypothesis testing (47) as are clearly not hypothesis testing (14). Of subjects reaching criterion, 45% of Intuitive and 38% of Analytic subjects clearly tested hypotheses. Eighty-two percent of the subjects who reached criterion also tested hypotheses.

TABLE X
EXTENT OF HYPOTHESIS TESTING

	Different Rules	Adjusted One Rule	One Rule to Criterion	One Incorrect or No Rule
Intuitive	16	7	5	8
Analytic	20	4	6	6

A chi-square test was performed to determine whether there was a relationship between hypothesis testing and identification of the correct rule. Subjects were cross-classified in terms of (a) whether they tested hypotheses and (b) whether they were able to verbalize a rule. The 47 subjects who tested hypotheses were classified as 11 verbalizers and 36 nonverbalizers. Similarly, the 14 subjects who did not test hypotheses were classified as 0 verbalizers and 14 nonverbalizers. Subjects who reached criterion with one hypothesis and a generally or locally correct rule were excluded from this analysis, as it could not be determined whether they were or were not testing hypotheses. Using Yates' correction for continuity to correct for two low cell frequencies (Fisher, 1970), $\chi^2(1) = 2.57$, which indicates that

no significant relationship exists between hypothesis testing and the ability to identify the correct rule.

CHAPTER IV

DISCUSSION

1. Did the experimental manipulation produce intuitive and analytic learning?

Four measures considering only subjects who reached the learning criterion demonstrate similar performance in the two conditions:

- Both Intuitives and Analytics verbalized (the rule) equally well (70% and 55%).
- Learning in both conditions produced the same learning curves as shown by the precriterion proportion of correct responses (71% and 68%).
- Both Intuitives and Analytics tested hypotheses to the same extent (45% and 38%).
- Confidence in responses was the same for Intuitives as for Analytics (86% and 82% for correct responses and 72% and 75% for incorrect responses).

On these bases, it appears that the experimental manipulation failed to produce different modes of learning.

2. What are the effects of complexity on intuitive and analytic learning?

This question cannot be answered because there was no intuitive-analytic difference found. Complexity evidently had no effect on learning.

It was expected that the more rapidly-paced condition would induce intuitive learning. The notion that intuition is rapid (Hammond, 1981) also seems to be present in the studies of experts' chess performance (de Groot, 1965; Newell and Simon, 1972; Larkin, McDermott, Simon and Simon, 1980). A rapid pace was also hoped to present material in such a way that simultaneous processing would occur (Neisser, 1963). Self-paced presentation was thought to allow the subject more control over the task materials, which would allow analytic learning (Hammond, 1981). It would also promote sequential processing which would facilitate analytic learning (Neisser, 1963; Bruner, 1960). Giving instructions which asked the subject only to learn the stimuli was thought to facilitate intuitive learning so that subjects would gather information without trying to organize it or without having time to do so due to the rapid pace of presentation (Hammond, 1981; Heidbreder, 1946; Bruner, 1960). Instructions to find the rule as well as to learn the stimuli were expected to encourage analytic learning, as subjects in this condition used a step-by-step approach to be fully aware of and to organize the material (Peters, Hammond, and Summers, 1974; Hammond, 1981; Bruner, 1960; Heidbreder, 1946).

The two major findings suggest that learning in this experiment was

accomplished by essentially intuitive processes: (a) rate of presentation did not interact with the number of irrelevant variables in affecting the number of subjects who reached criterion, and (b) rate of presentation had no effect on the proportion of correct responses for those subjects who reached criterion (a measure of rate of learning). Consistent with this conclusion is the fact that most (65%) of those subjects who reached criterion were unable to verbalize the rule. While the fact that most (82%) of the subjects who reached criterion tested hypotheses does not support this interpretation, it may not be inconsistent with it. It may be possible for intuitive learning to go on concurrently with hypothesis testing.

A number of factors may have combined to tip the experiment in favor of intuitive processes. First, the stimuli were perceptual rather than symbolic. Second, the whole list/part list alternation may have (as intended) induced a substantial intuitive familiarity with individual stimuli. And third, the confidence rating task may have reduced the capacity available for analytic processing.

It would be possible to test the importance of the perceptual nature of the stimuli by changing to the number equivalents of the bars instead of showing bar graphs. If the visual qualities of the bar graphs are producing the intuitive component of learning in this experiment (or simply making analytic learning more difficult), having only numbers should allow the analytic subjects to perform much more effectively than the intuitive ones.

It would be possible to improve the sensitivity of the experimental

design by yoking subjects on the basis of stimulus sequence, thus eliminating random variation due to stimulus and stimulus-sequence difficulty.

It would be possible to improve learning in the following ways:

(a) by eliminating some blind alleys for subjects through more extensive instructions; (b) by eliminating confidence ratings, as they are distracting and provide an interruption between the response given and the feedback; (c) by limiting the length of the review list to 5 randomly selected stimuli because when the subject has learned a number of stimuli, the review list becomes so long that it limits the number of new stimuli introduced; and (d) by having a two- or three-task session, as pilot studies suggested the presence of a practice effect which was evidently not produced by the very simple practice stimuli in this experiment.

Though learning could be improved, there is nothing in the results of this experiment to indicate that improved learning would produce any differences between the intuitive and analytic groups. ANOVA's and MANOVA's of subjects in this experiment showed no significant effects or interactions for subjects who did reach criterion. Without these, it seems unlikely that complexity would have any more effect on improved learning than it did in this present procedure.

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