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CUES THAT ELICIT ANALYTIC-DEDUCTIVE METHODS IN CONCEPT ATTAINMENT*

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In inference concept attainment some subjects draw conclusions about concepts (global-hypothesis method) and some subjects draw conclusions about the relevance or irrelevance of dimensions (analytic-deductive method). Experiments were performed to determine whether the presence or absence of certain cues accompanying inference concept attainment problems would affect the incidence of analytic-deductive methods in these problems. Two such cues were identified. One effective cue was a series of three 'informational-analysis' questions which asked the subject what information he had, whether he had enough information to guess the concept, and, if not, what information he needed. The other effective cue was the introduction of multiple-choice answers using only analytic-deductive terms like 'relevant' and 'irrelevant', but permitting both global-hypothesis conclusions and analytic-deductive conclusions to be drawn using these terms. Both of the cues that elicited analytic-deductive conclusions to inference problems produced positive transfer to a selection concept attainment problem in which totally different responses were required.

I. INTRODUCTION

In an *inference* concept attainment problem subjects are given some examples and perhaps some non-examples of a concept. From this information they may be asked to determine the concept or to draw whatever conclusions they can about the concept. In a *selection* concept attainment problem, subjects are usually given one example of a concept. They are then permitted to select other instances and ask whether these instances are examples or non-examples. In this way they are to determine the concept as soon as possible.

The present experiment is concerned only with concepts that are *conjunctive* in form. The term 'conjunctive concept' will be used to refer to both *simple* and *and* concepts. Examples of a *simple* concept must meet one requirement (for example, red colour). Examples of an *and* concept must meet two or more requirements (for example, red colour and square shape). Subjects are instructed to assume that all concepts are conjunctive in form.

The instances in the present experiment are always six-place numbers. The dimensions of an instance are the six places of the number, and there are ten possible values for each dimension. Subjects are told what the dimensions and values are.

When the dimensions of the instances and the form of the concept are known, there are several possible methods for solving concept attainment problems. The methods can be categorized in two principal ways. First, does the method attack the problem as a whole (global method) or break up the problem into subproblems (analytic method)? A global approach to a concept attainment problem means trying to determine the concept. An analytic approach to a concept attainment problem means trying to determine the relevance or irrelevance of dimensions. Secondly, does

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the method involve formulating hypotheses that are consistent with the information, but not logically implied by the information (hypothesis method) or does the method involve only logical deductions from the information (deductive method)? This analytic scheme yields four types of problem solving methods for concept attainment: global-hypothesis, global-deductive, analytic-hypothesis, and analytic-deductive methods.

These four types of methods are slightly different from the concept attainment strategies suggested by Bruner, Goodnow & Austin (1956), but the relationship is close. These authors suggested two types of strategies for inference concept attainment problems: wholist and partist strategies. As Bruner *et al.* defined these strategies, both of them would be global-hypothesis methods since they both involve formulating hypotheses about the entire concept. These two strategies for inference concept attainment are clearly inadequate because they do not include any strategy that determines relevant dimensions from the information. Even in an experiment where subjects were forced to formulate hypotheses about the concept on each trial, Bruner *et al.* reported only a little better than 50 % adherence to the rules of the strategy a subject was classified as using.

Bruner *et al.* suggested four strategies for selection concept attainment problems: *simultaneous scanning*, *successive scanning*, *conservative focusing*, and *focus gambling*. *Simultaneous scanning* is a global-deductive method: (1) because information is used to eliminate concepts, not to determine the relevance of dimensions, and (2) because only logical deductions are made from the information. *Successive scanning* is a global-hypothesis method because information is used to generate and test hypotheses about the concept that are consistent with the information, but not implied by it. *Conservative focusing* and *focus gambling* are both analytic-deductive methods because information is used to make deductions about the relevance or irrelevance of dimensions. If a subject formulates hypotheses about the relevance or irrelevance of particular dimensions (these hypotheses being consistent with the information, but not implied by it), then the subject is using an analytic-hypothesis method.

Bruner *et al.* report no use of global-deductive methods or analytic-hypothesis methods in their experiments on concept attainment. Subjects used only global-hypothesis methods or analytic-deductive methods. Very little is known about the variables that determine the relative frequency of global-hypothesis methods as against analytic-deductive methods in concept attainment problems. For selection problems Bruner *et al.* report that presenting all possible instances in a *regular* array (adjacent instances differing in one or a few dimensions only) produces more use of analytic-deductive methods than does presenting the instances in a *random* array. Bruner *et al.* report also that *abstract* materials (geometric figures with different colour, shape, number of figures, etc.) produce more use of analytic-deductive methods than do *thematic* materials (human figures with different sex, dress, facial expressions, etc.). Both of these findings are open to alternative interpretations (Wickelgren, 1962).

Many further distinctions can be made between different global-hypothesis or analytic-deductive methods for concept attainment, but these distinctions are not relevant to the following experiment. The primary purpose of the following experiment is to determine some of the variables that influence the relative frequency of analytic-deductive methods as against global-hypothesis methods in concept attainment. Two variables were selected for investigation, both involving transfer from different conditions of prior training.

One type of training, called informational-analysis training, was designed to provide the cue that the information in a concept attainment problem should be divided into two categories. The two categories were: (1) the information about the concept that was possessed by the subject after reading the problem, and (2) the information about the concept that was still needed by the subject to solve for the concept after reading the problem.

The other type of training, called multiple-choice training, involved forcing the subject to select one or more multiple-choice answers to a concept attainment problem. The multiple-choice answers all used the analytic-deductive terms 'relevant' and 'irrelevant', but it was quite possible to draw an analytic-hypothesis conclusion about the concept by specifying the relevance or irrelevance of every dimension.

The effect of these two types of training on the frequency of analytic-deductive as against global-hypothesis conclusions was determined by comparison with various control groups receiving different types of training. The concept attainment problems used in this experiment were 'binary inference problems' in which two examples or one example and one non-example of a concept were presented and subjects were asked to draw conclusions from the information, using a restricted language that permitted both global-hypothesis conclusions about the concept and analytic-deductive conclusions about the relevance or irrelevance of dimensions. The information presented in the binary inference problems was always *insufficient* to determine one and only one concept.

Transfer from the informational-analysis training to the multiple-choice training was investigated, and also transfer from inference problems to selection problems.

II. Method

(*a*) *Procedure*

The instances employed in the experiment were six-place decimal numbers. The dimensions were the six places of the number, and there were ten possible values for each dimension. Subjects received complete instruction on this matter.

The test problems were binary inference problems that differed in one or two places. Thus, there were four different types of binary inference problems: two examples that differed in one place ($2EC_1$), two examples that differed in two places ($2EC_2$), one example and one non-example that differed in one place ($EC\text{–}NEC_1$), and one example and one non-example that differed in two places ($EC\text{–}NEC_2$). In the test problems, a subject was merely directed to draw conclusions from the information. He was not told what sort of conclusions to draw, being left to formulate the proper questions to ask of this information and the proper answers to the questions he asked.

To ensure unambiguous verbal reports, subjects were required to construct all their answers from the terms of a *limited response language*. The language was developed by reference to previous research on concept attainment and by pretesting which used intuition, thinking aloud, and extensive probing to determine the sort of concepts of which subjects make frequent use. The response language was explicitly taught in a 'teaching machine program' by requiring a subject to solve problems in the correct use of each of the terms. This provided a rigorous behavioural criterion for the assertion that subjects knew the meaning of each term in the language. Inasmuch as the number of possible statements that can be constructed from this relatively limited, well-defined vocabulary is extremely large, we gain many of the advantages of constructed response while avoiding ambiguity in interpretation of statements. No assertion is made that the nature of the vocabulary and the nature of the vocabulary training have no effect on the conclusions drawn in binary inference problems. However, these effects are constant in this experiment and open to investigation in other experiments by manipulating the vocabulary or the vocabulary training.

This vocabulary was as follows:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9
P1, P2, P3, P4, P5, P6 = Place 1, ..., Place 6
And, And/Or, Or, is, are, in, if, then, whether

C = Concept	NC = Not concept
EC = Example of concept	NEC = Not example of concept
PC = Part of concept	NPC = Not part of concept
Rel = Relevant to concept	Irr = Irrelevant to concept

A binary inference problem looked like this:

The following are an example and a non-example of a Simple or And concept: 7 4 0 5 9 1 is EC. 7 4 0 5 3 1 is NEC. Your conclusions are?

An informational-analysis problem looked like this:

7 4 0 5 9 1 is EC. 7 4 0 5 3 1 is NEC. (For a Simple or And C.) What information do you have? Do you have enough information to guess C? (If you said yes) What is C? (If you said no) What information do you need?

Feedback was provided for only the second question; subjects were told they did not have enough information to guess the concept. This had the effect of forcing them to analyse information into two categories, without ever suggesting the appropriate way to do it.

A multiple-choice problem looked like this:

7 4 0 5 9 1 is EC. 7 4 0 5 3 1 is NEC. (For a Simple or And C.) Choose *one or more* of the following statements as correct logical inferences to be made on the above information: P5 is Rel. P1, P2, P3, P4, and P6 are Rel. P5 is Irr. P1, P2, P3, P4, and P6 are Irr.

All subjects received extensive language training in the meaning of C, EC, NEC, Pi, j in Pi, And, Or, And/Or, PC, NPC, Rel, and Irr. In addition, all subjects were given two ordinary inference concept attainment problems *without answers*. The ordinary inference problems presented examples and non-examples in sufficient number to determine the concept uniquely. Then all subjects were given the first test of the four binary inference problems. All 'tests' of the binary inference problems presented the four problems, once each. Following the first test of the binary inference problems, subjects assigned to six different groups received different problems. Three of the groups then received eight informational-analysis problems. The other three groups served as various control groups for the effects of the informational-analysis problems.

The *informational-analysis spontaneous-thinking control group* received 36 filler problems on the meaning of C, EC and NEC. These language instruction problems had previously been presented and were well learned. An already well-learned task was selected as most likely to give subjects opportunity for whatever spontaneous thinking about the test problems might occur. Any test-retest improvement is also measured by this control group.

The *informational-analysis problem-familiarization control group* received the eight binary inference problems given in the informational-analysis problems, in test form without the additional informational-analysis questions. This group was designed to determine what learning of analytic-deductive conclusions occurs as a result of doing a series of binary inference problems.

The *informational-analysis concept-guessing-denial control group* received the eight binary inference problems accompanied only by the question, 'Do you have enough information to guess the concept?' Feedback was provided for this question as in the informational-analysis problems. This group was designed to determine whether denying the global-hypothesis method of concept guessing was sufficient to reduce the frequency of global-hypothesis conclusions and increase the frequency of analytic-deductive conclusions.

Following the informational-analysis problems or the informational-analysis control problems, all three informational-analysis control groups and one of the three informational-analysis experimental groups were given 12 multiple-choice binary inference problems, the alternative answers being restricted to conclusions about the relevance and irrelevance of dimensions. A subject had to choose an answer in the analytic-deductive language, but he might draw a conclusion not justified by the information in the same manner that a guess of the concept is not justified by the information in a binary inference problem. That is, a subject might draw a conclusion about the relevance of all places just as one does implicitly in guessing a concept. The informational-analysis experimental group that received the multiple-choice problems is called the *experimental group*.

One of the remaining two informational-analysis experimental groups became the *multiple-choice spontaneous-thinking control group* receiving 12 filler problems on the meaning of C, EC and NEC, instead of the multiple-choice binary inference problems.

The other informational-analysis experimental group became the *multiple-choice problem-familiarization control group* receiving 12 binary inference problems in test form without multiple-choice answers.

Following multiple-choice binary inference problems or multiple-choice control group problems, all six groups were given a test of the binary inference problems, then eight multiple-choice binary inference problems with feedback as to the correct answers, then a final test of the binary inference problems and finally a selection concept attainment task to test transfer from inference to selection methods.

(*b*) *Subjects*

Eighteen subjects were randomly assigned to each control group, except for two groups which had 19. Thirty-one subjects were assigned to the experimental group.

The greater number of subjects assigned to the experimental group is statistically efficient since the experimental group is used in almost every comparison. Males and females were separately assigned to each group, and each group had almost exactly half males and half females. Subjects were University of California at Berkeley undergraduates enrolled in undergraduate psychology courses; they participated in the experiment as part of their course requirements.

Subjects were self paced, but the average time to completion (about 2 hr.) did not differ significantly among the six groups. Although each 2-hr. session included subjects in all six groups, almost no added instruction from the experimenter was necessary, and it was possible to administer the experiment to as many as 30 subjects at one time.

III. RESULTS

(a) *Types of conclusions to binary inference problems*

The correct analytic-deductive conclusion to a $2EC_1$ problem is that the place in which the digit was changed is irrelevant. The correct analytic-deductive conclusion to a $2EC_2$ problem is that both places in which digits were changed are irrelevant. The correct analytic-deductive conclusion to an $EC\text{--}NEC_1$ problem is that the place in which the digit was changed is relevant. The correct analytic-deductive conclusion to an $EC\text{--}NEC_2$ problem is that at least one (and possibly both) of the places in which digits were changed is relevant. If a subject drew a correct analytic-deductive conclusion to a binary inference problem, he was scored as using the analytic-deductive method.

A subject was scored as using a global-hypothesis method on a particular binary inference problem if he formulated a concept as his conclusion to the problem. These concepts were always consistent with the information given in the problem, but never implied by the information.

A few subjects in a few problems used the global-deductive method and defined the entire set of concepts consistent with the information. These occurrences were included in the totals for the correct analytic-deductive conclusions to avoid undue subdivision of the data.

Analogously, some subjects on some problems used the analytic-hypothesis method and drew conclusions about the relevance or irrelevance of every dimension, and thus, in essence, formed an hypothesis about the concept. These occurrences were included in the totals for the global-hypothesis method to avoid undue subdivision of the data.

Therefore, the two classes of methods for answering binary inference problems were *hypothesis methods* as against *deductive methods*. The terms 'global-hypothesis method' and 'analytic-deductive method' are retained in the discussion of the results to indicate that the overwhelming majority of all hypothesis conclusions were global, and of all deductive conclusions were analytic, in agreement with previous findings by Bruner *et al.* (1956).

There were two other categories of answers to binary inference problems: (1) incorrect analytic-deductive conclusions that were not specifications of an entire concept and (2) no conclusion in response to the problem. In general, the results were tabulated as *correct deductive conclusions* as against *all other conclusions* (including the above two categories of answers). In one the dichotomy was *hypothesis conclusions* as against *all other conclusions.*

(*b*) *What is learned from informational-analysis problems?*

Table 1 presents the number of subjects in the informational-analysis experimental and control groups who gave *correct deductive answers* to each of the four binary inference problems on the test *following* the informational-analysis experimental or control problems, of those subjects who answered the corresponding problem *incorrectly* on the test *before* these problems. Neither experimental nor control problems had any appreciable effect on subjects who answered the binary inference problems *correctly* on the first test.

Table 1. *Effect of informational-analysis problems on the frequency of correct deductive conclusions*

(Number of subjects giving D conclusions on T 2 of those subjects giving ND conclusions on T 1.)

Group	2 EC_1			2 EC_2			EC–NEC_1			EC–NEC_2		
	D	ND	*P*	D	ND	*P*	D	ND	*P*	D	ND	*P*
Informational-analysis experimental	21	30	—	23	29	—	17	28	—	13	47	—
Informational-analysis spontaneous-thinking control	2	11	—	3	9	—	1	9	—	1	15	—
Informational-analysis problem-familiarization control	1	13	*	1	12	*	1	13	*	1	16	—
Informational-analysis concept-guessing-denial control	1	14	*	1	14	**	2	16	*	1	16	—
Total informational-analysis control	4	38	***	5	35	**	4	38	**	3	47	*

D, correct deductive conclusion; ND, not correct deductive conclusion. T 1, first test of the binary inference problems; T 2, second test. *P*, * < 0·05, ** < 0·01, *** < 0·001, one-tailed probability of difference from experimental group (Fisher's Exact Test).

The pattern of results in Table 1 is clear. The control groups are identical in performance and show almost no evidence of learning. In the experimental group, with the informational-analysis questions, roughly 40 % of the previously incorrect subjects learned to give correct deductive conclusions to the first three types of binary inference problems, and 25 % of the subjects learned to solve EC–NEC_2.

Table 2 pertains only to those subjects who gave hypothesis conclusions on the first test of the binary inference problems. It shows the number of these subjects who did and did not give hypothesis conclusions on the second test of these problems, which immediately followed the informational-analysis problems.

Of the subjects who were giving hypotheses in the 2 EC problems and the EC–NEC_2 problem, over 80 % abandoned hypothesis conclusions following the informational-analysis problems. For the EC–NEC_1 problem, the figure is 61 %. The control groups are not significantly different in abandoning hypothesis conclusions, but are significantly below the experimental group on every binary inference problem. Over the four binary inference problems an average of 20 % of the subjects in the three control groups abandoned hypothesis conclusions.

The informational-analysis problems increase correct analytic-deductive conclusions at the expense of incorrect global-hypothesis conclusions. The principal variable responsible for this effect is the cue of analysing information into two categories.

Spontaneous thinking, familiarization with binary inference problems, and denial of concept guessing are not sufficient to produce much learning of the analytic-deductive method or abandonment of the global-hypothesis method.

Table 2. *Effect of informational-analysis problems on the frequency of hypothesis conclusions*

(Number of subjects giving H conclusions on T 2 of those subjects giving H conclusions on T 1.

Group	2 EC_1			2 EC_2			EC–NEC_1			EC–NEC_2		
	NGH	GH	*P*	NGH	GH	*P*	NGH	GH	*P*	NGH	GH	*P*
Informational-analysis experimental	33	7	—	32	8	—	22	14	—	36	8	—
Informational-analysis spontaneous-thinking control	1	7	***	1	7	***	0	8	***	0	8	***
Informational-analysis problem-familiarization control	3	5	*	2	5	*	0	5	*	0	6	***
Informational-analysis concept-guessing-denial control	5	7	**	4	8	**	3	10	*	3	10	***
Total informational-analysis control	9	19	***	7	20	***	3	23	***	3	24	***

H, hypothesis conclusion; NH, not an hypothesis conclusion. T 1, first test of the binary inference problems; T 2, second test. *P*, * < 0·05, ** < 0·01, *** < 0·001, one-tailed probability of difference from experimental group (Fisher's Exact Test).

(c) *What is learned from multiple-choice problems?*

Table 3 reports the differences in learning of the deductive method among the experimental and multiple-choice control groups from the second to the third test of the binary inference problems. The second test occurred just prior and the third test just subsequently to the multiple-choice binary inference problems. Recall that all these subjects had received the informational-analysis problems just prior to the second test, and the data reported here are for only those subjects who were still *not* drawing correct deductive conclusions on the second test. The three types of problems (multiple-choice, constructed-response, or filler) presented after the second test of the binary inference problems had no differential effects on subjects who drew *correct* deductive conclusions on the second test.

The results in Table 3 are clear. The multiple-choice control groups are identical in

Table 3. *Effect of multiple-choice problems on the frequency of correct deductive conclusions*

(Number of subjects giving D conclusions on T 3 of these subjects giving ND conclusions on T 2)

Group	2 EC_1			2 EC_2			EC–NEC_1			EC–NEC_2		
	D	ND	*P*	D	ND	*P*	D	ND	*P*	D	ND	*P*
Experimental	7	4	—	7	4	—	7	3	—	9	9	—
Multiple-choice spontaneous-thinking control	0	9	**	0	9	**	0	10	**	0	17	***
Multiple-choice problem-familiarization control	2	7	**	2	7	—	0	8	**	1	12	*
Total multiple-choice control	2	16	**	2	16	**	0	18	***	1	29	**

D, correct deductive conclusion; ND, not correct deductive conclusion. T 2, second test of the binary inference problems; T 3, third test. *P*, * < 0·05, ** < 0·01, *** < 0·001, one-tailed probability of difference from the experimental group (Fisher's Exact Test).

performance, showing almost no evidence of learning the correct deductive conclusions via spontaneous thinking or further familiarization with binary inference problems. The experimental group with the multiple-choice problems shows significantly greater learning of the correct deductive conclusions with roughly 70 % of the subjects learning to draw correct conclusions to the first three binary inference problems and 50 % of the subjects learning to solve EC–NEC_2. Forcing a subject to use the analytic-deductive language for a series of multiple-choice problems produced substantial learning of the correct analytic-deductive conclusions to the binary inference problems as demonstrated on a subsequent constructed-response test, by subjects who were drawing incorrect conclusions on the test prior to the multiple-choice series.

(*d*) *Transfer from informational-analysis problems to multiple-choice problems*

The experimental group and the three informational-analysis control groups were all given the multiple-choice problems after the second test. Table 4 reports the performance on the third test, which followed the multiple-choice problems, for the subjects from the experimental and informational-analysis control groups who answered the binary inference problems incorrectly on the second test. Recall that the experimental group and the informational-analysis control groups received the same multiple-choice problems and differed only in that the experimental group had had prior training in the informational-analysis problems and the control groups had not.

Table 4. *Transfer from informational-analysis to multiple-choice problems*

(Number of subjects giving D conclusions on T3 of those subjects giving ND conclusions on T2.)

	2 EC_1			2 EC_2			EC–NEC_1			EC–NEC_2		
Group	D	ND	*P*	D	ND	*P*	D	ND	*P*	D	ND	*P*
Experimental	7	4	—	7	4	—	7	3	—	9	9	—
Informational-analysis spontaneous-thinking control	4	7	—	4	6	—	1	9	—	3	12	—
Informational-analysis problem-familiarization control	5	8	—	4	8	—	5	9	—	1	15	—
Informational-analysis concept-guessing-denial control	6	8	—	7	7	—	5	11	—	4	13	—
Total informational-analysis control	15	23	—	15	21	—	11	29	*	8	40	**

D, correct deductive conclusion; ND, not correct deductive conclusion. T2, second test of the binary inference problems; T3, third test. *P*, * < 0·05, ** < 0·01, one-tailed probability of difference from the experimental group (Fisher's Exact Test or χ^2).

The informational-analysis control groups are not significantly different from each other. The experimental and informational-analysis control groups are not significantly different on the 2EC problems, but the differences are in the expected direction. For the EC–NEC problems, the differences are significant. It should be noted that since a significantly higher percentage of subjects in the experimental group answered the problems correctly on the second test, there is heavy subject selection operating *against* the experimental group in later tests. Despite this, the remaining subjects in the experimental group show better learning in the multiple-choice problems than do the control groups. Thus, the results are even more significant than they appear.

Even among subjects who did not learn the correct analytic-deductive conclusions on the preceding test, learning of these conclusions in the multiple-choice problems is facilitated by prior experience with the informational-analysis problems. Since the subjects considered in this analysis had not learned the correct analytic-deductive conclusions to binary inference problems, the superior transfer of the experimental subjects must be due to something else that was learned from the informational-analysis problems. In the absence of any reasonable counter-conjecture, this provides some evidence that the informational-analysis cue evokes a general analytic-deductive method rather than directly evoking a concept attainment analytic-deductive method or specific concept attainment conclusions.

(e) *Transfer from inference to selection problems*

On the final test of the binary inference problems, given after eight binary inference problems *accompanied by feedback*, subjects in all six groups produced an average of 85 % correct analytic-deductive conclusions, but many more subjects in the informational-analysis and multiple-choice control groups than in the experimental group had learned the correct conclusions *only* when the answers were shown them. There were no significant differences between the six groups in inferences on the final test of the binary inference problems. Almost all of the subjects in each group had learned the correct analytic-deductive conclusions to the binary inference problems, but of course this does not mean that all had learned the same thing. To demonstrate that what is learned in the informational-analysis and multiple-choice problems is a general method (set, habit, tendency, etc.) of analytic-deduction in concept attainment problems, and not a particular set of verbal responses, a selection problem was given to all subjects after the final test of the inference problems.

The analytic-deductive selection method (focusing) involves varying one or a few dimensions in each selection to determine if the dimensions are relevant or irrelevant. The global-hypothesis selection method (scanning) involves varying all the dimensions except those included in the hypothesis about the concept. It is impossible to decide with perfect accuracy from selection data alone whether a subject is using the analytic-deductive method or the global-hypothesis method on any given trial. However, if all that is desired is a measure of the relative frequency of analytic-deductive selection methods, as opposed to global-hypothesis selection methods, in different groups on a given trial, then a statistic such as the number of subjects who vary only one dimension on that trial is a satisfactory index. The optimal selection method for the problem in this experiment was to vary only one dimension on a given trial. Subjects making analytic-deductive selections would vary fewer dimensions on the average than subjects making global-hypothesis selections, and the choice of a cut-off point, whether at one, two, or three varied dimensions on a trial, is a matter best determined by the maximally powerful statistical procedure of dividing at the median. For our experiments this meant a cut-off between one and two dimensions varied on a given trial.

The first trial of the selection problem is most sensitive to differences in transfer from prior experience because substantial learning to use the analytic-deductive selection method occurs in the course of a single selection problem. The three informational-analysis control groups were combined for the purposes of comparison with the experimental group because there were no significant differences among them in either inference or selection performance. The two multiple-choice control groups were combined for the same reason. Table 5 reports the number of subjects in the experimental, informational-analysis control, and multiple-choice control groups that made analytic-deductive selections (varied only one dimension from the initial example given to all subjects) on the first trial of the selection problem.

The experimental group, which received both the informational-analysis problems and the multiple-choice problems, made significantly more analytic-deductive selections on the first trial of the selection problem than the control groups, which lacked *either* informational-analysis problems *or* multiple-choice problems. Both the multiple-choice problems and the informational-analysis problems produce learning of an analytic-deductive method for concept attainment that transfers from inference to selection problems.

Table 5. *First trial selection method*

Group	Number of dimensions varied on first trial: 1	2–6	*P*
Experimental	29	2	—
Multiple-choice control	24	12	**
Informational-analysis control	35	21	**

P, ** $< 0{\cdot}01$, one-tailed probability of difference from experimental group (Fisher's Exact Test).

What is learned is a general method of solving concept attainment problems, not a particular set of verbal responses. Subjects in the control groups have learned the correct verbal responses to make in the inference problems, but this produces far less transfer to the selection problem than the general analytic-deductive method which is learned in the informational-analysis problems by some subjects and in the multiple-choice problems by other subjects.

IV. Conclusions

If we take the point of view that problem solving results from long chains of associations to the stimuli presented in a problem, then it may happen that an individual will fail to generate the correct solution to a problem not because his associative memory lacks the appropriate concepts for solving the problem, but because these concepts are not activated by the stimuli in the problem. If adequate stimuli for the activation of these concepts are added to the problem, in the form of either new information or new questions, then solution is achieved.

It bears mentioning that what an individual learns in the solution of any given problem may be a general method for solving a class of problems, not just the answer to the given problem. This experiment asked two *types* of questions about how individuals solve for the analytic-deductive conclusions to binary inference problems. First what stimuli evoke the analytic-deductive conclusions? Secondly, what is learned when an individual solves for the analytic-deductive conclusions to these problems?

It has been established that questions directing a subject to analyse information into two categories—possessed and needed—result in a substantial increase in the incidence of analytic-deductive conclusions in binary inference problems. This implies nothing about the importance of any other cues for evoking analytic-deductive conclusions, and, by itself, it implies nothing about the internal 'processing' of this cue that eventually results in analytic-deductive conclusions. However, this experiment has also established that the informational-analysis cue evokes an analytic-deductive *method* for concept attainment, not a specific set of conclusions to the binary inference problems. This was established by demonstrating that the informational-analysis training on binary inference problems transfers to a selection problem to produce a higher initial incidence of analytic-deductive selections. The responses required in selection problems are totally different from those required in inference problems.

Furthermore, we have also provided suggestive evidence that the informational-analysis cue produces learning of the analytic-deductive method for concept attainment by first evoking a general analytic-deductive method which operates on the binary inference problems to produce the analytic-deductive method for concept attainment. This hypothesis is supported by the superior learning of the analytic-deductive conclusions in the multiple-choice problems on the part of subjects who had had prior experience with the informational-analysis problems, but who had *failed* to learn the analytic-deductive conclusions for concept attainment in the informational-analysis problems. These subjects have clearly learned something, even though they have not learned the analytic-deductive method for concept attainment. This something facilitates learning to plan. Naturally we cannot be certain that this same something, which we have called a general analytic-deductive method, was elicited in the subjects who *learned* the analytic-deductive method for concept attainment in the informational-analysis problems, but this hypothesis appears much more likely as a result of the evidence obtained from subjects who *did not learn* the analytic-deductive method for concept attainment until the multiple-choice problems.

Perhaps it is not surprising that forcing a subject to use analytic-deductive conclusions in the multiple-choice problems results in a higher incidence of correct analytic-deductive conclusions in the binary inference problems, even after the subject is again free to use either global-hypothesis or analytic-deductive language. However, the positive transfer from the multiple-choice inference problems to the selection problem demonstrates that what is learned in the multiple-choice problems is not the specific conclusions alone, but a more general analytic-deductive method for concept attainment problems that results in analytic-deductive selections as well as analytic-deductive inferences.

Finally, it should be noted that all of the findings on the cues that evoke analytic-deductive methods, as well as the findings on what is learned when analytic-deductive methods are evoked by these cues, are findings valid for a substantial number of subjects, but certainly not all subjects. Inability to account for individual differences in some general theoretical framework is a defect of all studies of problem solving, but that makes it no less a defect.

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