EFFECTS OF PERCEPTION OF ORGANIZATION AND INFORMATION ABOUT ORGANIZATION ON PROBLEM SOLVING

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ABSTRACT

EFFECTS OF PERCEPTION OF ORGANIZATION AND INFORMATION ABOUT ORGANIZATION ON PROBLEM SOLVING

By

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If education is to benefit all students, it must take into account not only the information to be presented but also the student's existing knowledge of information encoding techniques, such as how to organize information into more easily remembered units. To study encoding processes, four problems were presented in a haphazard manner so that subjects would have to reorganize the information. As hypothesized, differences in organizational structures were highly related to successful problem solution, on a sample of 59 introductory psychology students. Four treatments were then introduced to change the structures. Only one was successful: a complete demonstration of the most appropriate structure. Even this was incapable of changing the success rate, suggesting that problem success is not simply a function of subject's structure. Rather both the structure and the successful solution may be a function of some third variable.

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INTRODUCTION

When a teacher asks a student to take an essay exam, he is usually interested in the student's ability to organize the material. Understanding the underlying organization of a body of knowledge is generally considered to be one of the most important goals of education.

This traditional notion also appears in a recent discussion of problem solving by Newell and Simon (1972). They use the term "problem space" to refer to the problem solver's selection and organization of information in the task environment and they suggest that problem-solving success is a function of how accurately the problem space represents the task environment. This problem space is the product of the subject's encoding of the task environment and the relationships he sees there. Research in problem solving needs to deal with the relation between the problem space and the real environment and the encoding processes used to develop a problem space.

A few attempts have been made to study pictorial representations of knowledge; but, in many cases, these need not reflect a problem space. Problem space refers not only to the pictorial representation of the environment but to the set of relations that the subject sees in the environment. In cases where diagrams reflect relationships, then they may represent the problem space.

The research to date has dealt mostly with spatial information: measurement problems or pictorial problems. Since most material learned in schools is verbal, the techniques need to be extended to verbal problems and their accompanying problem spaces. To accomplish this, verbal tasks are needed where different organizational structures are possible and where overt responses analagous to the spatial drawings might be used to infer the problem spaces. This was the goal of this research.

Given such verbal problems, it was of interest to see how strong the subjects' tendencies were to use the same organizational structure on a series of different problems, all of which were considered, externally at least, to be the same.

The general goal of the study was to investigate the phenomena of encoded structures of verbal information. There were four specific goals: (a) to determine the possibility of infering an internal structure from overt responses to a problem, (b) to see whether differences in structure were related to problem-solving success, (c) to try to change the structures, and (d) to generate hypotheses about processes used to derive the structures.

In Chapter 1, systems of logically related material are inspected for their ability to induce the needed overt responses, and consideration is given to the veridicality of infering internal structures. The second chapter reviews the literature for suggestions of treatments that might cause subjects to change structures. In Chapter 3, there is a description of the research techniques and statistical analyses used. Finally, a review of the entire project and some conclusions comprise Chapter 4.

CHAPTER 1

INFERENCE OF STRUCTURES

A review of studies which have isolated differences in organizational techniques is needed. Let us adopt these criteria as a means of stipulating such studies:

1. They must have dealt with <u>qualitative</u> individual differences; that is, differences of a categorical type, rather than those typically assumed to be based on an underlying continuous dimension. That these categorical differences may in fact be a function of a single underlying ability cannot be denied, but the point is that to date no such finding is available.

2. The particular individual difference must appear to reflect an internalized representation of relations in verbal material.

3. One type of subject must have been found to be more successful in problem solving than any others. (This criterion need not nullify the

requirement that no single underlying attribute be at the base of the differences, or even that a rank ordering of these categorical differences can be made.)

One of the earliest and most well-known studies dealing with categorical individual differences was Bruner, Goodnow, and Austin's (1956). Though their study dealt more with how subjects developed and tested hypotheses about information than with how they encoded the total structure, still, the behaviors they observed at least provide us with evidence that qualitative individual differences do exist. The task put to the subjects was a concept-formation task: subjects (*S*s) had to guess which attribute(s) in a set of displays were "right." In other words, they had to abstract a common property from a collection of varying instances. Their methods were:

1. *Focusing*: *S*s using this method began by finding one positive instance of the concept; that is, they found a display that they knew was an example of the concept. Their task was then to discover which attributes of that display were the ones that made it an example. They compared each new instance to this focal one, and by a process of elimination, derived the relevant attributes. In *conservative* focusing, *S*s chose comparison instances that differed from the original on

only one attribute. If the new one were found not to be an example, they could conclude that the attribute (on which this instance and the focal instance differed) was important to the concept. In focus gambling, *S*s chose instances that differed from the focal one on more than one dimension. If the new instance were correct, they would not know which of the attributes caused it to be so; but if it were incorrect, they could conclude that the entire set of attributes was important to the concept.

2. Scanning: In this strategy, *S*s picked individual attributes as hypotheses, rather than whole displays. With no focal display to use for comparisons, hypotheses were tested using only one instance at a time, selected because it had or did not have the hypothesized attribute. In simultaneous scanning, *S*s tested more than one attribute at a time, whereas in successive scanning, they tested only one attribute at a time and chose their instances on the basis of whether or not they had that attribute.

Using measures such as the number of trials to correct solution, Bruner, et al., were able to show differences in the efficiency of these various approaches. Their data satisfy two of the criteria set out above;

that is, they demonstrate (a) that qualitatively different approaches are possible on a single task, and (b) that one of these approaches can be recognized as more effective than the others. The third criterion, however, is not so easily met. Even though different strategies are apparent, it is not obvious that these reflect different organizations of the stimulus material. For example, two subjects may perceive the data as a display-by-attribute matrix:

	D_1	D_2	D_3	$\ldots D_n$
A_1	+	−	+	. . .
A_2	−	+	+	. . .
A_3	+	−	−	
.	.			
.	.			
.	.			
A_k				

where the pluses and minuses represent the presence or absence of each attribute in each display. Yet one of them may choose to compare columns (focusing on one) while another could choose to test individual rows (scan). These tasks, then, cannot be used to answer the questions asked in this study.

Shipstone (1960) was interested in variations in subjects' organization of material. His interest centered on the different attributes selected by *S*s as bases for sorting materials. The material used was letter sequences, varying in length, pattern, and complexity. They were considered to represent English sentences. Shipstone isolated two general approaches: "ready-made" strategies, based on such arbitrary sorting categories as the length of the sequence or its starting letter; and "problem-dependent" strategies, more likely to depend on the material at hand. Success was defined as using a problem-dependent strategy, a formula-type sorting system. Like Bruner's study, Shipstone's demonstrated that subjects do approach tasks in qualitatively different ways. Moreover, these different sorting strategies may represent different internal organizations of the material. But Shipstone did not require his Ss to use the information once it was sorted. We cannot know, therefore, how the sort might have influenced an S's later ability to use the information. Shipstone's tasks, therefore, also are not adequate for our purposes.

Schwartz (1972) also found individual differences in organization. He presented Ss with mystery problems that had information so profuse that Ss had to reorganize it in order to solve the problems. He observed four different organizational approaches:

1. About 25% of the Ss used a matrix to organize the information. Each row, for example, was used for one character in the mystery; and each column

contained some aspect of information about that character, such as his name, his clothing, or the car he drove. Once the matrix was completed, S could easily see which person was where at what time. This method was successful 84% of the time.

2. Approximately 50% of them arranged the information into clusters, each cluster containing all the data on one character. The success rate for this method was 60%.

3. A few (8%) used tree diagrams. Here, information might be strewn about the page, but with several connecting lines crossing back and forth. These Ss were successful 70% of the time.

4. Some (3%) used simple sentences, basically rewriting the original information. Their success rate was around 50%.

The remaining 10% were lumped into a catch-all category, as not being codable, or not seeming to use any systematic method. These subjects had a 25% success rate. Schwartz had an interrater agreement of approximately .88 when he categorized these protocols.

Schwartz's data satisfy all the criteria set out above: they demonstrate qualitative individual differences, they suggest that one approach is superior to the others, and the approaches seem to reflect differing perceptions of the problem structure. These mystery problems of Schwartz's, then, were chosen for use in this study.

Here is an example of such a problem:[1]

> Judge Wharton presided over several important trials last year. Each involved a different crime, and each resulted in a different sentence.
> 1. Yelon kidnapped children.
> 2. The five-year sentence was served at Jackson Prison.
> 3. One of the defendents got a forty-seven year sentence.
> 4. Porter got ten years.
> 5. Kennedy was sent to San Quentin.
> 6. One of them was sent to Alcatraz.
> 7. Teitelbaum stole money.
> 8. The one who stole secret documents got life.
> 9. One of them would serve eight years at Leavenworth.
> 10. The jewel thief got five years.
> 11. Porter stole cars.
>
> WHAT WAS JOHNSON'S SENTENCE?
> (Answer: five years)

Now, it may be argued that this problem is trivial and should not be used in serious psychological research. But it provides an opportunity to observe the behaviors of interest in a setting unfamiliar to S. Moreover, the problem lends itself to control of extraneous variables such as number of dimensions, number of elements in each dimension, and number of clues. It also is a closed system, one that requires no information from outside sources.

However, Schwartz's categories of observed organizations cannot be taken off-handedly to represent the

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[1]This particular example is from the material used in this study, not Schwartz's.

internal structures of interest to us. It would be naive to suppose that people encoded all information in the form of sentences, diagrams, or tables within their heads. Schwartz's categories are based on written protocols. To create a set of individual differences that reflect the underlying structure, a new coding system was developed that reflected the relationships in the problem rather than just the method of rewriting them. The following analysis demonstrates this coding scheme. It was derived from and tested on a pilot sample of 20 Ss.

There are two important aspects to the above problem that must be recognized prior to an efficient search for the answer. First, S must recognize that the system is closed. That is, he must know that he need not rely on previous knowledge to solve the problem. All necessary information is given, and a unique solution is possible. Second, he must recognize that the information is bidimensional or cross-referenced. This means that each element of information belongs to a category as well as to a person.

A written display of the information which would demonstrate both of these aspects is this:

NAME	SENTENCE	PRISON	CRIME
Johnson	5	Jackson	Jewel Thief
Porter	10	Alcatraz	Stole cars
Yelon	47	Ingham County	Kidnapping
Kennedy	Life	San Quentin	Secret Doc.
Teitelbaum	8	Leavenworth	Stole Money

This display will be referred to as a matrix. It demonstrates the bidimensionality by suggesting that each item belongs to both a row (a person) and a column (a category).

Representing the situation in this manner is not sufficient for solution of the problem, however. After recognition of the bidimensionality, the solver needs to use the structure to find the answer to the question. To demonstrate this, we will fill in a matrix step by step as it would be done by a problem solver.

The first step is to designate the rows and columns of the structure. The first information to be entered in the cells is normally the list of names (column 1) since these are all given in the problem and easily accessible. Then, statements that connect these names with items from other columns may be used to fill in the other cells as follows:

NAME	SENTENCE	PRISON	CRIME
Yelon			kids (1)
Porter	10 (4)		cars (11)
Kennedy		San Quentin (5)	
Teitelbaum			money (7)
Johnson			

(Numbers in parentheses represent the statement from which the information was taken)

Finally, those statements where no name is mentioned must be used. We must still connect cells across columns, but without the aid of a person's name. For example, statement (2) tells us that five years (a sentence) connects with Jackson (a prison). But into which row shall we put this connection? Not the third, since there is already a sentence listed there, and not the fourth since a prison is listed there. This still leaves rows one, four, and five to choose from. We need more information, and statement (10) provides it. It connects jewel thieving (a crime) with the other two columns, for a three-column match. Because it adds a crime to the set, it eliminates rows one and four from the running, since they both already have listings in the crime column. We therefore conclude that Johnson's row (row five) holds that data.

As was mentioned earlier, the solution has two stages. The first is the act of encoding the structure of the information, and the second is the process of using the structure to deductively reason through the data to a solution.

If the above two-dimensional structure is adopted, the second stage involves placing items into a matrix. If some other structure were used, the second stage may be quite different. Our interest is in the difficulties subjects have as a function of the first stage, the encoding of the structure. If a subject solves the problem in the manner demonstrated above, one could conclude that he had correctly encoded the main aspects of this body of information, i.e., that it was closed, and that it was two-dimensional. Let us now consider the protocol of an S who did not see this bidimensionality but did recognize that it was a closed system.

Such a subject would not use a matrix to represent his information. Rather, he would have to sort the information into clusters, or groups of items seen to "go together." Each cluster would represent a unidimensional category, or a grouping of items seen to belong to one common category, rather than two. His protocol might look like this:

Yelon--Ingham County Jail, Kidnapped children
Jewel thief--Five years,--Jackson

Porter------stole cars-10

Teitelbaum---, money

Johnson------?

This S was not able to find a solution to the problem with his structure. Because the bidimensionality was not represented and because it is so helpful in the second stage of problem solving, we assume the subject was not aware of it. The only relationships he encoded, then, were those provided by the face values of the sentences: that the items are connected to people.

We have now considered two different ways in which this information might be encoded. The main difference between them was that the first saw two dimensions of relations, where the second saw only one. There are other ways in which an S might perceive the situation. He may, for example, recognize that it is a closed body of information, but fail to see any structure in the information at all. It may appear to be a set of distinct sentences, each of which describes a particular relationship; but none of which describe the relationship between the sentences. For such an S, the information is simply a chaotic set of facts. His only recourse for solving is to try to match pairs of sentences on whatever basis he can, be it persons, crimes, or sentences. He may rewrite the information to make pairs, or he may simply draw lines between the statements in the original presentation. He will not group the data into clusters but only match pairs that have a common referent.

The matching subject may also begin by listing, for example, all the crimes and then try to match them with people. When he sees that this won't work, he may begin again with a list of names. An example of such a protocol follows:

Yelon----

Porter----10

Kennedy---

Yelon----Kidnapped kids   Went to ICJ

five years--Jewel thief------?

47 years

Porter----10 years---stole cars

Kennedy----San Quentin

Teitelbaum-----Stole money

5 years----jewels ——————— Johnson*

47 years---Yelon

10 years----cars

Life----Documents

8 years----Teitelbaum

---

*Apparently, this solution was an afterthought.

This S began the problem fresh four different times, showing his inability to perceive any structure in the information. His purpose in writing seems to be to discover the structure, whatever it is. This particular example of a matching protocol demonstrates that it is possible to solve the problem without using the matrix representation. That is, the deductive process may occur without S having encoded all aspects of the structure. The difference between this solution and the first lies in the ease with which deduction could occur. While the matrix solver was able to systematically analyze the information, the matcher haphazardly eliminated and re-matched items until he ferreted out the solution.

One final type of subject must still be considered: the person who does not see the problem as closed. This person would attempt an answer from information he had outside the laboratory situation. For example, he may introduce information that one of these prisons is no longer open, or that one of them is a county jail, while the rest are Federal prisons. He will then use this information somehow to solve the problem. His actual solution is still one of the alternatives presented, but his choice is not reached deductively from the presented material.

Only four exemplary protocols have been shown here. A selection of actual protocol samples appears in Appendix D.

Before continuing, a disclaimer should be introduced. This discussion has assumed a two-stage model of problem solving. It was not intended that this model be generalized to all types of problems, nor that it be complete even for these problems. The purpose of the model has been to simplify the discussion of the structural characteristics of the information and the individual's awareness of them.

The concern in this chapter was the relationship between written representations and the internally encoded structures. The first goal listed in the introduction was to determine whether the internal structure could be infered from a written protocol. In an attempt to answer that question, we have listed the various characteristics of a system of verbal information and have considered the written protocols expected to derive from each possible perception of that problem's structural characteristics. It is now being argued, on the basis of the previous discussion, that it is indeed possible to infer the encoded structure from written protocols and that the problems used here are adequate for this task.

A new scoring scheme, based on this analysis, was tested on a pilot sample of twenty Ss. A comparison of the frequencies of each solution method with the frequencies Schwartz found using his coding scheme shows the following:

Schwartz's Data		These Data	
Matrix users	25%	Matrix users	8.7%
Clusterers	50%	Clusterers	15%
Diagrammers	8%	Matchers	36%
Sentence users	3%	Ss using no structure	22%
Unclassifiable	10%	Mixed Methods	19%

As to scoring accuracy, several estimates of rater agreement were used. One attempt was made to emulate Schwartz's classification scheme. But where Schwartz found 88% agreement, we only achieved 76%. However, the new scoring system, described above, yielded 85% agreement between E_1 and E_2, and 95% agreement between E_1 and herself, with a two-week delay between ratings. Since several of the disagreements were easily resolved (that is, they resulted from one E failing to see part of S's protocol, or failing to remember one of the coding rules), the scoring system was considered to be acceptably accurate. All data were then scored twice to check accuracy.

Also tallied, and shown above, is the agreement of the subjects with themselves. The row labeled "mixed methods," represents subjects who failed to encode the same structural aspects on two different problems. It is difficult to know whether these disagreements represent problems in the reliability of the scoring scheme, or true variations in the perceptions of the subjects. A perusal of these data by both $\underline{E}_1$ and $\underline{E}_2$ suggested that the differences were due to changes in the subjects' responses, rather than to nonobjectivity of the scoring system.

This concludes the discussion of the problem material. The remaining questions set forth in the Introduction were: Do these individual differences predict the success of problem solution? Can we change these structures? Can we generate hypotheses about the processes used to generate these structures?

Since one sample was used to answer both the second and third questions, we shall discuss the data from that sample as it relates to both of these questions simultaneously, and this shall be our goal in Chapter 3. We will use Chapter 2, then, to consider the types of information that might be used to change an S's perception of the structure.

CHAPTER 2

INSTRUCTIONS TO RESTRUCTURE

Because Schwartz varied problem format in his study and found no effects due to variations in problem, this study will emphasize only influences of information, holding problem formats constant.

This chapter, then, considers various verbal instructions used in the past to assist problem solvers. Of course, in each case, different problems were used, and slightly different instructions were given. It was therefore necessary to consider each in detail to see how it would relate to the current study. Of especial interest were data on partial information treatments. Common sense would suggest that no treatment at all would have no effect, while careful and detailed demonstration would surely be successful. We therefore were interested in forms of partial information and how successful they had been in helping subjects change their organizations of the problem.

One early study was Ewert and Lambert's (1932). They used the disc problem which requires Ss to move a stack of discs, graduated in size, from one peg to another. There were two restrictions: the discs had to be moved one at a time; and no disc could be placed on top of one smaller than itself. Because Ss had to physically move the pieces, the experimenters could easily count the number of excess moves, false starts, and so forth. Ewert and Lambert used four treatments: no information, suggestions to search for a rule, information about what the rule was, and information about the rule coupled with a demonstration of it. These last two treatments were about equally effective, while the others trailed equally far behind. The two dependent variables were time to solution and number of excess moves. Ewert and Lambert also asked Ss to state the principle after they had finished and found that Ss who received partial or no information were unable to recite it. The rule was, "If the number of discs is odd, move the first disc to the circle to which you want to go eventually; if the number of discs is even, move the first to the circle to which you do not want to go eventually" (Ewert and Lambert, 1932, p. 403).

Duncan (1963), too, studied the use of partial information and of what he called partial instruction. But where Ewert and Lambert asked subjects to search for a rule, Duncan simply suggested that they think carefully before they begin. The task was a lights-and-switches problem, wherein Ss had to turn on a particular pattern of lights on a panel. The complication was that each switch was connected to more than one light and would change each from on to off, or off to on, depending on the starting condition. In his first experiment, Duncan only varied instructions (information about the goal of the task). After finding a significant effect there, he repeated the experiment varying both instructions and information about the solution rule.

Both types of treatments showed a significant difference between their complete and partial forms. However, the nature of his instructions leads to a suspicion that he may have stimulated a need to achieve. Several Ss were so anxious after receiving instructions that they were unable to continue and had to be dropped from the study. This suspicion of confounded effects was further supported by the fact that Duncan got a Treatment-by-Sex Interaction such that only males benefited from the instructions. (Instructions designed to arouse a need to achieve are notoriously poor at affecting females.) For these reasons, we cannot regard his data on instructions as meaningful for the current study.

This possibility prompts us to consider only his data on information. Though his partial information treatment was not exactly the same as Ewert and Lamberts, its effect seemed equally poor. The rule for Duncan's problem was, "If a light is off, turning a switch that is connected to that light will always turn it on. If the light is already on, turning a switch that is connected to it will always turn it off. . . . Turning a switch that is either up or down will always reverse the state of affairs" (Duncan, 1963, pp. 322-23).

Corman (1957) suggested that a distinction be made between information about the rule and information about the method. He felt Ss were not ready to learn a rule until they had found a method of attack. That is, they need to complete some trial-and-error sequences successfully before the rule would be meaningful to them. To test this, he gave Ss three levels of information about the underlying principle and three levels of information about the method. The tasks were Katona's matchstick problems. Ss had to move a number of matches to form a specified pattern. As Corman predicted, information about the method was more successful than any level of information about the rule. None of the previous studies had considered this variable. More surprising, though, was that Ss who received partial rule information in Corman's study did worse than Ss who received no information. This finding contradicts all others reported above. But Corman's partial information treatment was again somewhat different from either Duncan's or Ewert and Lambert's. Rather than telling Ss simply to search for a rule, or to think carefully, he gave them a hint about what the rule entailed. He told Ss that the rule involved the total number of matches in the design. Conceivably, this hint misdirected Ss and thereby hindered them more than it helped.

A second unexpected finding in the Corman study was that partial information about the method was as good as complete information. It is the first successful example of partial information we have seen. Again, his partial information treatment concerning method was somewhat different from previously considered partial information treatments. This particular treatment appears to have been a demonstration of the rule, without explicitly stating it. The effect was like guided instruction. Corman's rule: "Matches should be moved so that no square has a common side with any other square. Every match should be the side of only one square" (Corman, 1957, p. 6).

Recall that the purpose of this chapter was to review previous partial information treatments and to select treatments for this study. One difference between the current study and others was that this one dealt not only with successful solution of the problem but also with the Ss' perceptions of the structure of the information given. Because some aspects of these perceptions could be inferred from written protocols, these data could be used to assess the effects of treatments on Ss' perceptions, as well as their success. Data gathered in the other studies could only address treatment influences on success. Let us now discuss the treatments finally selected for this study.

Before considering forms of partial information, we should consider "end points," that is, treatments with no information and with complete information. These two treatments were included simply for comparative purposes. The previous research left us quite certain that the first condition would exert no influence over Ss' behavior, while the second would be highly effective.

The original concern for stability of structures is defined as "susceptibility to influence." These treatments should therefore reflect different amounts of influence or of information designed to influence the structure. The more difficult question, then, asks which types of partial information should be tried. Vague suggestions (e.g., "search for a rule," or "think before you act") were no more effective in the past than no information at all. But there was a weakness in the previous studies: they could not investigate the reasons for this inadequacy. It is possible that these vague suggestions did induce Ss to change their approaches but not to change them in the right way. Our study can consider that possibility, since it can assess the written protocols and see whether Ss did change their structures. It was therefore considered worthwhile to include this treatment in the study, not because we expected it to affect S's success, but because we wished to see its effect on S's perception of the structure of the problems.

This left us with three treatments. Two were included for their known good and bad effects, and one was included to assess its effects on the qualitative aspects of our data: the encoded structures. Now Corman's study, because of its complicated results, demands replication of one of its treatments, the partial rule information that lowered Ss' success. It will be recalled that in this treatment, he gave Ss a hint of what the rule entailed. In his study, that hint stated that the solution had something to do with the number of matches in the design. In the present study, the hint said that the solution had something to do with the use of a matrix. Our interest in this treatment was twofold: first, simply to replicate Corman's findings, and second, to look at the qualitative differences among Ss (i.e., their written protocols) to see if they were indeed misdirected by this treatment.

These four treatments constituted the treatments finally adopted for the study. The exact verbal information used for each treatment is provided in Appendix C.

During the course of this discussion, stability of structural perceptions has been interpreted as resistance to outside influence. That is, we have talked of using suggestions as a way of changing these perceptions. But another measure of stability is Ss' ability to generalize the structure to new situations. To assess this aspect of stability, subjects were given two different posttests: the first was similar in format and amount of information to the pretests. The second, however, was presented in a paragraph format, rather than by numbered statements and several pieces of extraneous information were added. This problem was designed to observe Ss' ability to generalize from the first three problems to a new situation.

The design of the study has unfolded. In Chapter 1, four different types of subjects were described, and in Chapter 2, four different treatments. A second, transfer posttest, has been added to the standard posttest. A description of the hypotheses and experimental procedures will be described in Chapter 3.

CHAPTER 3

DESIGN OF EXPERIMENT AND ANALYSIS OF RESULTS

The design focuses around two of the questions listed in the Introduction: whether encoded structure is related to ability to solve problems; and how easily the structure can be changed.

One sample was used to test both structural effects and treatment effects on problem success. To do this, pretest data were used to assess structural influences on problem solving, and posttest data were used to compare treatment effects. Before a detailed discussion of the procedures, we shall review the hypotheses.

Hypotheses

Since all treatments were modeled after those used in earlier studies, certain results were expected. For example, the pretest data were expected to parallel Schwartz's data: matrix solvers would be more successful and would solve in less time. Similarly, there was good reason to believe the treatments would have effects similar to those seen before: *S*s receiving the suggestion and hint should be less successful than complete information and require more time.

Other questions were raised for which there were no precedents but for which hypotheses were still put forth. The vague suggestion and the hint were each expected to increase the number of incorrect changes of organization. That is, rather than causing *S*s to change to a matrix, they would result in changes to some other structure. The complete information, on the other hand, was expected to increase the number of changes to the optimal method (the matrix method).

But other results could not so easily be predicted. For example, it could not be known if there would be a Treatment-by-Method interaction. It was therefore considered necessary to develop a design that would test for this possibility.

Finally, the transfer test was expected to take longer than the direct posttest.

The hypotheses, then, are as follows:

Pretests

Matrix solvers will be more successful and will use less time than other subjects.

Treatments

1. Subjects receiving vague suggestions will use more time and be less successful than subjects receiving complete information.

2. Of those not using matrices on the pretest, subjects receiving vague suggestions and hints will change more often to structures other than the matrix than Ss with no treatment or with complete information.

3. Subjects receiving complete information will more frequently use the matrix than subjects from vague or hint treatments or from the no-treatment condition.

Transfer Test

The transfer problem will require more time than the initial posttest problem.

Sample

Ss were undergraduate volunteers from an introductory psychology course at Michigan State University. Since the course is a popular elective, the sample contains students from disciplines other than psychology. Their ages ranged from 17 to 22, with a mean of 18 1/2. The sexes were approximately even, with 29 females and 30 males. Seven were black. Grade-point averages ranged from below 2.00 to nearly 4.00 with the mean estimated at 2.8.

Procedure

All Ss solved four problems: two pretests and two posttests. Ss were divided into four groups according to their written protocols on the pretest problems. The groups were: matrix solvers, clusterers, matchers, and those apparently using no structure. If an S did not use the same approach on both of the pretest problems, he was dropped from subsequent analyses. This was done to make the groups more homogeneous. Schwartz claimed that 80% of his subjects were consistent for at least four of six problems. His problems, though, varied in type of logical connectives, number of dimensions, and whether the information was positive or negative. It was expected that Ss in this study would be more consistent than in Schwartz's, since the problems were more similar. But, as we saw in Chapter 1, only 81% of these Ss maintained a consistent model across the two pretest problems.

After Ss completed the first two problems, and were assigned to treatments, they each independently received their treatments. The entire sequence occurred in one session lasting approximately 45 minutes. The use of a single session was stimulated by the need to retain subjects who often do not return for a second session. (Recall that the transfer test was not a test of transfer over time but of transfer to a new format.)

Appendix A shows the problems. The transfer problem differs in that the information is given in paragraph format rather than by numbered sentences and in that three extraneous pieces of information were added.

Unfortunately, as we saw in Chapter 1, subjects were not equally distributed among the various categories. To acquire equal cell sizes, it was necessary to oversample and randomly drop some Ss. Since oversampling was excessive, a final design with only two Ss per cell was adopted.

Altogether, Ss were dropped from the study for any of the following reasons:

1. No constant method was used across the two pretests (11/59).
2. Ss were randomly dropped to obtain equal cell sizes (18/59).
3. Matrix solvers were not given any treatments (5/59).
4. One subject was dropped because he failed to complete the task in the required time limit (Ss had to complete the two pretests within a 45-minute time limit).

Ss were scheduled two at a time, at hourly intervals, but worked in separate cubicles. Upon entering the laboratory, each S was given the following information:

> This is a problem-solving study. (Showing S the first problem) Your task is to answer the question at the end (indicating) on the basis of the information given above. At first it will seem as though there is no answer, but there is. You'll have to manipulate the information however you want to, to

find the answer. I've left space below for you if you want to rewrite the information. OK? (Checking for questions from S)

There are four problems altogether, but I want you to do them one at a time, so I can time them. You can bring each back when you are ready for another one. (Handing S his first problem) Just take any booth in the back.

(If two Ss arrived at once, E's last statement was modified to "Each of you can take a different booth in the back.")

Ss were given no feedback on their performance until they had completed all four problems. However, E scored each problem as it was completed, according to the scoring scheme outlined in Chapter 1 (see Appendix B for the exact rules). After completion of the first two problems, Ss were randomly assigned to treatments. The exact information given in each treatment condition is shown in Appendix C. No further information was given until Ss had completed all four problems. At this time, any questions S had about the problem, its solution, or the experiment were answered. The most common questions were, "Are you sure there is an answer to this?" or "Are you sure there is a way to find the answer?" These two questions, or their variants, were answered in the affirmative whenever they occurred throughout the experiment.

Since testing took place over a period of weeks, Ss were scored daily and tallies of each category were maintained. Relative frequencies of each type of subject remained approximately constant, suggesting that early Ss probably did not discuss the experiment with those who participated later on.

Analysis of the Data

The hypotheses suggested that the following measures be taken: (a) time to solution; (b) correctness of solution (scored one or zero); (c) whether S changed to a matrix (scored one or zero); (d) whether S changed, but to a different nonmatrix method (scored one or zero). Of these measures, time is probably the most crude, since it can reflect a number of activities other than thinking.

At the completion of the experiment, the 58 Ss who completed all four problems fell into the design shown in Table 1.

Table 1

Design of the Study

	No Treatment	Vague Suggestion	Hint	Complete Directions	Total
Matrix Users	N = 5				5
Clusters Users	N = 2	N = 3	N = 3	N = 2	10
Matchers	N = 9	N = 4	N = 4	N = 3	20
No Structure	N = 4	N = 4	N = 2	N = 3	13
Mixed Methods	N = 3	N = 3	N = 1	N = 3	10
Total	23	14	10	11	58

Pretests. The first hypothesis, dealing with pretest data, suggested that the matrix solvers would be both faster and more successful than other groups of Ss. To test this, the 48 Ss who maintained a consistent model were placed into a Groups-by-Repeated-Measures design, with the two pretest problems as measures. However, when an analysis of variance was done on the first dependent variable, time, the cell variances appeared to be quite heterogeneous (see Table 3). The analysis of variance assumes homogeneous variances, but is robust to that assumption when the cell sizes are equal. Rather than drop Ss to achieve equal cell sizes, and thereby insure robustness to violation of the test's assumption, a nonparametric counterpart to this analysis was done: the Kruskal-Wallis multisample test (see Koch, 1967). Table 2 shows the results of both the parametric and the nonparametric tests, and Table 3 gives the means and variances of each cell.

The probability levels reported by the two tests of group differences are not a great deal different, and both suggest that the observed difference is not likely to be due to chance. Omega squared ($\hat{\omega}^2$), a measure of the proportion of variance accounted for, suggests that 28% is accounted for by group membership. (For a discussion of $\hat{\omega}^2$, see Kirk, 1969, page 127.) However, the table of means suggests that the differences are not in

Table 2

Analysis of Variance and Kruskal-Wallis Tests of Group Differences in Time on Pretest Problems

A. Analysis of Variance

Source	d.f.	Mean Square	F	P
Groups (G)	3	199.729	4.192	.0108
S:Groups	44	47.641		
Measures (M)	1	3.010	.178	.6797
G x M	3	12.057	.712	.5501
S:G x M	44	16.939		

Proportion of variance ($\hat{\omega}^2$) accounted for by groups = .28

B. Kruskal-Wallis Test

Test	d.f.	Chi Square	P
Groups	6	14.6530	.0236
Measures	1	.783	< .30
G x M	3	2.6266	.5444

Table 3

Means in Minutes, Variances, and Mean Ranks Used to Perform the Two Analyses on Pretests

Group	Means			Variances		Mean Ranks	
	1	2	1 & 2	1	2	1	2
Matrix Users	10.00	12.40	11.20	12.5	11.80	25.3	33.4
Clusterers	12.33	14.00	13.16	19.25	81.00	30.72	31.18
Matchers	11.43	11.76	11.59	35.66	49.89	26.83	26.5
No Structure Used	7.15	5.85	6.50	9.14	10.14	16.115	13.231

Using Box's test for equality of variance-covariance matrices, $\chi^2 = 25.646$, with 9 degrees of freedom (Significant at < .01).

the direction hypothesized. The matrix solvers apparently did not use less time than clusterers or matchers. In fact, the fastest group was the group using no structure at all. This finding is especially interesting in light of previous problem-solving research in which speed has often been equated with good performance.

Because the analysis-of-variance results were similar to those of the Kruskal-Wallis test, it was decided that the inequality of variances was not too serious; and Scheffé post-hoc comparisons could be made. Two comparisons were made, one comparing the cluster solvers with the other two groups using a structure, and another comparing the no-structure group with the three who used structures. The first was nonsignificant (at .05). The second was significant; using weights of -1, -1, -1, and 3, an interval of 144-173 was formed. This comparison suggests that the differences among these groups are mostly due to the difference between those who used a structure and those who apparently did not. There are two possible reasons for this difference. First, the subjects not using any structure may simply be guessing at their answers. In this case, we would consider differences in time to be largely due to differences in motivation. However, a second reason may be that subjects who are using a structure need a few more minutes to encode it, prior to fitting the data into it. If encoding were the cause for these time differences, it may lend support to the two-stage model of problem solving outlined in Chapter 1. Obviously, we cannot know which of these alternative hypotheses can account best for the differences but should keep them in mind as we consider the rest of the data.

The second part of the pretest hypothesis dealt with the success rates of the different groups. It was hoped that chi-square tests could be used on these data, thus allowing those Ss who changed methods to be included in the analysis. But since there were so few matrix solvers, the expected cell frequencies were too small for chi-square tests. (Normally, expected values must be at least 5 to use the chi-square test.) Table 4 shows the observed and expected values for each group.

Table 4

Success Rate for Each group on Each of the Pretest Problems[a]

Group	Problem One[b]				Problem Two[c]			
	N	Obs.	%	Exp.	N	Obs.	%	Exp.
Matrix	8	6	75	2	7	5	71	1.6
Clusterers	12	4	33	3	13	7	53	3.1
Matchers	24	3	12.5	6.1	24	2	8	5.8
No Structure	15	2	13.3	2	14	0	6	3.5

[a]Since each problem was analyzed separately, those who changed structures were included.

[b]$\chi^2 = 14.04$, $\phi = .44$, tabled $p \leq .01$

[c]$\chi^2 = 23.13$, $\phi = .53$, tabled $p \leq .001$

Since the group of interest (the matrix users) was the group whose expected cell values were the lowest, it was not possible to collapse across cells. Rather than rely on the chi-square test, a second analysis was done using analysis of variance on an arcsine transformation of the proportions correct in each cell. This procedure reduces the data to one observation per cell, so the interaction term must serve as an error term. It is recommended by D'Angostino (1972) as a method of equalizing the within cell variances of dichotomous data and of normalizing the distribution. The results of this analysis are shown in Table 5. ("Measures" refers to the two problems used.)

Table 5

Analysis of Variance on Arcsine Transformed Pretest Success Rate

Source	d.f.	Mean Square	F	P
Groups (G)	3	3.003328	37.5416	.007
Measures (M)	1	.058311	.6964	.4735
G x M	3	.083736		

$\hat{\omega}^2$ groups = .942

Clearly, the matrix users were significantly more successful than the other groups; in fact, the relation between structure and success appears to be quite strong.

Now this first hypothesis stated that the matrix users would be more successful and would use less time than other subjects. Since group differences were actually tested twice, once for each dependent variable, the combined alpha level is larger than either individual alpha. Technically, we should not reject our null version of that hypothesis, since the matrix users did not use less time than other Ss. But as mentioned previously, time is at best a crude index of problem-solving ability. In fact, for these data, the correlation between time and success was close to zero on each problem. However, we leave this portion of the study with the conviction that the matrix users did indeed have an advantage over the other subjects. We shall now turn to the second portion of the analysis which deals with the effects of treatments on Ss' speed and success.

Posttests. Throughout this discussion, S's structure was considered as something that was "seen" in the problem. Our interest in the treatments was in how easily this perception could be influenced. (Recall that Schwartz had already found problem variations ineffective in changing S's protocol.) Four different treatments were used, and two posttest measures were given: a problem similar to the pretest problems and a transfer test (testing S's ability to generalize his structure to a slightly different appearing problem).

Since our interest was in introducing the matrix structure, only those subjects who had not used matrices on the pretest problems were included. The final design was a groups-by-treatments-by-repeated measures design (3 x 4 x 2). Each dependent measure was analyzed separately. Table 6 shows the results of the repeated-measures analysis of covariance on the first measure, time. The covariate was time used to solve the first pretest problem.

Table 6

Repeated-Measures Analysis of Covariance on the Dependent Variable Time

Source	d.f.	$SS_{unadj.}$	MS	MS_{adj}	F	P
Groups (G)	2	3.292		2.48	.6032	.5643
Treatments (T)	3	84.667		17.67	4.2888	.0311
G x T	6	200.708		11.65	2.8277	.0645
S:GT	11	197.000		4.12		
Measures (M)	1	0.083	.0833		.0086	.9286
G x M	2	9.042	4.5208		.4747	.6333
T x M	3	74.916	24.9722		2.5824	.1019
G x T x M	6	64.958	10.8264		1.1196	.4068
S:GT x M	12	116.000	9.6667			

$\hat{\omega}^2$ for treatments is .15. Slope of dependent variable on covariate = .7346, P = .0043.

Though the analysis suggests that there are differences among the treatments, it also suggests the possibility of an interaction between treatments and groups (at p = .0645). The actual proportion of variance ($\hat{\omega}^2$) accounted for by this source of variation was 38%. Since the Groups-by-Treatments interaction has accounted for such a large proportion of the variance, it seems necessary to look at it. Table 7 shows the adjusted cell means, and Figure 1 graphs them.

Table 7

Adjusted Means for Each Group on Each Treatment for the Dependent Variable Time (Summed Across the Two Problems)

Group	No Treatment	Vague Suggestion	Hint	Complete Directions
Clusterers	9.1	25.4	16.0	20.4
Matchers	11.9	18.6	24.9	20.3
No Structure Used	20.1	18.6	17.0	25.2
Treatment Means	13.9	20.9	19.2	20.6

To aid inspection of the graph, two treatment effects have been put in dashed lines, and the other two solid. The solid lines represent the two extreme forms of treatments, no information and complete information, and the dashed lines represent the two forms of partial information. The line representing time for subjects receiving no treatment can be likened to a simple practice effect. The line representing complete information seems to be nearly parallel to this one, suggesting that, though subjects needed more time to use this information, the amount of time did not differ greatly across the groups.

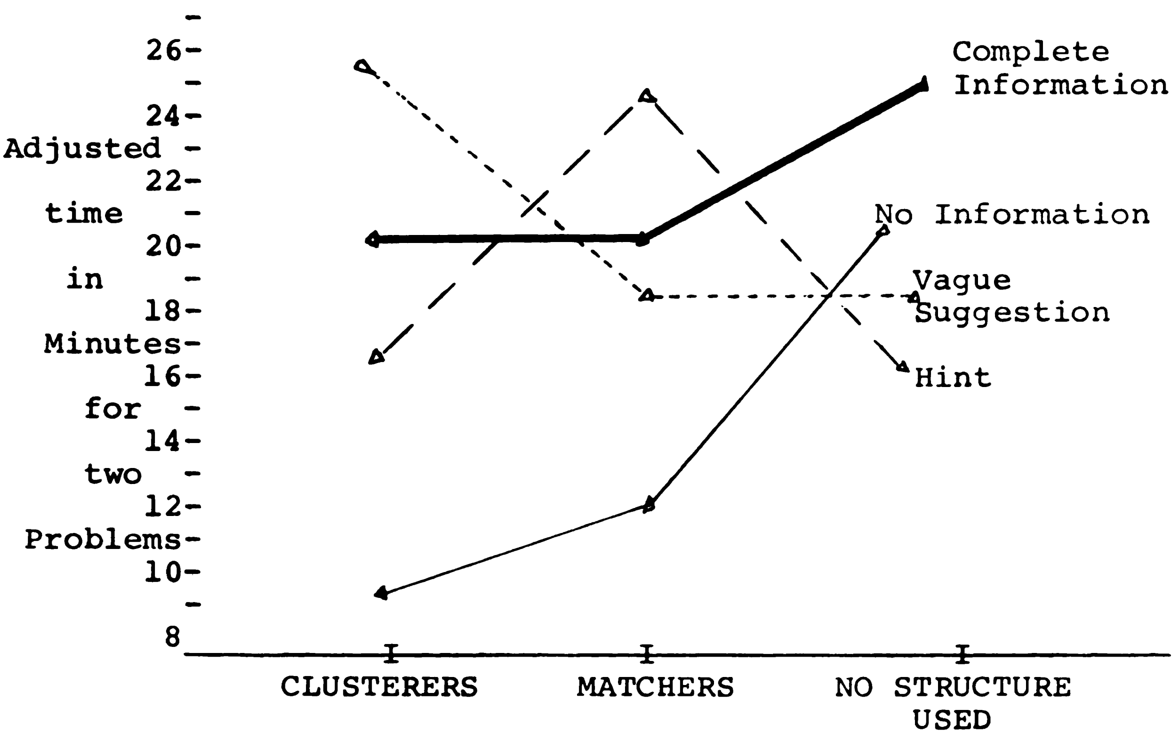

Fig. 1. Interaction Between Treatment and Group on Time to Solve Posttest Problems (Adjusted for Covariate)

The two partial-information treatments seem to be mostly responsible for the interaction effect. If one could assume that the groups of subjects saw different amounts of information in the problem, and that the various treatments provided different amounts of new information, then the largest amounts of time seem to have been spent when the sums of these two sources of information were the greatest. That is, the largest times were spent when (a) clusterers received little information, (b) matchers received medium amounts of information, and (c) those subjects who seemed to see no structure in the stories received complete information.

Looking past the interaction, at the treatment main effects, there seems to be little difference between the three treatment groups, and the cause of the treatment effect is apparently due to the difference between those receiving no treatment and those receiving some amount of information.

Because the interaction was not significant at less than .05, and because so many tests have been made with these subjects, we cannot consider this finding as highly reliable, so no post-hoc comparisons were made. It was displayed because of its disordinality (i.e., the lines cross one another), a situation which usually implies that further discussion of treatments main effects is unwarranted. In this case, the main effect accounted for less variance than the interaction effect, but also had a larger F ratio. To say the least, the possibility of a disordinal interaction clouds the issue of treatment main effects. Again, some of the difficulties here may be due to measurement problems but certainly not all. Where speed has in the past been considered a valid measure of problem-solving ability, it does not appear to be for these problems. This invalidity may also be the cause of the lack of difference between the two posttest measures. Recall that the second posttest was expected to require more time than the first.

So far, the discussion of treatment effects has centered around effects on time. Also of interest were effects of the treatments on choice of structure and on success rate. We will now address ourselves to these questions. Since these measures were all scored with ones and zeros, and since there were large differences in the proportion of ones from cell to cell, it was again necessary to transform the data with an arcsine transformation (see D'angostino, 1972). Cell means were calculated and then transformed to their arcines. This was followed by a repeated-measures analysis of variance, with one observation per cell. The procedure requires the additional assumption of no three-way interaction since this interaction term must be used as the error term in the analysis. There is a test for this interaction which was not performed here. The test costs a degree of freedom, and informal inspection of the cell proportions leads to the conclusion that such an interaction is unlikely. Table 8 gives the results of the ANOVA on this transformed variable.

Clearly, the treatments were differentially effective in changing subjects to a matrix approach. Before looking at specific treatment differences, however, we should turn to the analysis of success rate to see if there were parallel results. Table 9 shows these results.

Table 8

Analysis of Variance on Correct Change to Matrix Use
(Transformed to Arcsines of Cell Proportions)

Source	d.f.	M.S.	F	P
Groups (G)	2	.211	2.8588	.1343
Treatments (T)	3	1.943	26.3478	.0007
Measures (M)	1	.032	.4373	.5397
G x T	6	.071	.9656	.5164
G x M	2	.032	.4376	.6647
T x M	3	.074	1.0000	.4547
G x T x M	6	.074		

$\hat{\omega}^2$ for treatments = .69

Table 9

Analysis of Variance on Transformed Proportions Successful

Source	d.f.	M.S.	F	P
Groups (G)	2	.814	4.9848	.0530
Treatments (T)	3	.061	.3755	.7744
Measures (M)	1	.094	.5742	.4851
G x T	6	.227	1.3875	.3505
G x M	2	.046	.2821	.7637
T x M	3	.280	1.7166	.2623
G x T x M	6	.163		

Apparently, though there were treatment differences in use of the matrix, the effect did not transfer to successful solution of the problems. In fact, the only source of variation that does suggest differences in success is that of group membership, the same variable found to affect success on the pretests. Perhaps those subjects who did change to a matrix were as yet unsure of how to use it.

Table 10 gives the actual proportions of Ss from each treatment who changed to a matrix and who were successful on the posttests. When complete information was provided, 90% of the subjects were able to use the matrix structure to work the problem, yet only 38.5% actually solved the problem correctly. This percentage is no larger than that of those solving with no treatment at all. Apparently, perception of the structure is not sufficient for problem success. This will be discussed in more detail later.

Table 10

Proportions of Subjects from Each Treatment Who Changed to a Matrix and Who Solved Correctly on the Posttest

Group	% Used Matrix	% Answered Correctly
No Treatment	0.000	.385
Vague Suggestion	.008	.150
Hint	.125	.313
Complete Information	.900	.375

Table 11 compares the proportions of Ss in each group who were correct on the pretests and posttests.

Table 11

Percentage of Each Group Solving Correctly on the Pretests and on the Posttests

Group	Pretests		Posttests	
Clusterers	.33	.54	.55	.55
Matchers	.13	.08	.29	.29
Ss with no structure	.13	.00	.08	.08

These relative proportions have not changed considerably from problem to problem. Because the differences between the groups are so similar across problems, it is likely that the data do not reflect a type II error; that is, it is not likely that, upon replicating the study, large changes in relative frequency would occur after treatment. Incidentally, the equality of some of the proportions is coincidental and does not reflect the same set of individuals.

We shall now turn to the last remaining dependent variable, the proportion of subjects changing incorrectly to a nonmatrix structure. Because there were no treatment differences in success, this analysis is less interesting than it might have been. Again, the arcsine transformation was used and again no test for nonadditivity was performed. The results of this analysis are shown in Table 12.

Table 12

Analysis of Variance on Arcsine Transformations of Proportions of Subjects Changing to Wrong Structure

Sources	d.f.	M.S.	F	P
Groups (G)	2	2.912	2.6672	.1483
Treatments (T)	3	.100	.0918	.9619
Measures (M)	6	1.362	1.2477	.3067
G x T	6	.287	.2632	.9355
G x M	2	.251	.2294	.8017
T x M	3	.060	.0545	.9817
G x T x M	6	1.092		

Apparently no treatments were more likely than any others to induce changes to other nonmatrix structures. The hint did not have the negative effects seen in the Corman study.

Since several analyses have transpired since the hypotheses were first stated, these analyses will be summarized in terms of those hypotheses. First, we hypothesized that prior to treatments, there would be differences among the groups of subjects in time to solve and in success rate. Though time differences were found, they were not in the direction hypothesized: the subjects who apparently used no structure were faster than any group using a structure. However, the hypothesis that subjects using a matrix would be more successful was supported.

Regarding treatment differences, it was hypothesized that the vague and hint treatments would require more time. But what little differences could be discerned between the treatments were not large enough to be meaningful; all require about the same amount of time and differed from the nontreatment condition equally. If group differences in time on the pretests could have been known in advance, this hypothesis would not have been made. Effects on time were also less meaningful because of the suggestion of a disordinal interaction between treatments and groups.

The complete treatment, however, did significantly affect the structures used on the posttests, as hypothesized.

It was also hypothesized that the vague suggestion and hint treatments would cause subjects to change to structures other than the matrix, but this was not found to be the case. Finally, it was hypothesized that the transfer test would require more time than the direct posttest and this was found not to be the case. Again, this may be due to invalidity of the measure. It is doubtful that it is due to a type II error, since differences between the two posttests were so small.

In summary, then, while matrix solvers were most successful, those using no structure were fastest; and complete demonstration was the only treatment that could effectively change the structure. Even then, however, there was no corresponding change in success rate. Implications of these findings will be addressed in the next chapter.

CHAPTER 4

SUMMARY AND CONCLUSION

To evaluate this study, we will first review the goals listed in the introduction. The study was aimed at the manner in which people perceived structures in their environments. There were four main goals: (a) to determine whether written representations of verbal information can be taken to reflect the perceived structure of that material, (b) to see if that structure was related to success in solving the problems, (c) to assess the stability of the structure, and (d) to develop hypotheses about the processes used to develop the structures.

The first goal was addressed in Chapter 1 where an analysis of the logical structure of the problem material was performed, and conjectures were adduced about the nature of written protocols that might result from different perceptions of the structure. On the basis of this analysis, it seemed feasible to use written protocols to infer the perceived structure of these problems.

The second and third questions were addressed in Chapter 3 where an analysis of data on several subjects led us to believe that the structures were highly related to the subjects' success and that little less than complete detailed demonstration of the structure could force subjects to see it. Even this information was not sufficient to increase the success rate of the subjects. That is, change to a matrix solution will not bring with it a change to correct answer. The structures were considered stable for two reasons: nothing short of complete demonstration changed them, and they did not change when the transfer problem was presented.

Effects of the Treatments

First, the vague suggestion was used primarily to see if it changed S's perception of the problem. Vague treatments have been used in the past and were not successful; but past research was only able to measure S's success and did not look at changes in his approach to the problem. The question here was whether the vague suggestion would influence this aspect of S's behavior, even though it did not influence his success. It did not. There was not a significantly greater proportion of Ss from this treatment changing structures, either correctly or incorrectly. In previous studies, partial information treatments were based on rules about what S should do. We now know that these not only cannot change what he does but also cannot change the way in which he considers the problem to be organized.

Second, one treatment consisted of a hint that a matrix should be used. There is a possibility that some *S*s did not know what a matrix is, though only one *S* asked. The hint was intended to parallel Corman's (1957) hint that solution had something to do with the total number of matches in a design. It was suggested that such a hint may actually mislead *S*s since it does not state how the solution is related to this number. Corman found that subjects exposed to this treatment actually did worse than subjects with no treatment at all. Our aim was to replicate this finding, but these results did not agree with Corman's. The hint did not hinder success but neither did it aid it. However, some of the protocols did suggest that *S*s were misdirected. Four different subjects wrongly attempted matrices. That is, they failed to design a matrix that showed the two dimensions of information that were in the problem. Their protocols looked like this:

	Jackson	Alcatraz	Levinworth	Ing. Ct. J.	San Q.
Yelon				X	
Johnson					
Teitelbaum					
Porter					
Kennedy					X

This form of matrix was unsuccessful and was usually followed by a guess of which sentence was Johnson's.

Finally, the complete demonstration, as hypothesized, was effective in changing the structures used. This treatment, however, stored a surprise: It did not improve success. This may be evidence for a two-stage model of problem solving, such that the first stage involves perceiving the structure; and the second stage involves using the structure to solve the problem. This particular form of complete information, then, was not as complete as was expected. It placed heavy emphasis on the construction of the matrix but minimal emphasis on its use. We shall consider the implications of this more when we discuss the possible processes used to develop these structures.

New Hypotheses

The fourth goal of this study was to obtain new hypotheses about the processes involved in developing these structures. Some of these have been suggested throughout this paper and will now be discussed in detail.

First, recall that a two-stage model of problem solving was suggested in Chapter 1. Its main purpose was to aid the discussion of structures, that is, to separate the formation of a structure from the use of one. Some of the analyses reported in Chapter 3 may shed light on these two processes.

Consider two specific findings: first, that S's demonstration of the appropriate structure resulted in its use but not in increased success, suggesting that structure building, the first stage, is not a necessary or a sufficient condition for problem solution. But consider the second finding: that before treatment, there was a high relationship between structure and success. Apparently, even if the abilities are distinguishable, they must normally be correlated. Perhaps both stages (i.e., the development of the structure and the use of it) are the result of a third variable. Perhaps, for example, differences in goals are behind the differences in structures. In this case, each structure would have been designed for a particular use, designed in order to be used, not designed and then used. If this were the case, knowledge of how to use the structure would actually precede construction of it. This hypothesis would explain why subjects who have been shown the structure cannot use it: they were not taught the goal for which it was intended. It cannot be certain from these data, however, that the structure had any direct relation to success.

The relation observed may only be an artifact of the presence of this third variable.

Some conjecture is possible, however, regarding variables that may be behind these individual differences. One hypothesis is that there may be individual differences in flexibility, or ability to adapt one's perceptions to new situations. This skill would include the ability to change encoding strategies with each new situation. Those without it would have a standard assortment of coding strategies which they would use in all situations, regardless of whether they were appropriate to the situation or not. Recall Shipstone's (1960) finding that there were two basic types of sorters in his task: those who used ready-made sorting systems, based on arbitrary characteristics such as the first letter in the sequence; and those who used problem-dependent sorts, or strategies developed on the basis of the material at hand. These sorters were more likely to use sorting formulae. The formula sorters of Shipstone's study may be similar to the matrix users of this study. Both groups of subjects are demonstrating some sort of flexibility, an ability to adapt to new situations.

How might we investigate this flexibility? One answer would be with a factor analysis of several problem solution protocols. We should search for other situations which fit the criteria originally given for this study, situations where there are individual differences in the manner in which the problem is solved and where one method of solution appears to be superior to the others. An analysis of several of these situations may disclose a general characteristic of flexibility in problem solving.

A second hypothesis is that the ability to see the structure may be related to contextual independence. That is, the ability to free one's self from the story, or context, and look only at the organizational structure.

There is some evidence from subject's reactions to their task that these structures are not automatically imposed on the information but rather are developed after careful inspection of the situation. For example, matchers often re-started their organization several times. They seemed to be searching for some organizational structure and searching by means of trial and error. Even some matrix solvers began their first problem by matching or clustering and then scratched out this first attempt so that they could draw a matrix. Apparently, they discovered or suddenly perceived the matrix after they had difficulty working with their first structure. This was not a common occurrence, however. Most subjects seemed trapped by their first perception of the structure and were unable to free themselves from it in spite of its lack of usefulness in solving the problem. They seemed to look at the context, or the story framework around the data, rather than at its relational structure. Because these subjects looked more at the context than at the task, they have been labeled contextually dependent.

The ability to free one's self from the context seems conceptually at least to be similar to field independence, a variable discovered and measured by Witkin, Dyk, Faterson, Goodenough, and Karp (1962). This is the ability to perceive a physical object independently of its background. One type of task used to measure this ability is the familiar game picture titled "find the hidden ______ in this picture." Objects familiar to us, such as dogs, etc., are drawn into the foliage of a tree or some other confusing background. Spatial tasks, such as aligning a rod to a vertical position when it is placed before a wall of angular stripes, are also included in this ability.

All of Witkin's tasks were perceptual; and, though the tasks in this study were verbal, many subjects still failed to separate the structure from the context. This often led to mistaken assumptions, added information, or forced relations. For example, one subject argued that an ex-exhibitionist was also an ex-convict. His reason: how would we know he was an ex-exhibitionist if he hadn't been convicted? One subject, upon leaving the experiment, said, "This has been fun. . . . I'm not used to dealing with the criminal mind." These statements suggest that *S*s did not see the appropriate organizational patterns in the problems but instead saw the problems as dealing with a story.

Another contextually dependent approach used by subjects involved the insertion of a story of their own to create the relations between names and biographical data. For example, one subject found himself with two possible solutions for one problem: either Dixie was an ex-prostitute (and hence the lookout), or she was the brains behind the operation. The final solution was a combination of these: "Dixie was a smart lady who was a prostitute but decided robbing stores would lead to more money and so was the brains behind the operation." This subject, incidentally, was clustering. He was using a fairly sophisticated structure and still felt a need to insert a story to build the relations that he couldn't find with his structure. Context, then, is seen to function in a manner similar to the background or field in a perceptual task, since it engages the subject's attention and keeps the figure, or structure, hidden from him.

A third hypothesis, again not derived solely from the presented data, is that discrepancies among various subjects may reflect differences in motivation.

Perhaps the time difference represents a difference between an active and a passive approach to problem solving. Perhaps, too, the use of a structure to organize information is a voluntary act, done by those more motivated to do well. Certainly, the relationships between flexibility, contextual dependence, and this active/passive variable should be investigated.

We have, then, three possible hypotheses to account for the differences among these subjects: (a) flexibility, (b) contextual dependence, and (c) an active/passive approach. All three suggest continuous abilities, rather than the qualitative differences observed; and all are probably correlated with one another.

Relevance to Education

It was suggested in the Introduction that organization may be an important requisite to problem solving and, further, that schools should show interest beyond a single organization to the organization of new situations that students may encounter long after they leave the classrooms. Our concern has been aimed at the processes used to perceive organizational structures in new bodies of information.

That structures may appear different from individual to individual is disconcerting enough for a teacher, but to add to this that it may be a long time before we can teach students to adduce appropriate structures is plain disappointing. Though the treatments used here were not intended to be genuine instructions but to facilitate observation of Ss' reactions to various degrees of influence, we should still take time here to consider this study and its relevance to educators.

Consider first of all the simple situation of communication between teacher and student. There may often be misunderstandings that derive from different frames of reference. For example, the teacher may assume the student sees the situation in the same way he does, but this may not be the case. For most areas of knowledge, there is no easy way to observe the student's perceptions. The problems used in this study were self-contained bodies of knowledge, and no real subject matters are as simple as this. These findings suggest that the teacher ought to be especially careful, though, when discussing relationships, to insure that the student sees the same relations that the teacher does.

But this is a rather elementary observation. More important are the implications of this study to educational theory. For example, consider the area of aptitude-treatment-interaction (ATI) (see Cronbach, 1967). The research in this area is aimed at finding student abilities that are differentially affected by different treatments or instructional techniques. It has been suggested, for example, that students higher in intelligence may prefer a discovery approach while students of lower ability may improve more in a highly structured environment. Few of these ATI's have been found. The trend now is to search for qualitative differences (for example, see Glaser, 1972) rather than dividing students on continuous measures such as IQ. The variable investigated in this study may be such a qualitative variable.

But those who oppose ATI (e.g., Carroll, 1967) have suggested that this approach may in the end harm students, since it will encourage them toward rigid rather than flexible behavior. If, for example, we wanted to teach subjects how to solve problems such as those used in this study, we could do one of two things: we could teach them the most appropriate structure and then teach them how to use it, or we could see what structure they begin with and then try to teach them as best we could with the structures they preferred. The first instructional method shows him the optimal organization; the second teaches him to get by with what he has.

Even using the first method, we may not be teaching flexible behavior but only a series of formulae for those situations which are taught in school. Discovery of a general ability to adapt, such as that labeled flexibility, must precede questions of how to teach it, or whether it can be taught.

Another instructional technique that has gained in popularity over the years is the use of advanced organizers. These are brief introductions to new areas of knowledge, designed to provide structure. Ausubel (1968) suggests that this organizer should tie the new knowledge into previous knowledge so that its structure will have a good "fit" with the structures already known to the student. But this technique may also backfire if the teacher is unaware of the student's existing structures. DeCecco (1968) has suggested that methods of measuring these existing structures are needed and that they should be included in the teaching-learning system, in the assessment of "entering behavior."

The hypotheses discussed earlier, however, suggested that Ss' role may be much more active than these theorists have implied. If those hypotheses have any merit, then better measures of entering behavior might come from measures of such general characteristics as flexibility, contextual independence, or general active/passive approach to new material.

Finally, the relationship between the two "stages" of problem solving may help teachers. Knowledge of which comes first and how the two interact may help teachers to understand the whole of problem solving and thereby enable them to teach the process better.

Summary

There were four main goals. The first was to find verbal material for which different structural perceptions could be observed. Then the relationship between these perceptions and success at solving problems was measured. The relation was quite high. Four treatments were then compared for their effects on these structures. Only one was able to influence the structure, and it was not able to affect success on the problem. Implications of this finding were discussed as well as the relevance of the study to educators. Some avenues for future research were listed.

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APPENDICES

APPENDIX A

THE PROBLEM MATERIAL

Appendix A

The Problem Material

Problem One

Judge Wharton presided over several important trials last year. Each involved a different crime, and each resulted in a different sentence.

1. Yelon kidnapped children.
2. The five-year sentence was served at Jackson prison.
3. One of the defendents got a forty-seven year sentence.
4. Porter got ten years.
5. Kennedy was sent to San Quentin Prison.
6. One of them was sent to Alcatraz.
7. Teitlebaum had stolen money.
8. The one who stole secret documents got life.
9. One of them would serve eight years at Leavenworth.
10. The jewel thief got five years.
11. Porter stole cars.
12. Yelon was sent to the Ingham County jail.

WHAT WAS JOHNSON'S SENTENCE? (Answer: 5 years at Jackson Prison)

Problem Two

A gang of men are planning to rob a bank tomorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hide-out cabin.
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hide-out cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Answer: rent the hide-out)

Problem Three

Last week, a gang of women robbed an adult bookstore. Each came from a different background before entering the gang, and each had a different motive for the crime.

1. One of them was the brains behind the operation.
2. The standby wanted to rob the store for its magazines.
3. Peggy used to be a go-go dancer.
4. The getaway driver wanted to rob the store for its lottery tickets.
5. Myrna carried the gun on the job.
6. The lookout used to be a prostitute.
7. Katy wanted the films from the store.
8. One of them wanted the money.
9. Bertha used to be a roller derby champion.
10. The getaway driver was an ex-convict.
11. Myrna used to race cars.
12. The ex-roller derby champion wanted to rob the store for its books.

WHAT BACKGROUND DID DIXIE COME FROM BEFORE SHE ENTERED THE GANG? (Answer: she was an ex-convict)

Problem Four

Pillar of the community, Herman Merker, was murdered last Thursday afternoon. Several suspects have been identified. Each has a different motive and a different alibi. One motive was blackmail. Smith was a lawyer. Jackson's favorite ice cream was tutti-fruitti. The dentist said he was at the races. Jones claimed he was working. Brown's motive was anger over a recent business deal. One of the suspects was left-handed. Miller was a corporate executive. The restauranteur claimed he was yachting when the crime occurred. The lawyer's motive was money. One of the suspects insisted he had been dining with his lover. The one who said he was golfing was angry over an insult. One of them had a wooden leg. An old army grudge proved to be the motive for the supposed yachter. Jones was a doctor.

WHAT WAS JACKSON'S ALIBI? (Answer: he was yachting)

APPENDIX B

INSTRUCTIONS FOR CATEGORIZING SUBJECTS

Appendix B

Instructions for Categorizing Subjects

Our interest is in the manner in which subjects perceive the information present to be organized. There are four identifiably different perceptions that a subject may have when faced with one of these problems. They are labeled according to the methods each type uses to represent the information on paper. Subjects are called matrix users, clusterers, matchers, or no-structure users. The organization has certain recognizable characteristics that are reflected in each of these paper and pencil representations. The material is closed, for example. That is, the subject need not use any information outside of that presented to solve the problem. If he does use outside information, he is called a no-structure user. This does not mean that he is not using any organization at all, but simply that he is not using any organization that is based on the actual information.

Another characteristic of the information is that it is two-dimensional. This means that each element of information can be cross-referenced. Any subject that recognizes this fact will organize the data on paper in a manner that will reflect this: he will use a matrix.

Between these two extremes are two other categories: matchers, who recognize that the system is closed but do not see any structure, and clusterers, who also recognize that the system is closed, but do see part of the structure. The clusterers see the data as organized according to one dimension but fail to see the second dimension.

These four types of subjects need to be objectively recognized and separated from one another on the basis of their written protocols. The following description provides detailed rules for recognizing each type and assigning each subject to his appropriate category.

I. Matrix users:

Clues that a matrix was used are:

(a) Each piece of information must share either a column or a row with other information of the same type. That is, if a given column or row contains names of people, it may not include names of crimes, past histories, or any other type of information.

(b) Either the spatial arrangement must be orderly and compact, there must be lines drawn between the columns and rows, or there must be titles given to the columns or rows, thus providing clear evidence that the information was intended to be classified according to its category as well as according to the person with whom it is identified.

II. Clusterers:

The label of cluster should result from protocols containing clearly separated groups of words. Clues to help you recognize a clusterer are:

(a) The information may take the same arrangement as that of a matrix but with markings to suggest that only one of the dimensions was used in the organization. That is, there may be wide separation between the columns so that each appears to be a separate grouping; or there may be hyphens connecting the items in each row thus making each row appear as a separate group. If either of these criteria is used, the information collected into a group must not belong to the same category, but instead must be connected to the other items by way of a common referent person.

(b) Certain markings may suggest clustering intentions: encircled groups of words, irregular placement of groups (as opposed to the horizontal and vertical placements found among matrix users), or hyphenated groups of words.

The main distinction between matrix solvers and clusterers is in their perception of the organization as unidimensional or bidimensional. If it cannot be determined which of these categories a subject belongs in, he should be put into the matrix group.

III. Matchers:

This label is given to persons who seem to have recognized that the system is closed but who have not seen any structure in the information. They are called matchers because, in their search for a structure, they tend to match statements that seem to go together. If rewriting occurs, the information will still not be grouped as it is in a cluster solution. Some clues to a matcher are:

(a) The subject may begin anew several times in his attempt to solve the problem.

(b) The protocol may appear to consist of one list of some element (for example, all crimes, or all sentences) with one or two of the items in the list connected to one other item.

(c) Rather than writing any information, the subject may simply draw lines between different numbered statements in the original presentation or list statement numbers below, connecting these numbers.

IV. Nonmethod users:

There are two basic types of protocols which fall into this category: those where nothing is written except the answer to the question and those where some justification is included along with the answer, but the justification has no bearing on the information presented to S. This category contains those Ss who apparently do not even perceive that the system is closed. They, therefore, feel that they are left to their own devices to arrive at an answer and will either simply guess or will use sources outside the problem to help them solve.

APPENDIX C

THE TREATMENTS

Appendix C

The Treatments

Vague Suggestion

"Before you do the next two, let me give you a hint. The trick to these problems is in the way you organize the information. When you do the next ones, try to think of the best possible way to organize the information. Don't even try to find an answer until after you have discovered the best organization."

Hint

"Before you do the next two, let me give you a hint. The trick to these problems is in the way you organize the information. When you do the next ones, try to organize the information into a matrix. Don't even try to answer the question until you have discovered how to use the matrix to organize the material."

Complete Information

"Before you do the next two, let me give you a hint. The trick to these problems is in the way you organize the information. When you do the next ones, try to organize the information into a matrix. Here's how: List all the people in a column. (*E* performs all behaviors as he describes them to *S*.) Now you know that there are three things you need to know about each person: their part in the crime, their cars, and their past histories. So make a column for each of these things. (E draws the column and row dividing lines.) This is called a matrix, and you can use it to figure out the problem. All you have to do is figure out what goes into each of the squares. I usually start by putting in all the things that are connected to a name. For example, the third sentence connects the Chevrolet with Al. (E writes "Chevrolet" into the car column across from Al's name.) Then go through and pick out all the items that can be connected to names. (E enters all possible items.) Are you following me? (Answers any questions up to this point.)

Now you have to try to connect cells that don't have any names with them. For example, this one says (the second one) the Ford owner will rent the hideout. That connects a car with a part in the crime, but you don't know which person it goes with. It can be either Monk or Skip, because they're the only ones who have those columns open. (Pause to check if S is following the reasoning.) So you have to find some other sentence about the same thing. (Peruses the list until pointing at number ten.) Here it is. This one tells us that it was the exhibitionist that drove the Ford. Now we can connect up the past with the part in the crime and the car. This leaves Fred as the person since he is the only one with all three of those columns empty. (Any questions are answered.)

APPENDIX D

EXAMPLES OF PROTOCOLS

APPENDIX D

Last week, a gang of women robbed an adult bookstore. Each came from a different background, before entering the gang, and each had a different motive for the crime.

1. One of them was the brains behind the operation.
2. The standby wanted to rob the store for its magazines.
3. Peggy used to be a go-go dancer.
4. The getaway driver wanted to rob the store for its lottery tickets.
5. Myrna carried the gun on the job.
6. The lookout used to be a prostitute.
7. Katy wanted the films from the store.
8. One of them wanted the money.
9. Bertha used to be a roller derby champion.
10. The getaway driver was an ex-convict.
11. Myrna used to race cars.
12. The ex-roller derby champion wanted to rob the store for its books.

WHAT BACKGROUND DID DIXIE COME FROM BEFORE SHE ENTERED THE GANG? (Please do your scratchwork on this side of the page, but write your answer on the back.)

	Background	Did on job
Peggy	go go Dancer	
Myrna	race cars	gun
Kathy	ex con	wanted films
Bertha	Roller Derby	wanted Books
Dixe	Prost	

MATRIX

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hideout cabin.
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

AL
Chev.
gas

Skip
president ASMSU
Dodge

Joe
gun
Honda
suitcase?
ex-con.

Fred
Mer + Ford
rent cabin

Monk
guard

CLUSTERS

Pillar of the community, Herman Merker, was murdered last Thursday afternoon. Several suspects have been identified. Each has a different motive and a different alibi. One motive was blackmail. Smith was a lawyer. Jackson's favorite ice cream was tutti-frutti. The dentist said he was at the races. Jones claimed he was working. Brown's motive was anger over a recent business deal. One of the suspects was left-handed. Miller was a corporate executive. The restaurateur claimed he was yachting when the crime occurred. The lawyer's motive was money. One of the suspects insisted he had been dining with his lover. The one who said he was golfing was angry over an insult. One of them had a wooden leg. An old army grudge proved to be the motive for the supposed yachter. Jones was a doctor.

WHAT WAS JACKSON'S ALIBI? (Please do your scratchwork on this side of the paper, but write your answer on the back.)

NO STRUCTURE

Last week, a gang of women robbed an adult bookstore. Each came from a different background, before entering the gang, and each had a different motive for the crime.

1. One of them was the brains behind the operation.
2. The standby wanted to rob the store for its magazines.
3. Peggy used to be a go-go dancer.
—4. The getaway driver wanted to rob the store for its lottery tickets.
5. Myrna carried the gun on the job.
6. The lookout used to be a prostitute.
7. Katy wanted the films from the store.
8. One of them wanted the money.
9. Bertha used to be a roller derby champion.
—10. The getaway driver was an ex-convict.
11. Myrna used to race cars.
12. The ex-roller derby champion wanted to rob the store for its books.

WHAT BACKGROUND DID DIXIE COME FROM BEFORE SHE ENTERED THE GANG?
(Please do your scratchwork on this side of the page, but write your answer on the back.)

Peggy
go-go dancer

Myrna
race cars
carried gun

Katy
wanted films

Bertha
roller derby
wanted books

Dixie

brains
getaway driver D
carried gun M
lookout K D
standby M P D

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hideout cabin.
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

The ideaman for the gang

NO STRUCTURE

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hideout cabin.
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

2 - 10
5 - 9
8 - 12
3 - 11
1 - 7

MATCHING

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hideout cabin. m F
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict. a g F
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner. m F
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin. a g F
11. One of them used to be a gas station attendant. a g F
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

Al	Joe	Monk	Fred	Skip
(1) chevy	(1) Honda	(1)	(1)	(1) Dodge
(2)	(2) gun	(2)	(2)	(2)
(3)	(3)	(3) guard	(3)	(3) pres.

MATRIX

Last week, a gang of women robbed an adult bookstore. Each came from a different background, before entering the gang, and each had a different motive for the crime.

1. One of them was the brains behind the operation.
2. The standby wanted to rob the store for its magazines.
3. Peggy used to be a go-go dancer.
4. The getaway driver wanted to rob the store for its lottery tickets.
5. Myrna oarried the gun on the job.
6. The lookout used to be a prostitute.
7. Katy wanted the films from the store.
8. One of them wanted the money.
9. Bertha used to be a roller derby champion.
10. The getaway driver was an ex-convict.
11. Myrna used to race cars.
12. The ex-roller derby champion wanted to rob the store for its books.

WHAT BACKGROUND DID DIXIE COME FROM BEFORE SHE ENTERED THE GANG? (Please do your scratchwork on this side of the page, but write your answer on the back.)

MATCHES

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. ~~The Ford owner will rent the hideout cabin.~~
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. ~~Joe will carry the gun.~~
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. ~~Skip owns a Dodge.~~
9. ~~Joe drives a Honda.~~
10. ~~The ex-exhibitionist will rent the hideout cabin.~~
11. One of them used to be a gas station attendant.
12. ~~The Dodge owner used to be ASMSU president.~~

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper; but write your answer on the back.)

11 / carry 3 — suitcase 1

gasstation 11

monk security guard 7

MATCHES

Piller of the community, Herman Merker, was murdered last Thursday afternoon. Several suspects have been identified. Each has a different motive and a different alibi. One motive was blackmail. Smith was a lawyer. Jackson's favorite ice cream was tutti-frutti. The dentist ~~said he~~ was at the races. Jones claimed he was working. Brown's motive was anger over a recent business deal. One of the suspects was left-handed. Miller was a corporate executive. The restaurateur claimed he was yachting when the crime occurred. T~~he lawyer's motive was money.~~ One of the suspects insisted he had been dining with his lover. The one who said he was golfing was angry over an insult. One of them had a wooden leg. An old army grudge proved to be the motive for the supposed yachter. Jones was a doctor.

WHAT WAS JACKSON'S ALIBI? (Please do your scratchwork on this side of the paper, but write your answer on the back.)

SMITH

LAWYER

MOTIVE B

JACKSON

TUTTI FRUTTI

BROWN

MOTIVE ANGER

BUSSINESS DEAL

JONES

WORKING

DOCTOR

MILLER

CORPORATE EXEC.

CLUSTERS

Last week, a gang of women robbed an adult bookstore. Each came from a different background, before entering the gang, and each had a different motive for the crime.

1. One of them was the brains behind the operation.
2. The standby wanted to rob the store for its magazines.
3. Peggy used to be a go-go dancer.
4. The getaway driver wanted to rob the store for its lottery tickets.
5. Myrna carried the gun on the job.
6. The lookout used to be a prostitute.
7. Katy wanted the films from the store.
8. One of them wanted the money.
9. Bertha used to be a roller derby champion.
10. The getaway driver was an ex-convict.
11. Myrna used to race cars.
12. The ex-roller derby champion wanted to rob the store for its books.

Bertha

WHAT BACKGROUND DID DIXIE COME FROM BEFORE SHE ENTERED THE GANG?
(Please do your scratchwork on this side of the page, but write your answer on the back.)

MATCHES

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
2. The Ford owner will rent the hideout cabin.
3. Al owns a Chevrolet.
4. The ideaman for the gang is an ex-convict.
5. Joe will carry the gun.
6. The getaway will be maneuvered by the Mercedes owner.
7. Monk used to be a bookstore security guard before he entered the gang.
8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

1, 2, 4, 6, 10, 11, 12

NO STRUCTURE

A gang of men are planning to rob a bank tommorrow. Each will have a different part in the crime, and each came from a different background before entering the gang.

1. One of them will carry the suitcase.
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8. Skip owns a Dodge.
9. Joe drives a Honda.
10. The ex-exhibitionist will rent the hideout cabin.
11. One of them used to be a gas station attendant.
12. The Dodge owner used to be ASMSU president.

WHAT PART WILL FRED HAVE IN THE CRIME? (Please do your scratch-work on this side of the paper, but write your answer on the back.)

Name	car	~~duty~~ part in crime	previous occupation
		~~carry suitcase~~	
Fred	Ford	hideout cabin	ex-exhibitionist
Al	Chevy	→ Idea man?	ex con
Joe	Honda ~~mercedes~~	carry gun ~~getaway car~~	gas station attendant
Monk	Merc	getaway car	bookstore security guard
Skip	Dodge	carry suitcase	~~[illegible]~~ ASMSU president ~~gas station attendant~~
~~Fred~~			

MATRIX