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Problem Solving Processes as a Function of the Organization of the Problem Situation and Its Relation to the Task Requirements

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PROBLEM SOLVING PROCESSES AS A FUNCTION OF THE ORGANIZATION OF THE PROBLEM SITUATION AND ITS RELATION TO THE TASK REQUIREMENTS

by

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VITA

The author, John Robert Buri, is the son of Robert Francis Buri and Catherine (Pierick) Buri. He was born on February 8, 1950, in Dubuque, Iowa.

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In September, 1968, he entered Loras College in Dubuque, Iowa as a Presidential Scholar, and in May, 1972, he received the degree of Bachelor of Arts with a major in psychology. While attending Loras College, he was elected to the Delta Epsilon Sigma National Honor Society in 1969. He was also elected to "Who's Who Among American College and University Students" in 1971 and 1972.

Upon graduation from Loras College, he was awarded one of five national post-graduate scholarships granted by the National Collegiate Athletic Association, and in September, 1972, he was granted an assistantship in Psychology at Loyola University of Chicago.

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CHAPTER I

INTRODUCTION

Bourne, Ekstrand, and Dominowski (1971) have stated that problem solving investigations may be characterized as attempts to obtain the answers to two related questions: a) "How do people go about solving a problem?" and b) "What manipulations affect the difficulty of that problem?" These two questions essentially comprise complementary sides of the same issue. Data which specify the problem-solving processes which individuals employ will obviously indicate what variables can affect problem difficulty; and conversely, manipulations which affect problem solving difficulty will provide information as to the processes which are important in obtaining the solution to the problem.

Answers to the first question above are derived in the present study through the use of a selection paradigm within a search-type problem-solving task. In such a task, several alternative paths to the solution of the problem are presented, and S is free to select for use any one of those paths provided. The specific path chosen by S may be recorded both in terms of the number of items of information necessary for the solution to be reached and in terms of the order in which these items are selected. The manipulations employed in this investigation which pertain to the second question above (i.e., manipulations which may affect problem difficulty) are

concerned with the organization of the problem situation and its solution state.

/ Problem situations have been variously defined by several researchers. Duncker (1945) stated that a problem arises when an organism desires a goal, but some obstacle prevents him from reaching this goal. As a result, the organism must devise some plan of action which will overcome the difficulties of the existing situation to produce an unobstructed path to the goal. Problems have been similarly described in a gestaltist manner by Raaheim (1971), who has stated that a problem exists when there is a "gap" in the "structure" of a situation. During the problem-solving process, an individual attempts to fill this "gap" by satisfying the constraining conditions which surround the problem situation. Bourne et al. (1971) have defined a problem as a situation to which a person must respond in order to produce a solution which meets certain specific requirements. Each of these definitions differs somewhat from the others, but it appears that they all suggest that the person confronted by a problem situation is forced to respond to that problem situation, altering it, if necessary, to meet the requirements imposed by the constraining conditions encompassing that situation. / As Duncker (1945) has pointed out, a person always reaches the solution to a problem through a consideration of the demands made by the requirements of the problem situation upon what is given in the problem.

The person who is confronted by a problem is intent upon transforming the existing problem state into the desired goal state. Organization of the problem situation is an important step in this

process, for as Simon and Newell (1971) have asserted, structure provides redundancy which may be used to predict certain properties of the problem, thereby making the various parts of the problem situation more accessible to Ss for systematic manipulation. To illustrate, suppose that you wish to find the book For Whom the Bell Tolls by Ernest Hemingway in the library. If the books in the library were not organized according to some system (e.g., Library of Congress Classification System), this would obviously constitute an overwhelming task. However, because of the organization that has been imposed upon these books, you are able to accurately predict that For Whom the Bell Tolls will be found on a particular floor of the library, in a specific section on that floor, and on a particular bookshelf in that section; you will not even have to randomly search through the books on that bookshelf because they have been sequentially numbered for you. Structure thus produces predictability that allows for a selective (rather than a random) search through the elements of the problem situation.

Wortman and Greenberg (1971) have suggested that an understanding of the categorical interrelationships of the elements which make up the problem situation is an important aspect in this structuring process. Bruner, Goodnow, and Austin (1956) have reported data which confirm this suggestion. They found that in a concept-learning task using a selection paradigm, Ss who were presented the problem attributes and their respective values in an ordered array, formed the concept more quickly and with fewer errors than did those Ss who were given the same task but with the attributes and values

presented in a random array.

Schwartz (1971) has stated that the organization of problem materials into a matrix structure, which is a false-hierarchical structure (i.e., the categories of the problem and their interrelationships are enumerated in a factorial display rather than in a superordinate-subordinate organization which is indicative of a true-hierarchical structure), is similarly conducive to efficient problem-solving behavior. Schwartz (1971) and Schwartz and Fattaleh (1972) reported that matrix representations of problem situations resulted in problem-solving performance which was superior to the performance of Ss who were presented the problem situations in such a way that their respective parts were informally grouped.

Bourne at al. (1971) have stated that as the degree or quality of the organization of the problem situation increases, the more difficult it becomes to rearrange that problem situation. This has been demonstrated by several researchers in the area of anagram solution. Mayzner and Tresselt (1959) reported that anagrams composed of high-frequency bigrams not found in the solution words were more difficult to solve than were anagrams composed of low-frequency bigrams not found in the solution words. These findings were interpreted as indicating that the anagrams containing high-frequency bigrams were better organized into cognitive patterns or units, which resulted in greater difficulty in solving these anagrams since their elements were rearranged less easily than were the elements of the low-frequency-bigram anagrams. Seemingly disconfirming evidence has been presented by Dominowski and Duncan (1964)

and Dominowski (1967), but Mayzner and Tresselt's findings have received support from a recent formulation by Solso, Topper, and Macey (1973). These latter researchers have suggested that bigram versatility, which is defined as the number of different words in which a given bigram may occur, is an important variable when considering the influence of bigram frequency upon anagram solution time. Thus, in the case of bigrams contained in the anagrams but not in the solution word, a high-frequency bigram which is also high in bigram versatility (e.g., "th") will generate a greater number of potential solution words that must be considered by S before he may examine another bigram than will a high-frequency bigram that is low in bigram versatility (e.g., "of"). Such anagrams which are organized into high-frequency, high-versatility bigrams will result in a greater delay of the letter-sampling and rearrangement process; and, as Warren and Thomson (1969) have pointed out, any variable which postpones this process will inevitably increase the amount of solution time required. Further support for the contention that as the organization of the problem situation increases, the ease with which that problem situation may be rearranged decreases, is provided by Herbert and Rogers (1966) who demonstrated that the easier an anagram is to pronounce, the easier it is to organize and to handle as a cohesive unit, and therefore the harder it is to solve since rearrangements of it are more difficult. Dominowski (1969) corroborated these findings, demonstrating that as the pronunciation of nonsense anagrams increased, the number of anagrams solved decreased. The logical extreme of this experimental design is to present as the

to-be-solved anagram, a word (e.g., "earth") different from the required solution word (e.g., "heart"). This idea has been variously manipulated by Beilin and Horn (1962), Beilin (1967), and Ekstrand and Dominowski (1965; 1968), from which research has emerged the firm conclusion that word anagrams are more difficult to solve than are nonsense anagrams.

The research considered thus far has all demonstrated circumstances in which the more organized the problem situation is, the more difficult it is to solve that problem. It should not be concluded from this, however, that a positive correlation necessarily exists between the organization of the problem situation and problem difficulty, for as Bourne et al. (1971) have pointed out, the more similar is the organization of the problem situation to the solution state, the easier that problem is to solve. It has been suggested that this is due to the fact that as the similarity of the organization of the problem situation to the solution state increases, fewer changes and rearrangements are needed in order to go from the problem to the solution. Once again these findings have been demonstrated in the area of anagram solution. Mayzner and Tresselt (1958) compiled a list of anagrams composed of "easy" letter orders (i.e., more similar to the letter orders of the solution words) and a list of anagrams composed of "hard" letter orders (i.e., less similar to the letter orders of the solution words). It was found that the "easy" letter-order anagrams were solved more quickly than were the "hard" letter-order anagrams. It was suggested that these results were due to the fewer number of letter rearrangements

required to get from the anagram to the solution word when the "easy" letter orders were used. Dominowski (1966) obtained results which support this suggestion. Although problem difficulty was not a simple linear function of the number of letter moves required to solve the problem, it was found that anagrams which required one letter move for solution were much easier to solve than were anagrams requiring more than one letter move in order to solve the problem.

A consideration of the data discussed thus far suggests that it might be beneficial here to treat the organization of the problem situation as a variable along a continuum of difficulty ranging from an organized problem situation that is similar to the solution state, to an unorganized problem situation, to an organized problem situation that is dissimilar to the solution state. An understanding of why problem-solving behavior should be consistent with these expectations may be derived from a consideration of Guthrie's (1971) account of the effect of the verbal statements of object problems [e.g., Maier's (1931) two-string problem and Duncker's (1945) candle problem] upon problem solution. Guthrie asserted that the verbal statement of a problem, which serves as the stimulus, evokes mediators which are used by S to reach a solution to the problem. He found that whether or not the solution to the problem was reached in an efficient manner was largely dependent upon whether or not the mediators evoked by the verbal statement of the problem were conducive to problem solution. Consistent with these findings, Safren (1962) found that anagram solution was facilitated when the presentation of the list of anagrams to be solved by S was accompanied by a label

which was an associate of the solution words from which the anagrams were formed. In agreement with Osgood's (1953) considerations of associates as mediators, Safren interpreted the label as serving a mediating function, eliciting the solution words. These data suggest that a verbal organization of a problem situation that is similar to the solution state will generate more mediators that are conducive to the problem solution than will a verbal organization of that problem situation that is dissimilar to the solution state.

An example here might serve to clarify how the organization of a problem situation can generate mediators that may be conducive or non-conducive to the solution of the problem. In Duncker's (1945) candle problem, S is required to attach a candle to the wall in such a way that it will burn without dripping wax on the floor. The S must accomplish this task by using only those items which have been provided, which include a candle, a small box, some tacks, and some matches. The solution to the problem may be reached by attaching the box to the wall with the tacks and then placing the candle on the box, which thus serves as a platform. Performance on this task is to a large extent determined by the way in which the problem materials are presented. Adamson (1952) and Glucksberg (1962) reported that when the problem materials were organized in such a way that the tacks were placed in the box, performance was poorer than when the tacks and the box were presented separately. Glucksberg and Weisberg (1966) suggested that these results were due to the fact that Ss failed to notice the box as a distinct object when it was used to hold the tacks. In support of this suggestion, Glucksberg and Weisberg found

that performance on the candle problem was facilitated when each object was labeled separately. Thus the organization of the problem situation that was dissimilar to the solution state (i.e., the tacks were placed in the box) generated mediators that were not conducive to problem solution, that is, they emphasized the box not as a distinct object, but rather as an object bound to its function as a container; and the organization of the problem situation that was similar to the solution state in that each object was labeled separately generated mediators that were conducive to problem solution since they emphasized the box as a separate object apart from its function as a container.

The concept of cues has been similarly discussed in a mediational manner. Harlow (1951) described cues as stimuli which elicit "organized response patterns" in the individual which may be used in obtaining the solution to the problem. Bourne (1966) stated that words often serve as cues, providing an efficient and convenient way in which information may be transferred. The organization imposed upon a problem situation through the verbal statement of that problem may thus be viewed as serving a cuing function. As such, the _E_-imposed organization of the problem situation may be used by _S_, as may all other cues available to him, in order to solve the problem. [As Jenkins (1974) has pointed out, individuals who are confronted by a task within an experimental setting _will_ make use of any materials, devices, schemes, etc. which the task requirements will allow in order to organize the experimental items and complete the task.]

Easterbrook (1959) has also discussed the concept of cues

mediationally, describing them as any aspects of a situation which a person observes and uses, thereby transferring information in order to arrive at a response. Restle (1955) has similarly defined cues as any objects in the stimulus situation to which S can learn to make a differential response. Both Easterbrook and Restle have asserted that cues can be either relevant or irrelevant, depending upon whether or not they may be used by S to predict how a reward may be obtained, or equivalently, how the problem may be solved. Consistent with Easterbrook's discussion of cues, to the extent that the responses given by S are congruent with the organizational cues of the problem statement, those organizational cues may be said to have been used and to have transferred information. Just as the cues from which the information is transferred may be relevant or irrelevant, so too the information may be relevant or irrelevant. However, the relevance of the information is not an intrinsic part of the information itself; rather, its relevance is dependent upon the relation between the information and the requirements of the task. Thus, if the organization of a problem situation imposed by E through the verbal statement of the problem is consistent with the task requirements, then the information transferred from these organizational cues may be relevant to the problem solution and therefore facilitative; however, if the organization of the problem situation is inconsistent with the task requirements, then the information transferred may be irrelevant, and therefore it may have an impairing effect.

Postman and Senders (1946) have approached this issue in a

slightly different manner. It is their contention that learning is always the result of an antecedent cuing or "priming" of the individual, whether that priming be overt, through explicit instructions to learn, or covert, through subtle cues in the experimental situation. Such priming results in a set, which Bourne et al. (1971) have defined as a tendency to respond to a situation in a particular way. Whether such an induced set will facilitate or impair problem-solving performance is dependent upon the applicability of that set to the problem. Thus, if the set is consistent with the task requirements, it may aid problem-solving behavior. However, if it is inconsistent with the task requirements, it may hinder performance on the problem.

To illustrate, suppose that S has been presented Luchins' (1942) water-jars problem in which he is required to measure a certain amount of water using three jars of specified capacity. Set is generally induced in this task be requiring S to solve a series of problems, all of which must be solved by the same method (e.g., fill jar A, then pour water from it filling jar B once and filling jar C twice; the water remaining in jar A is the required amount). By altering the capacities of the jars presented to S, a series of different problems that all require the use of the same solution method may be constructed. Once the set to use the determined method has been established in a series of problems, if the next problem presented to S may be solved by using that method set, then that set will facilitate the problem-solving behavior. However, if the next problem presented to S cannot be solved by using the established

method set, then problem-solving performance will be impaired.

Johnson, Lincoln, and Hall (1961) suggested that analyses of problem-solving behavior often neglect an essential aspect of the problem-solving process, namely, preparatory activity. In a series of investigations (Johnson & Hall, 1961; Johnson, 1961; Johnson & Jennings, 1963), Johnson and his associates have demonstrated that before S will attempt to produce or select a solution to a problem, he will first formulate the problem, processing the material presented. This processing activity may take the form of an examining, a synthesizing, a structuring, or an encoding of the problem materials. After S has completed this initial preparatory stage, if he is unable to find a solution that matches his formulation, he will reformulate the problem and again look for a solution. Simon and Barenfeld (1969) have similarly reported that much of the structure which an S will impose upon a problem situation within problem-solving experiments takes place during the initial period of exposure to the problem. During this initial exposure period, an organizing activity occurs in which S is interested in gathering information about the structure of the problem situation itself, rather than in gaining information about the constraining conditions surrounding the problem situation. As Simon and Barenfeld stated, only after the essential properties of the problem situation itself are understood will S engage in a systematic search through the restricting conditions encompassing that problem situation. If this is so, it seems reasonable to expect that if Ss are required to structure the problem situation themselves before proceeding to find the solution to the

problem and if the problem-solving task is such that several paths to the solution of the problem exist, then when different groups of Ss are presented task requirements which restrict to differing degrees the number of paths to the solution that may be used, differences in problem-solving performance will result. The problem situation surrounded by less-constraining conditions (i.e., allow the use of more paths to the solution) offers S greater freedom in choosing an efficient means of solving the problem than does the problem situation that is encompassed by more restrictive requirements (i.e., limit the number of paths to the solution that may be used). If Ss consider the restrictive requirements surrounding the problem situation before they structure the problem, then there should be no differences in performance between those Ss who are presented a problem situation which has highly restrictive conditions and those Ss who are presented a problem situation with fewer constraining requirements. However, if Ss structure a problem before they give any consideration to the conditions which restrict the ways in which that problem may be solved, then this premature structuring of the problem may hinder the subsequent attempts to solve that problem. Therefore, according to the argument put forth above, the Ss who are presented a problem situation in which more of the paths to the solution may be used should perform better than those Ss who are given a problem situation in which the number of paths to the solution that may be used is limited. These results are expected simply because the former Ss have a greater chance (from a purely stochastic standpoint) of structuring the problem situation in a way that is consistent with the

task requirements.

In the present study, each S was presented a problem situation and a set of items of information which he could use in solving the problem. The problems used here had a logical structure, and the information available enabled a solution to be obtained in a logical and straightforward manner. That is, the solution could be achieved through the selection of a specific sequence of informative items. Such an organized sequence of responses made in an effort to achieve the solution to a problem has been termed a "strategy" (Bourne et al., 1971). To the extent that an S's strategy approximates the logical structure of the problem, his strategy may be said to be efficient. Measures of problem-solving efficiency may be obtained through analyses of the strategies employed by Ss. The analyses made in the present study provided two such efficiency measures for each S: a) the number of items of information needed to solve the problem; and b) the sequence in which these selections were made. These two measures were used to compute an Efficiency Score for each S. In addition to the Efficiency Score, measures were also taken on the accuracy of the solution that was achieved, the total time needed to obtain the solution, and the inter-item latencies.

The amount of information that could be used to solve the problem was manipulated in the present study. Some Ss were presented problem situations in which the use of any one of several efficient strategies was possible, while other Ss were presented problem situations in which restricted informative sets allowed the use of only one efficient strategy. A second manipulation involved the

presentation of the elements of the problem situation in a random vs. a hierarchical organization. These two manipulations of the problem materials were brought about to test several hypotheses.

The first hypothesis that is proposed here is concerned with the differential effects of presenting the elements of the problem situation in a random vs. a hierarchical order. Due to the increased complexity and the heightened informational load produced by the random presentation of the problem situation, it was hypothesized that the performance by Ss on problems whose elements have been hierarchically organized is superior to the performance by Ss on problems whose elements have been randomly ordered.

The organizational and mediational data discussed above suggest that if the problem situation is hierarchically organized in such a way that this organization is consistent with the task requirements, then the resultant hierarchical priming will produce more efficient problem-solving processes than will the priming that is the result of a hierarchical organization of the problem situation, which is inconsistent with the task requirements. The following hypothesis was therefore proposed: When the elements of the problem situation are hierarchically organized, Ss who are presented a problem situation whose organization is consistent with the items of information available perform better than those Ss who are presented a problem situation whose organization is not consistent with the information provided.

A third hypothesis is derived from the discussion of the research above which suggested the existence of an initial preparatory

activity in problem-solving behavior. Such organizational activity early in the problem-solving process may be beneficial or harmful, depending upon whether or not there is information available that is consistent with the initial formulation of the problem. It was therefore hypothesized that when the elements of the problem situation are randomly ordered, Ss who are presented more items of information that may be used in order to solve the problem perform better than those Ss for whom the number of items of information that may be used has been limited.

One further manipulation was incorporated into the present study to corroborate and extend the findings of Peterson and Aller (1971). These authors reported a study in which Ss were required to solve arithmetic addition problems in which the operations to be performed were presented in equations which took one of two forms: either a) the values to be added were presented and S was required to give the total value (e.g., $2 + 5 = x$), or b) one of the values to be added was presented along with the total value and S was required to provide the missing additive value (e.g., $2 + x = 7$). Peterson and Aller called this latter operation "negative addition." It was found that simple addition problems (i.e., those stated as "$2 + 5 = x$") were solved more rapidly by adults than were negative addition problems. In the present study, two types of word problems were constructed which correspond to these simple addition and negative addition problems. The simple addition problems here required that several additive values be summed in order to obtain a total, which was the desired solution. In the negative addition

problems, several additive values and the total value had to be manipulated in order to produce the desired solution, which was a missing additive value. It was hypothesized that performance by Ss on simple addition problems is better than the performance by Ss on the negative addition problems.

CHAPTER II

METHOD

Subjects

Ninety-six students participated in the experiment as part of an introductory psychology course requirement. Each S was tested individually in a session which lasted approximately 20 min.

Materials

Each problem was presented at the top of a 9" X 11" display board (Fig. 1). Beneath a paragraph explaining the problem that was to be solved were displayed a series of interrogative probes pertaining to that problem situation. These interrogative probes were questions whose answers could be used to solve the problem. They were presented on cardboard strips which were inserted in slots in the display board in such a way that the probes were visible through narrow rectangular windows. To the right of each interrogative probe was located its appropriate answer. Each answer was placed in such a manner that it was not visible until the cardboard strip on which it and its appropriate interrogative probe were presented were pulled to the right approximately ½ in., at which time the answer appeared in a small square window in the display board.

Score sheets were used which allowed E to record for each S the number of interrogative probes selected, the sequence in which these selections were made, the final solution to the problem that was given, the total time needed to reach the solution, and the

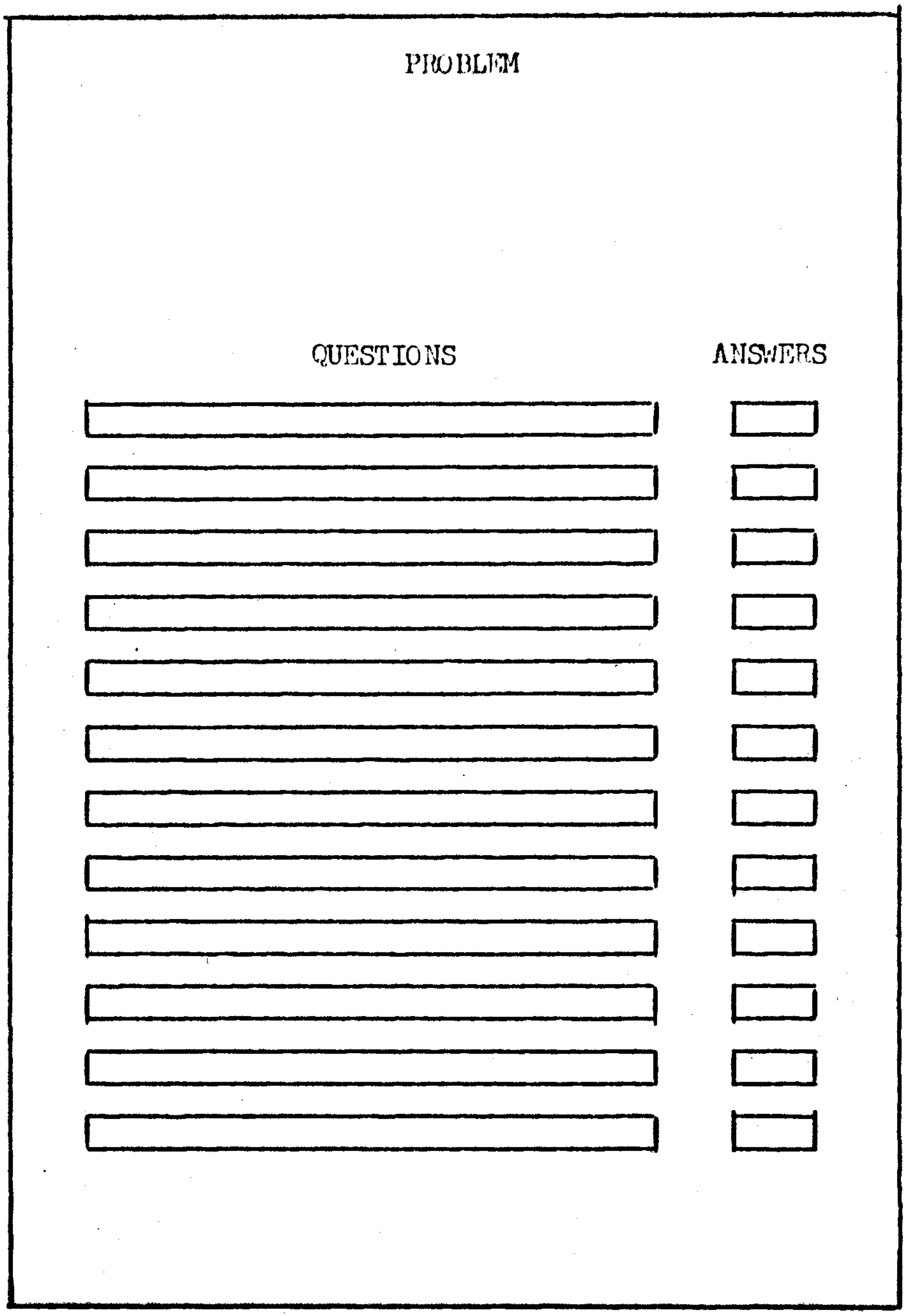

Fig. 1. Diagram of the display board.

inter-probe latencies.

The timing device used was a Sedeco impulse counter which registered 10 impulses per sec. from an impulse generator. The times were printed out by the counter onto a tape. The E was able to regulate the counter print-out by means of a control box which was wired to the timing device.

Procedure

Each S was required to solve three problems, the first two of which were practice problems. The first of these problems (Table 1) was based upon a situation in which there are two attributes (i.e., sex and achievement of students) with two values per attribute (i.e., male-female; pass-fail). The second of these practice problems (Table 2) was constructed from a situation in which there are two attributes (i.e., color and objective of airplanes) with three and two values per attribute, respectively (i.e., silver, gold, or white planes awaiting either take-off or landing instructions).

Each S was asked to solve a third problem consisting of a situation in which there are two attributes (i.e., make and body type of cars) with three values per attribute (i.e., Fords, Chevrolets, and Buicks; station wagons, compacts, and sedans). The structure and objective of this problem situation, along with the interrogative probes presented, were manipulated in order to construct the experimental treatment conditions. Four different statements of this problem, which constitute the structural manipulations of the problem situation, were generated. In two of these problem statements the elements of the problem situation were hierarchically organized;

TABLE 1

Practice Problem I: Two Attributes

with Two Values Per Attribute

Problem

Both males and females were enrolled in an introductory fine arts course at Loyola last semester. Only two grades were given, either pass or fail. How many males passed the course? 30

Questions	Answers
How many students were enrolled in the course?	63
How many tests were given in the course?	3
How many students passed the course?	49
How many students failed the course?	14
How many males were enrolled in the course?	40
How many times a week did the class meet?	3
How many females were enrolled in the course?	23
How many females failed the course?	4

TABLE 2

Practice Problem II: One Two-Valued Attribute

and One Three-Valued Attribute

Problem

On one particular day at Midway Airport there were several planes awaiting instructions. Some of these planes were on the ground awaiting take-off instructions and some of them were in the air awaiting landing instructions. Some of the planes on the ground awaiting take-off instructions were silver, some were gold, and some were white. Some of the planes in the air awaiting landing instructions were silver, some were gold, and some were white. How many white planes were on the ground awaiting take-off instructions?

Questions	Answers
How many white planes were in the air awaiting landing instructions?	10
How many silver planes were in the air awaiting landing instructions?	10
How many planes were there altogether awaiting instructions?	68
How many planes were in the air awaiting landing instructions?	28
How many gold planes were awaiting instructions?	21
How many people were waiting to board a plane at the airport?	538
How many gold planes were in the air awaiting landing instructions?	8
How many silver planes were awaiting instructions?	22
How many gold planes were on the ground awaiting take-off instructions?	13
Were weather conditions poor that day?	YES
How many silver planes were on the ground awaiting take-off instructions?	12

the remaining two problem statements presented the problem elements in a randomly organized manner. Appendix I contains the two hierarchically organized statements of the problem situation. The two randomly organized statements of the problem situation are presented in Appendix II. An important feature of this type of problem statement is that the attributes are interchangeable, that is, the attribute which is nested in one instance may become superordinate in another. In this way, a control of attribute order can be implemented, half the Ss in each experimental group receiving one presentation order of the attributes and the other half receiving the other attribute order. Thus, in the present problem, the cars may first be organized according to the makes of the cars followed by a structuring of the car body types within each car make (as in statement #1 in Appendix I), or they may be structured according to the car body types first with a subsequent organization according to the car makes within each body type (as in statement #2 in Appendix I). Thus the two hierarchically organized statements of the problem situation presented in Appendix I are transpositions of each other. Similarly, a transpositional wording was employed in the construction of the two randomly organized statements of the problem situation presented in Appendix II.

Two variations of the solution for which Ss were required to solve the problem constitute the manipulations of the objective of the problem situation. Each S was presented a problem in which either the total value (i.e., "How many cars did Mr. Jones look at altogether?"), or a single additive value (i.e., "How many Chevrolet

station wagons did Mr. Jones look at?", or equivalently, "How many station wagon Chevrolets did Mr. Jones look at?") was the solution required. Half the Ss in each experimental group which required the additive value were presented the former phrasing of the required additive value (i.e., "...Chevrolet station wagons...") while the other half received the latter phrasing (i.e., "...station wagon Chevrolets..."). In this way, a control for the effects of word order within the manipulations of the objective of the problem situation was implemented.

Each S was presented one of the four statements of the problem and one of the variations of the solution was required from each S. The resultant statement-solution combinations are listed in Table 3.

Further manipulations were accomplished through the presentation of the interrogative probes. All the interrogative probes that could be presented are listed in Table 4. Alternate phrasings of probes "C", "D", "E", "H", "I", and "K", corresponding to the alternate phrasing of the additive value solution (i.e., "How many station wagon Chevrolets did Mr. Jones look at?") discussed above, are presented in parentheses. These alternate phrasings were presented to half the Ss in each experimental group. (In those groups in which the additive value solution was required, these alternate phrasings accompanied the alternate phrasing of the additive value solution.) Thus a control for the effects of the word order of interrogative probes was implemented.

Twelve interrogative probes were presented to each S. Several

TABLE 3

Possible Statement-Solution Combinations

Organization	Statement	Solution Required: Total Value	Solution Required: Additive Value
Hierarchically Organized	Statement #1[a]	Statement #1 PLUS "How many cars did Mr. Jones look at altogether?"	Statement #1 PLUS "How many Chevrolet station wagons did Mr. Jones look at?" or "How many station wagon Chevrolets did Mr. Jones look at?"
	Statement #2[a]	Statement #2 PLUS "How many cars did Mr. Jones look at altogether?"	Statement #2 PLUS "How many Chevrolet station wagons did Mr. Jones look at?" or "How many station wagon Chevrolets did Mr. Jones look at?"
Randomly Organized	Statement #3[b]	Statement #3 PLUS "How many cars did Mr. Jones look at altogether?"	Statement #3 PLUS "How many Chevrolet station wagons did Mr. Jones look at?" or "How many station wagon Chevrolets did Mr. Jones look at?"
	Statement #4[b]	Statement #4 PLUS "How many cars did Mr. Jones look at altogether?"	Statement #4 PLUS "How many Chevrolet station wagons did Mr. Jones look at?" or "How many station wagon Chevrolets did Mr. Jones look at?"

[a] Statements #1 and #2 are presented in Appendix I.
[b] Statements #3 and #4 are presented in Appendix II.

TABLE 4

List of Possible Interrogative Probes

	Probes	Answers
A	How many Fords did Mr. Jones look at?	21
B	How many Buicks did Mr. Jones look at?	14
C	How many Chevrolet compacts did Mr. Jones look at?	9
	(How many compact Chevrolets did Mr. Jones look at?)	
D	How many Chevrolet sedans did Mr. Jones look at?	6
	(How many sedan Chevrolets did Mr. Jones look at?)	
E	How many Chevrolet station wagons did Mr. Jones look at?	10
	(How many station wagon Chevrolets did Mr. Jones look at?)	
F	How many sedans did Mr. Jones look at?	18
G	How many compacts did Mr. Jones look at?	21
H	How many Ford station wagons did Mr. Jones look at?	6
	(How many station wagon Fords did Mr. Jones look at?)	
I	How many Buick station wagons did Mr. Jones look at?	5
	(How many station wagon Buicks did Mr. Jones look at?)	
J	How many cars did Mr. Jones look at altogether?	60
K	How many Buick compacts did Mr. Jones look at?	5
	(How many compact Buicks did Mr. Jones look at?)	
L	How many cars does Mr. Jones own now?	2
M	How many children does Mr. Jones have?	6
N	How many different car lots did Mr. Jones go to while looking for a car?	18

distinct series of 12 interrogative probes were used. These distinct series of probes can be distributed into six separate groups. The placement of each series into a specific group was determined by the joint properties of the interrogative probes in that series. The series may first be grouped according to the objective of the problem situation (i.e., whether the total value or an additive value is the required solution). Each of these two classifications may then be subdivided into three groups, determined by the number and the quality of the paths to the solution of the problem that are allowed by the available interrogative probes. These three groups are: a) the series of probes allow the use of either of two paths to the solution; b) the series of probes allow the use of only one path to the solution, and that one permissible path is consistent with the hierarchical organization of the problem situation; and c) the series of probes allow the use of only one path to the solution, and that one permissible path is inconsistent with the hierarchical organization of the problem situation. The resultant six groups into which the several distinct series of interrogative probes were divided are presented in Table 5.

An example here might serve to clarify the relationship of the structure and the objective of the problem situation to the interrogative probes. Consider the problem situation as it is presented in statement #1 in Appendix I. Consider also that the solution that is required is the total number of cars that Mr. Jones looked at. There are two possible paths to the solution if the interrogative probes "A" through "I" from Table 4 accompany the problem situation

TABLE 5

Six Groups Into Which the Distinct Series of Interrogative Probes Were Divided

Solution Required	
Total Value	Additive Value
1) Allow the use of either of two paths to the solution	4) Allow the use of either of two paths to the solution
2) Allow the use of only one consistent path to the solution	5) Allow the use of only one consistent path to the solution
3) Allow the use of only one inconsistent path to the solution	6) Allow the use of only one inconsistent path to the solution

on the display board:

a) _S_ may first find out how many Fords ("A") and how many Buicks ("B") Mr. Jones looked at. Once this information has been obtained, _S_ only has to find out how many Chevrolets Mr. Jones looked at in order to solve the problem. This value may be determined by adding together the number of Chevrolet compacts ("C"), Chevrolet sedans ("D"), and Chevrolet station wagons ("E") that Mr. Jones looked at. By adding these five values, _S_ may determine the total number of cars that Mr. Jones looked at.

b) _S_ may first find out how many sedans ("F") and how many compacts ("G") Mr. Jones looked at. The problem could then be solved by finding out how many station wagons Mr. Jones looked at, which may be determined by summing the number of Chevrolet station wagons ("E"), Ford station wagons ("H"), and Buick station wagons ("I") that Mr. Jones looked at. By adding these five values the total number of cars that Mr. Jones looked at can be determined.

This example obviously describes a situation in which the interrogative probes presented allow either of two paths to be used in order to solve the problem. (Probes "L", "M", and "N", which are filler probes, are not relevant to the solution of the problem. These three probes, which are randomly presented along with the relevant probes, are used to fill out each series of interrogative probes so that 12 probes are presented to each _S_.)

Suppose now that probe "G" (i.e., "How many compacts did Mr.

Jones look at?") in the first example is replaced by probe "K" (i.e., "How many Buick compacts did Mr. Jones look at?", or equivalently, "How many compact Buicks did Mr. Jones look at?"). Due to the fact that probe "K" will not convey as much information as did probe "G", the second of the two paths to the solution listed above is destroyed (i.e., since it is no longer possible to determine how many compacts Mr. Jones looked at). Thus, when this series of interrogative probes is presented, S is restricted to the use of just one path to the solution, and this one path is consistent with the hierarchical organization of the problem situation as it is presented in statement #1 in Appendix I. In this statement, the cars are first organized according to their makes and then they are subsequently structured according to their body types within each make. For a path to the solution to be consistent with this hierarchical organization, it must allow S to find out the number of cars of each make which Mr. Jones looked at, since the makes of the cars was the primary variable of organization in the statement of the problem situation. Such a path is the first path described above, which is also the path that is made accessible in this latter example.

Suppose that instead of probe "K" replacing probe "G", which was done in the last example, now probe "K" (i.e., "How many Buick compacts did Mr. Jones look at?", or equivalently, "How many compact Buicks did Mr. Jones look at?") replaces probe "A" (i.e., How many Fords did Mr. Jones look at?"). Once again, this replacement has destroyed one of the possible paths to the solution. This time the first path above is destroyed because it is no longer possible to

determine how many Fords Mr. Jones looked at. In this example, the one path to the solution that may be employed is inconsistent with the organization of the problem situation as it is presented in statement #1 in Appendix I. This is due to the fact that instead of allowing S to find out how many cars of each make Mr. Jones looked at, S is forced to determine the number of cars of each body type that Mr. Jones looked at. Thus S is required to reach the solution to the problem by identifying the variable (i.e., body types of the cars) that was structured secondarily (i.e., nested within the variable of the makes of the cars) in the statement of the problem situation.

If statement #2 from Appendix I had been used in this example instead of statement #1 to explain the problem situation, the effects of the interrogative probes would have been different. In the case of the series of interrogative probes which allow the use of either of the two paths to the solution, no change would have occurred; that is, the series of interrogative probes which allowed the use of either of the two paths to the solution when statement #1 was used would also allow the use of either of the two paths if statement #2 were used. However, in the case of the series of interrogative probes which only allowed the use of the path to the solution that was consistent with the hierarchical organization presented in statement #1, those same interrogative probes would allow only the use of the path to the solution that was inconsistent with the hierarchical organization if statement #2 were presented. Similarly, the series of interrogative probes which only allowed the use of the

path to the solution that was inconsistent with the hierarchical organization in statement #1 would only allow the use of the path that was consistent with the hierarchical organization if statement #2 were used. Thus the problem statements and the interrogative probe sets may be manipulated to produce the derived variable called "consistency."

In the case of the randomly organized statements of the problem situation (i.e., the statements in Appendix II), the interrogative probes "A" through "I" will still allow the use of either of the two paths to the solution; and the replacing of probe "G" by probe "K" or the replacing of probe "A" by probe "K" will still each allow the use of only one path to the solution. However, it is not relevant here to discuss whether or not these paths are "consistent" since there is no longer any hierarchical organization with which they may be consistent or inconsistent.

There could have been another solution required in the examples above, namely, the additive value solution (instead of the total value solution). If this solution had been required, then probe "J" (i.e., "How many cars did Mr. Jones look at altogether?") would have replaced probe "E" (i.e., "How many Chevrolet station wagons did Mr. Jones look at?", or equivalently, "How many station wagon Chevrolets did Mr. Jones look at?") in the series of interrogative probes that were presented. With this replacement, the analyses that were made in the examples above will still apply to the case in which this new solution is required.

Twelve treatment conditions resulted from the manipulations

of the independent variables which have been discussed. By grouping together the statements in Table 3 which have the same organizational structure (i.e., statements #1 and #2 are both hierarchically organized; statements #3 and #4 are both randomly organized) <u>and</u> by grouping together the two phrasings of the additive value solution presented in Table 3, the following four groups were generated:

a) a hierarchically organized statement of the problem situation plus the total value solution,

b) a hierarchically organized statement of the problem situation plus the additive value solution,

c) a randomly organized statement of the problem situation plus the total value solution, and

d) a randomly organized statement of the problem situation plus the additive value solution.

These four groups were then crossed with the effects of the presentation of different series of interrogative probes, namely, a) two paths to the solution are allowed; b) one path to the solution is allowed which is consistent with the hierarchical organization of the problem situation; and c) one path is allowed which is inconsistent with the hierarchical organization of the problem situation. These interrelationships and the resultant 12 treatment conditions are presented in Table 6. The 12 treatment conditions are listed below:

Condition H B T = the problem statement is hierarchically organized (H = Hierarchical), the interrogative probes allow the use of either of the two paths to the solution (B = Both), and the

TABLE 6

Interrelationships of the Independent Variables

and Resultant Twelve Treatment Conditions

Organization of the Problem Situation	Interrogative Probes Presented	Solution Required	Relation of the Path to the Organization	Condition
Hierarchically Organized	Two paths to the solution are allowed	Total Value		H B T
		Additive Value		H B A
	One path to the solution is allowed	Total Value	Consistent Inconsistent	H C T H I T
		Additive Value	Consistent Inconsistent	H C A H I A
Randomly Organized	Two paths to the solution are allowed	Total Value		R B T
		Additive Value		R B A
	One path to the solution is allowed	Total Value	Consistent' Inconsistent'	R C' T R I' T
		Additive Value	Consistent' Inconsistent'	R C' A R I' A

total value solution is required (T = Total);

Condition H B A = the problem statement is hierarchically organized (H), the interrogative probes allow the use of either of the two paths (B), and the additive value solution is required (A = Additive);

Condition H C T = the problem statement is hierarchically organized (H), the interrogative probes allow the use of only one path which is consistent with the hierarchical organization of the problem situation (C = Consistent), and the total value solution is required (T);

Condition H C A = the problem statement is hierarchically organized (H), the interrogative probes allow the use of only one consistent path to the solution (C), and the additive value solution is required (A);

Condition H I T = the problem statement is hierarchically organized (H), the interrogative probes allow the use of only one path which is inconsistent with the hierarchical organization of the problem situation (I = Inconsistent), and the total value solution is required (T);

Condition H I A = the problem statement is hierarchically organized (H), the interrogative probes allow the use of only one inconsistent path to the solution (I), and the additive value solution is required (A);

Condition R B T = the problem statement is randomly organized (R = Random), the interrogative probes allow the use of either of the two paths (B), and the total value solution is

required (T);

Condition R B A = the problem statement is randomly organized (R), the interrogative probes allow the use of either of the two paths (B), and the additive value solution is required (A);

Condition R C' T = the problem statement is randomly organized (R), the interrogative probes allow the use of only one path to the solution, i.e., that path allowed in Conditions H C T and H C A (C'), and the total value is the solution required (T);

Condition R C' A = the problem statement is randomly organized (R), the interrogative probes only allow the use of the permissible path in Conditions H C T and H C A (C'), and the additive value solution is required (A);

Condition R I' T = the problem statement is randomly organized (R), the interrogative probes allow the use of only one path, i.e., that path allowed in Conditions H I T and H I A (I'), and the total value solution is required (T); and

Condition R I' A = the problem statement is randomly organized (R), the interrogative probes only allow the use of the permissible path in Conditions H I T and H I A (I'), and the additive value is the solution required (A).

Eight Ss participated in each of these treatment conditions. Assignment of Ss to treatment conditions was randomly determined. The order in which the interrogative probes were presented on the display boards was randomized within experimental conditions. Each

S was free to choose the number and the order of the interrogative probes he wished to have answered in solving the problem, but he was instructed to select only those interrogative probes which he felt were necessary to obtain the solution to the problem. Thus S was given the freedom to pursue the solution in any one of a number of different ways. This technique allowed E to directly observe the strategy employed by each S as it was demonstrated by the sequence of interrogative probes chosen to be answered. (It is, of course, a necessary assumption here that the strategy displayed by an S on any given problem does indeed reflect his search, evaluation, and subsequent utilization of the available information.) While many problem-solving tasks merely allow E to determine whether a solution was reached and, if so, how much time was needed to obtain that solution, the task employed in the present study allowed the investigator to determine in addition to these measures the number of interrogative probes needed for the solution to be achieved, the sequence in which these interrogative probes were selected, and the inter-probe latencies.

Scoring

The assumption has been made that an ideal strategy for the solution of the problem does exist, and that this ideal strategy is that sequence of selections of interrogative probes which accumulates the information needed to solve the problem in the most parsimonious manner, that is, without the selection of interrogative probes which provide irrelevant or redundant information or which constitute sequence reversals. A sequence reversal is that situation in which

interrogative probes are selected in some sequence other than the order in which the reduction of the uncertainty of the problem situation takes place at a maximum rate. Ten graduate student judges were chosen to independently rate the sequences in which the interrogative probes needed to solve the problem could be selected. This was done in an effort to ascertain how efficiently each sequence reduced the uncertainty of the problem situation. The possible sequences were divided into four sets:

a) sequence consisting of the interrogative probes needed when the total value solution is required, and when the solution may be achieved only by considering the car body types structured within the car makes;

b) sequences consisting of the interrogative probes needed when the total value solution is required, and when the solution may be reached only by considering the car makes organized within the car body types;

c) sequence consisting of the interrogative probes needed when the additive value solution is required, and when the solution may be obtained only by considering the car body types structured within the car makes; and

d) sequences consisting of the interrogative probes needed when the additive value solution is required, and when the solution may be reached only by considering the car makes ordered within the car body types.

Five interrogative probes are needed in each of these four sets in order to solve the problem. There are three distinctly different

sequences in which these five interrogative probes in each case may be selected (Appendix III). Each judge was presented these three distinct strategies from one of the groups and he was instructed to rank them according to "...what order of receiving the information will put the least (or the most) inferential and memory strain upon you when you are processing the information..." Once each judge had ranked the three strategies from one of the sets, he was presented the three strategies from the other set which required the same solution, and he was asked to rank these according to the same criterion of efficiency. This was done in an effort to obtain a measure of the consistency of the rankings made by each judge. The rankings which resulted and Kendall's coefficient of concordance (Siegel, 1956) for each group of rankings are presented in Table 7. (Kendall's W is used to assess the degree of agreement among the rankings of the judges.) There was considerable agreement within each of the sets, and there are only two instances in which judges' rankings were inconsistent (i.e., judge 5 and judge 8). Due to the large amount of overall agreement and consistency among the judges in Group I, sequences "A", "B", and "C" have been accepted as the most efficient, second-most efficient, and least efficient strategies and they have therefore been assigned the ranks of 1, 2, and 3, respectively. In Group II, however, there is considerable discrepancy of opinion. While sequence "A" was unanimously ranked as the most efficient strategy and has been assigned the rank of 1, sequences "B" and "C" appear to have produced some confusion as to which strategy is more efficient. Therefore these two strategies have been

TABLE 7

Rankings for Each of the Sets of Strategies and Kendall's Coefficient of Concordance (W) for Each Set of Rankings

Group I
Total Value Solution Strategies

Judges	Set 1: Body Types Organized Within Makes			Set 2: Makes Organized Within Body Types		
	Sequences:			Sequences:		
	A	B	C	A	B	C
	Ranks:			Ranks:		
1	1	2	3	1	2	3
2	1	2	3	1	2	3
3	1	2	3	1	2	3
4	1	2	3	1	2	3
5	1	2	3	3	1	2
	W = 1.0			W = 0.52		

Group II
Additive Value Solution Strategies

Judges	Set 3: Body Types Organized Within Makes			Set 4: Makes Organized Within Body Types		
	Sequences:			Sequences:		
	A	B	C	A	B	A
	Ranks:			Ranks:		
6	1	2	3	1	2	3
7	1	3	2	1	3	2
8	1	2	3	1	3	2
9	1	3	2	1	3	2
10	1	2	3	1	2	3
	W = 0.76			W = 0.76		

given the same rank of 2.5.

The following formula has been derived in order to assign an Efficiency Score to each S as determined by the sequence of interrogative probes which he selected:

1)

$$ES = R(.15) + I(.9), \text{ where}$$

ES = Efficiency Score,

R = the rank of the strategy employed as determined by the ratings of the judges, and

I = the number of intrusions, which have been defined as the number of interrogative probes that were selected which were not relevant to the solution strategy used to solve the problem.

R, the index concerned with the order of the selection of the interrogative probes that are relevant to the solution strategy employed, measures the extent to which sequence reversals have occurred. I, the index concerned with the selection of interrogative probes that are irrelevant to the solution strategy employed, measures the amount of irrelevant or redundant information that has been selected. R has been assigned a lesser weight than has I since the order of the selection of relevant interrogative probes is of lesser concern than is the selection of irrelevant probes. The respective weights have been assigned in such a way that the use of the most inefficient sequence reversal (i.e., sequence "C" in Group I in Table 7) will receive a score equal to ½ the value which is received when one irrelevant or redundant item of information is

selected.

In addition to the ES, the efficiency of the problem-solving behavior of each S was evaluated by three other measures. First, the solution given by each S was evaluated for its accuracy. Due to the crude nature of this measure, it was not expected to differentiate to a fine degree the variance among Ss' performances. Secondly, the total time to solution was recorded for each S. The E was able to operate the timing device, which was placed in an adjacent room, by means of a control box in the experimental room. By pressing a button on the control box, E was able to reset the timing device when S was presented the problem and again when S had achieved a solution to the problem. In this way the total time to solution was recorded on the timer print-out. The last measure of problem-solving efficiency recorded was the inter-probe latency. By means of a second button on the control box, E was able to engage the timing device, recording the time on the print-out without resetting the timer. By pressing this second button each time S selected an interrogative probe, E was able to keep a continuous timetable of the amount of time which elapsed between the selection of each interrogative probe. The Ss were not told that they were being timed.

CHAPTER III

RESULTS AND DISCUSSION

Two of the four hypotheses which were stated above are not testable from these data because of an artifact of the specific problem chosen for this experiment. The artifact has prevented the testing of those hypotheses which are concerned with the degree of consistency which the path to the solution has with the problem statement and its effect upon problem solution. The exact nature of this artifact is discussed below.

A 2 x 2 x 3 x 2 x 2 ANOVA was computed on the ES data. The results of this analysis are summarized in Table 8. The significant ($p < .05$) grand interaction is uninterpretable. This interaction may be a residual effect due to underestimates of variance for lower order terms in the model (i.e., 15 F ratios are less than unity).

The highly significant ($p < .01$) value (i.e., total versus additive value solution is required) by consistency (i.e., both paths are allowed versus one consistent path is allowed versus one inconsistent path is allowed) by statement (i.e., the organization in the problem statement of the car body types within the car makes versus the organization of the car makes within the car body types) interaction can be attributed to the artifact of the problem chosen for this study. Tests for simple simple main effects and simple interaction effects (Kirk, 1968, pp. 222-224), the results of which are

TABLE 8

Analysis of Variance for the ES Data

Source of Variance	SS	df	MS	F
Organization (O)	11.02	1	11.02	8.90 **
Value (V)	2.45	1	2.45	1.98
Consistency (C)	25.50	2	12.75	10.30 ***
Statement (S)	2.45	1	2.45	1.98
Wording (W)	7.61	1	7.61	6.15 *
O by V	3.22	1	3.22	2.60
O by C	0.30	2	0.15	
O by S	0.31	1	0.31	
O by W	0.81	1	0.81	
V by C	0.15	2	0.08	
V by S	1.09	1	1.09	
V by W	2.63	1	2.63	2.12
C by S	9.39	2	4.70	3.80 *
C by W	8.23	2	4.11	3.32 *
S by W	1.02	1	1.02	
O by V by C	6.75	2	3.38	2.73
O by V by S	0.57	1	0.57	
O by V by W	0.44	1	0.44	
O by C by S	6.05	2	3.02	2.44
O by C by W	4.13	2	2.06	1.67
O by S by W	0.07	1	0.07	
V by C by S	18.32	2	9.16	7.40 **
V by C by W	2.16	2	1.08	
V by S by W	1.35	1	1.35	1.09
C by S by W	2.81	2	1.40	1.13
O by V by C by S	0.03	2	0.01	
O by V by C by W	0.64	2	0.32	
O by C by S by W	0.19	2	0.09	
O by V by S by W	0.06	1	0.06	
V by C by S by W	1.31	2	0.65	
O by V by C by S by W	12.40	2	6.20	5.01 *
Error	59.41	48	1.24	

$^{*}p < .05$
$^{**}p < .01$
$^{***}p < .001$

summarized in Table 9, indicate that the value by consistency by statement interaction is primarily due to differences within the additive value solution condition (V_2). These differences occur across statement 1 (S_1) and statement 2 (S_2), and between those conditions in which one consistent path to the solution was allowed (C_2) and those conditions in which one inconsistent path to the solution was allowed (C_3). These differences are represented in Fig. 2. In the additive value condition, those Ss who were presented the problem in the form of statement 1 and who were only allowed to use the consistent path to the solution performed much better than did those Ss who were required to use the path to the solution which is inconsistent with statement 1. The reverse is true for statement 2: those Ss in the additive value condition who were only allowed to use the path that is consistent with problem statement 2 performed more poorly than did those Ss in the additive value condition who were required to use the path that is inconsistent with statement 2. If the significant factor in these data is the degree of consistency which the path to the solution has with the problem statement, then one would expect that those Ss who were required to use the path to the solution which is consistent with the problem statement presented would perform better than would those Ss who were only allowed to use the inconsistent path to the solution, regardless of which problem statement was presented. However, as is shown in Fig. 2, this has not been the case. The discriminating factor in these data has little to do with the form of the problem statement or the consistency which the permissible path to the solution has with that problem statement;

TABLE 9

Simple Simple Main Effects and Simple Interaction Effects in the Value by Consistency by Statement Interaction

Source of Variance	SS	df	MS	F
Consistency (C)	25.50	2	12.75	10.30 ***
C at VS_{11}	5.47	2	2.74	2.21
C at VS_{12}	6.31	2	3.16	2.55
C at VS_{21}	16.33	2	8.17	6.60 **
C at VS_{22}	25.24	2	12.62	10.20 ***
Value (V)	2.45	1	2.45	1.98
V at CS_{11}	1.04	1	1.04	
V at CS_{12}	0.04	1	0.04	
V at CS_{21}	1.14	1	1.14	
V at CS_{22}	6.38	1	6.38	5.15 *
V at CS_{31}	10.52	1	10.52	8.50 **
V at CS_{32}	2.89	1	2.89	2.34
Statement (S)	2.45	1	2.45	1.98
S at CV_{11}	0.17	1	0.17	
S at CV_{12}	2.62	1	2.62	2.12
S at CV_{21}	0.56	1	0.56	
S at CV_{22}	8.09	1	8.09	6.53 *
S at CV_{31}	0.28	1	0.28	
S at CV_{32}	19.53	1	19.53	15.78 ***
CV at S_1	9.30	1	9.30	7.51 **
CV at S_2	9.16	1	9.16	7.40 **
CS at V_1	0.86	1	0.86	
CS at V_2	26.85	1	26.85	21.69 ***
VS at C_1	0.72	1	0.72	
VS at C_2	6.46	1	6.46	5.22 *
VS at C_3	12.21	1	12.21	9.86 ***
Error	59.41	48	1.24	

*$p < .05$
**$p < .01$
***$p < .001$

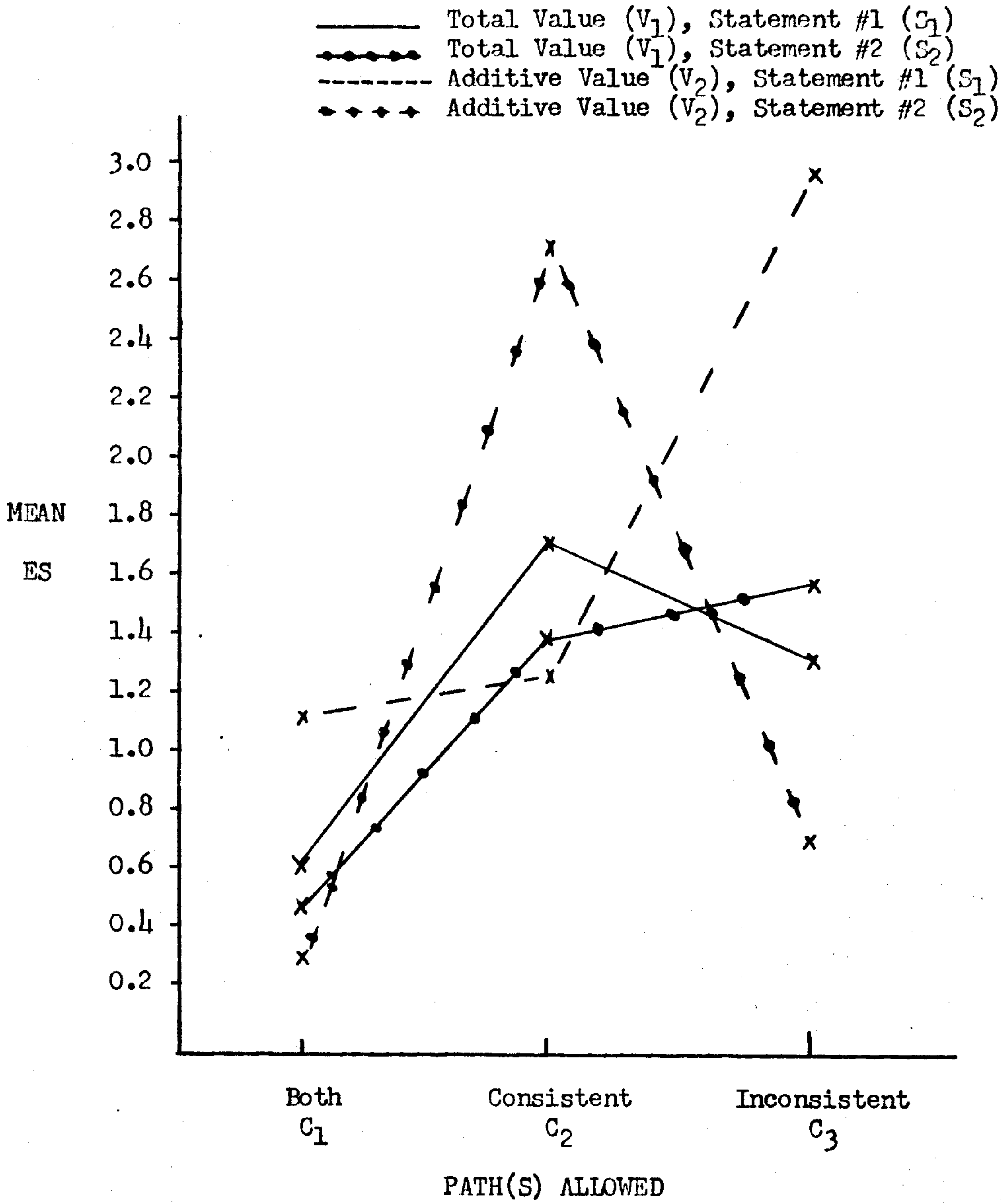

Fig. 2. The value by consistency by statement interaction for the ES data.

rather, the important factor is inherent in the paths themselves. For the path requiring that the cars first be organized according to the makes of the cars followed by a structuring of the car body types within each car make (i.e., path 1: in those conditions in which the only permissible path is either consistent with problem statement 1 or inconsistent with problem statement 2), performance was much better than when the path required that the cars be structured according to the car body types first with a subsequent organization according to the car makes within each car body type (i.e., path 2: in those conditions in which the only path allowed is either inconsistent with problem statement 1 or consistent with problem statement 2). Thus, if path 1 is the only permissible path, then problem-solving efficiency is much greater than if path 2 is the only path allowed, regardless of the statement or consistency variables. This relationship is clearly illustrated in the transformation of Fig. 2 which has been provided in Fig. 3. This transformation was brought about by means of a reorganization of the data according to absolute criteria (i.e., whether path 1 or path 2 was the only permissible path) rather than the previous organization of the data according to relative criteria (i.e., whether the permissible path was consistent or inconsistent with the problem statement). In Fig. 3, P_2 represents the conditions in which path 1 is the only permissible path to the solution, and P_3 represents the conditions in which path 2 is the only path allowed. It is clear from Fig. 3 that the characteristics of the specific problem chosen for this experiment have resulted in a systematic behavior which is due to the

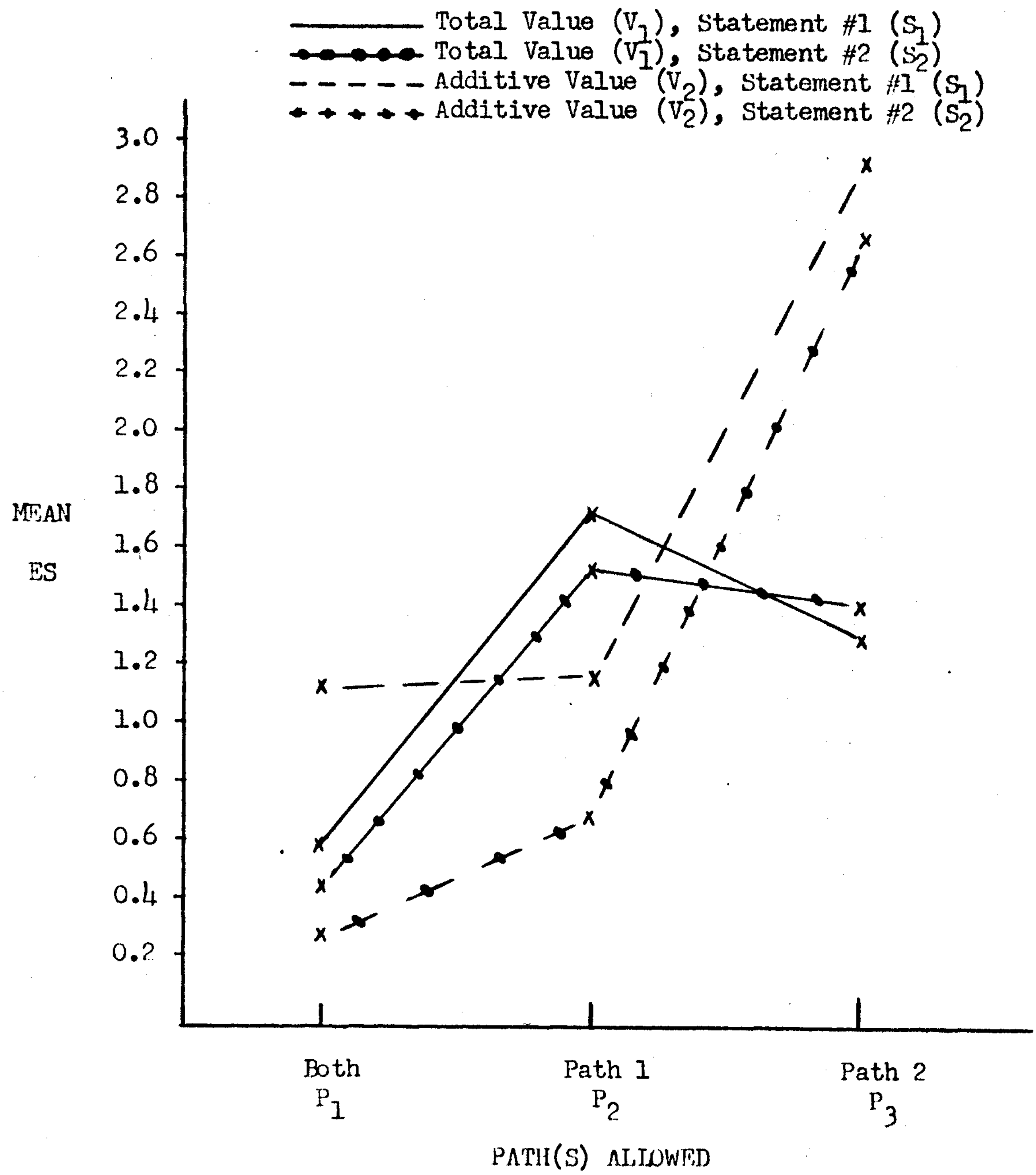

Fig. 3. Reorganization of the value by consistency by statement interaction according to absolute criteria.

paths themselves, and not to the degree of consistency which the paths have with the problem statements, as was originally expected.

The significant ($p < .05$) consistency by statement interaction is shown in Fig. 4. Once again the discriminating variable in these data is not the consistency of the permissible solution path with the problem statement, but rather the nature of the path which S was permitted to use. If S was only allowed to use path 1 (i.e., conditions CS_{21} and CS_{32}), his performance was much better than if he was required to use path 2 (i.e. conditions CS_{22} and CS_{31}).

One further interaction is significant ($p < .05$) in the ES data, the consistency by wording interaction. This interaction is shown in Fig. 5. Tests for simple main effects, the results of which are summarized in Table 10, indicate that this interaction is due to differences between wording 1 (i.e., the car makes precede the car body types in the solution required and in the interrogative probes presented; e.g., "...Chevrolet station wagons...?") and wording 2 (i.e., the car body types precede the car makes in the solution required and in the interrogative probes presented; e.g., "...station wagon Chevrolets...?") within the condition in which one consistent path to the solution was allowed (C_2). According to the interpretations of the interactions considered thus far, the consistency of a lone solution path with a problem statement is an irrelevant variable in these data. Rather, the discriminating factor is whether path 1 or path 2 is the only path to the solution which S was allowed to use. Thus, due to the irrelevant nature of the consistency factor, the consistency by wording interaction consists of an effect due to the

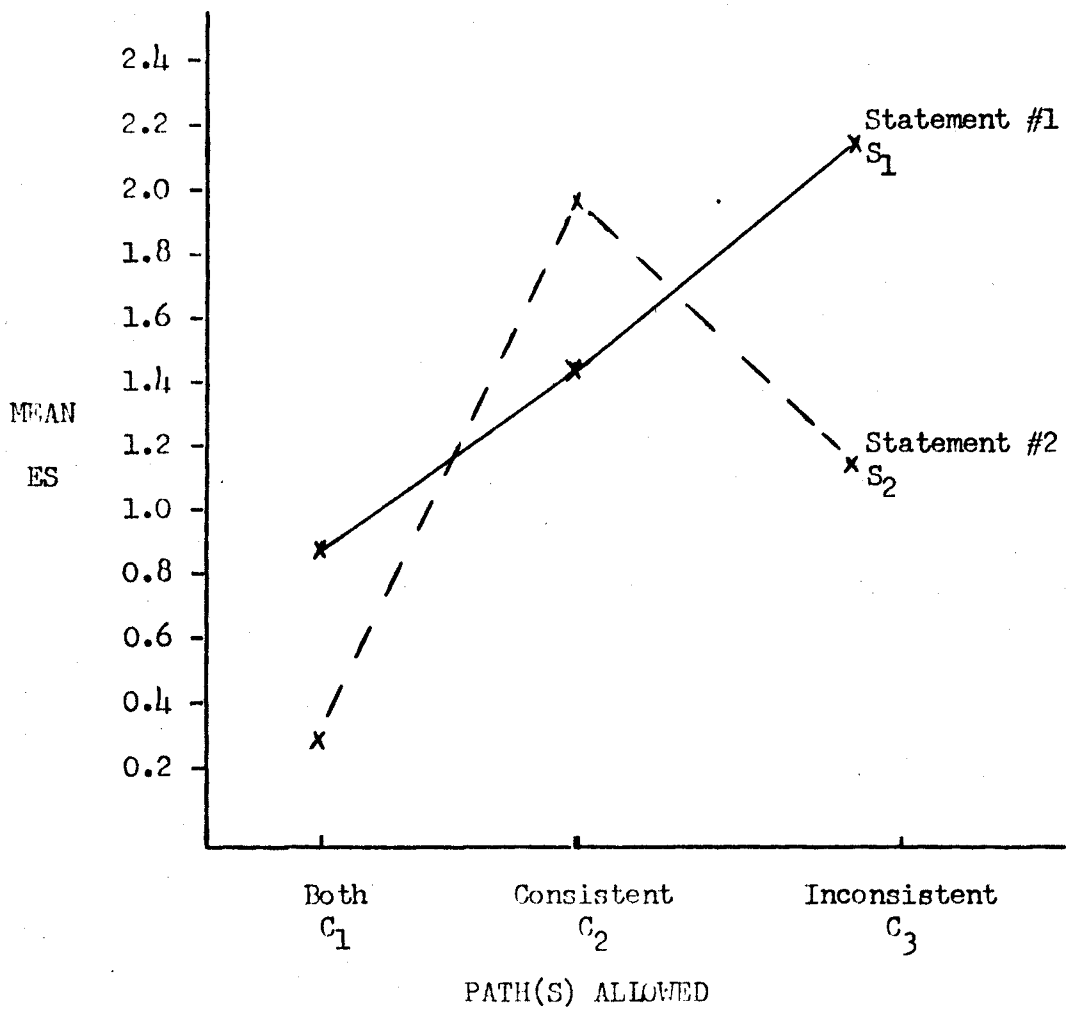

Fig. 4. The consistency by statement interaction for the ES data.

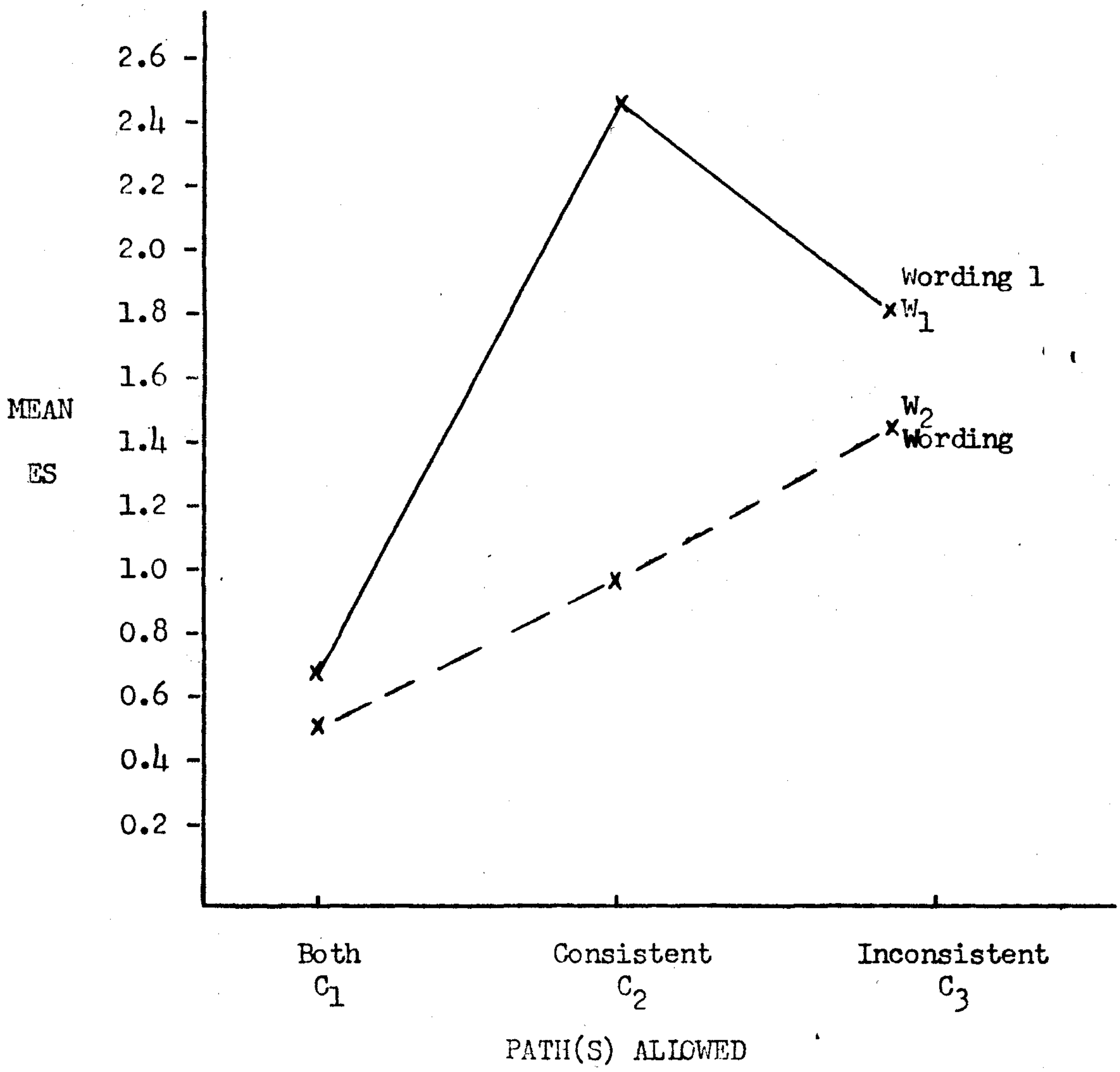

Fig. 5. The consistency by wording interaction for the ES data.

TABLE 10

Simple Main Effects in the Consistency by Wording Interaction

Source of Variance	SS	df	MS	F
Consistency (C)	25.50	2	12.75	10.30 ***
C at W_1	26.61	2	13.30	10.75 ***
C at W_2	7.11	2	3.56	2.87
Wording (W)	7.61	1	7.61	6.15 *
W at C_1	0.05	1	0.05	
W at C_2	15.37	1	15.37	12.42 **
W at C_3	0.41	1	0.41	
Error	59.41	48	1.24	

*$p < .05$
**$p < .01$
***$p < .001$

wording manipulation. Just such a significant ($p < .05$) wording effect was obtained in the ES data. The presentation of word order 2 (W_2) resulted in better performance than did the presentation of word order 1 (W_1). The mean ESs for Ss in conditions W_2 and W_1 were 1.06 and 1.63, respectively. These mean ESs were analyzed according to the path which S was required to use. Those Ss who were presented word order 2 and who were required to use path 1 had a mean ES of 1.05, while those Ss who were presented word order 2 and who were required to use path 2 had a mean ES of 1.56. This difference is not significant [$t(46) = 1.13$, $p > .10$]. Those Ss who were presented word order 1 and who were required to use path 1 or path 2 had mean ESs of 1.61 and 2.61, respectively. This difference is significant [$t(46) = 1.89$, $p < .05$]. These results indicate that those Ss who were presented word order 1 and who were required to use path 2 performed significantly poorer than did the Ss in any of the other three groups.

The highly significant ($p < .001$) effect of the consistency factor indicates that those Ss who were allowed to use either path to the solution (C_1 mean ES = 0.62) performed far better than did those Ss who were only allowed to use the path which was either consistent (C_2 mean ES = 1.78) or inconsistent (C_3 mean ES = 1.64) with the problem statement presented. With the thought that the required use of path 2 had resulted in a significant increase in the mean ESs of both C_2 and C_3, these data were rescored by the path required rather than by the consistency of the path with the problem statement. It was expected that this reanalysis would demonstrate that the mean score

of those Ss who were required to use the more accessible path, path 1, did not differ significantly from that of those Ss who were allowed to use either path to the solution. The mean ES of those Ss who were required to use path 1 was 1.33. This mean score differed significantly from that of those Ss who were allowed to use either of the paths to the solution [$t(62) = 2.37$, $p < .025$]. Thus Ss performed better when they were allowed to use either of the two paths to the solution than when they were only allowed to use the more accessible path. In an effort to confirm these findings, the ES data were further analyzed. Of those Ss who were allowed to use either of the paths to the solution, 21 Ss (66%) used path 1 and 11 Ss (34%) used path 2. These two sample proportions are the best unbiased estimates of path dominance, and were therefore used to partition those groups in which only one path was allowed. With the biasing assumption that high ESs reflect (in part, at least) the availability of the dominant path, the best 21 ESs from those Ss who were required to use path 1 were collected, as were the best 11 ESs from those Ss who were required to use path 2. These scores were then compared with the scores of those Ss who were allowed to use either of the paths to the solution. The 21 Ss who used path 1 when they were allowed to use either of the paths had a mean score of 0.62, while the best 21 Ss who were required to use path 1 had a mean score of 0.61; and similarly, the 11 Ss who used path 2 when they were allowed to use either path had a mean score of 0.62, while the best 11 Ss who were required to use path 2 had a mean score of 0.42. Apparently, among those Ss who are allowed to use only one of the paths to the solution, if an S's attention is

initially centered upon the permissible path, he will perform well. If, however, an S's attention is first centered upon the path which is not allowed, then he will have some difficulty in finding the permissible path, and consequently, in solving the problem. Those Ss, however, who are allowed to use either path to the solution find the necessary information to solve the problem regardless of which path they initially attend to.

The effect of the organization of the problem statements (i.e., hierarchically versus randomly organized) is highly significant ($p < .01$) in the predicted direction. Due to the increased complexity and the heightened informational and organizational requirements produced by the random presentation of the problem situation, those Ss who were presented the randomly organized problem statements performed much poorer (mean ES of 1.68) than did those Ss who were presented the hierarchically organized problem statements (mean ES of 1.01).

The results of a 2 x 2 x 3 x 2 x 2 ANOVA which was done on the total time data are summarized in Table 11. The significant ($p < .05$) consistency by statement interaction is represented in Fig. 6. As was the case with the significant interactions in the ES data, this consistency by statement interaction is attributable to the specific problem used in this experiment. In those conditions in which only one path to the solution is allowed, the degree of consistency which the permissible path has with a given problem statement is irrelevant. The discriminating variable is whether the only permissible path is path 1 or path 2. Performance is much better if path 1 is the only

TABLE 11

Analysis of Variance for the Total Time Data

Source of Variance	SS	df	MS	F
Consistency (C)	71907.8	2	35953.9	2.18
Value (V)	69563.4	1	69563.4	4.21 *
Organization (O)	417041.3	1	417041.3	25.25 ***
Statement (S)	1036.3	1	1036.3	
Wording (W)	376.0	1	376.0	
C by V	18243.3	2	9121.6	
C by O	19730.6	2	9865.3	
V by O	264.8	1	264.8	
C by S	148813.4	2	74406.7	4.51 *
V by S	138.4	1	138.4	
O by S	10527.4	1	10527.4	
C by W	68025.5	2	34012.8	2.06
V by W	4737.3	1	4737.3	
O by W	18556.9	1	18556.9	1.12
S by W	743.6	1	743.6	
C by V by O	29465.6	2	14732.8	
C by V by S	12639.0	2	6319.5	
C by O by S	32500.8	2	16250.4	
V by O by S	26.7	1	26.7	
C by V by W	33105.7	2	33105.7	1.00
C by O by W	26691.6	2	13345.8	
V by O by W	32153.4	1	32153.4	1.95
C by S by W	95217.8	2	47608.9	2.88
V by S by W	65.5	1	65.5	
O by S by W	263.3	1	263.3	
C by V by O by S	11502.7	2	5751.4	
C by V by O by W	14648.2	2	7324.1	
C by V by S by W	11505.4	2	5752.7	
C by O by S by W	88720.4	2	44360.2	2.69
V by O by S by W	1690.5	1	1690.5	
C by V by O by S by W	33028.1	2	16514.0	1.00
Error	792739.9	48	16515.4	

*$p < .05$
***$p < .001$

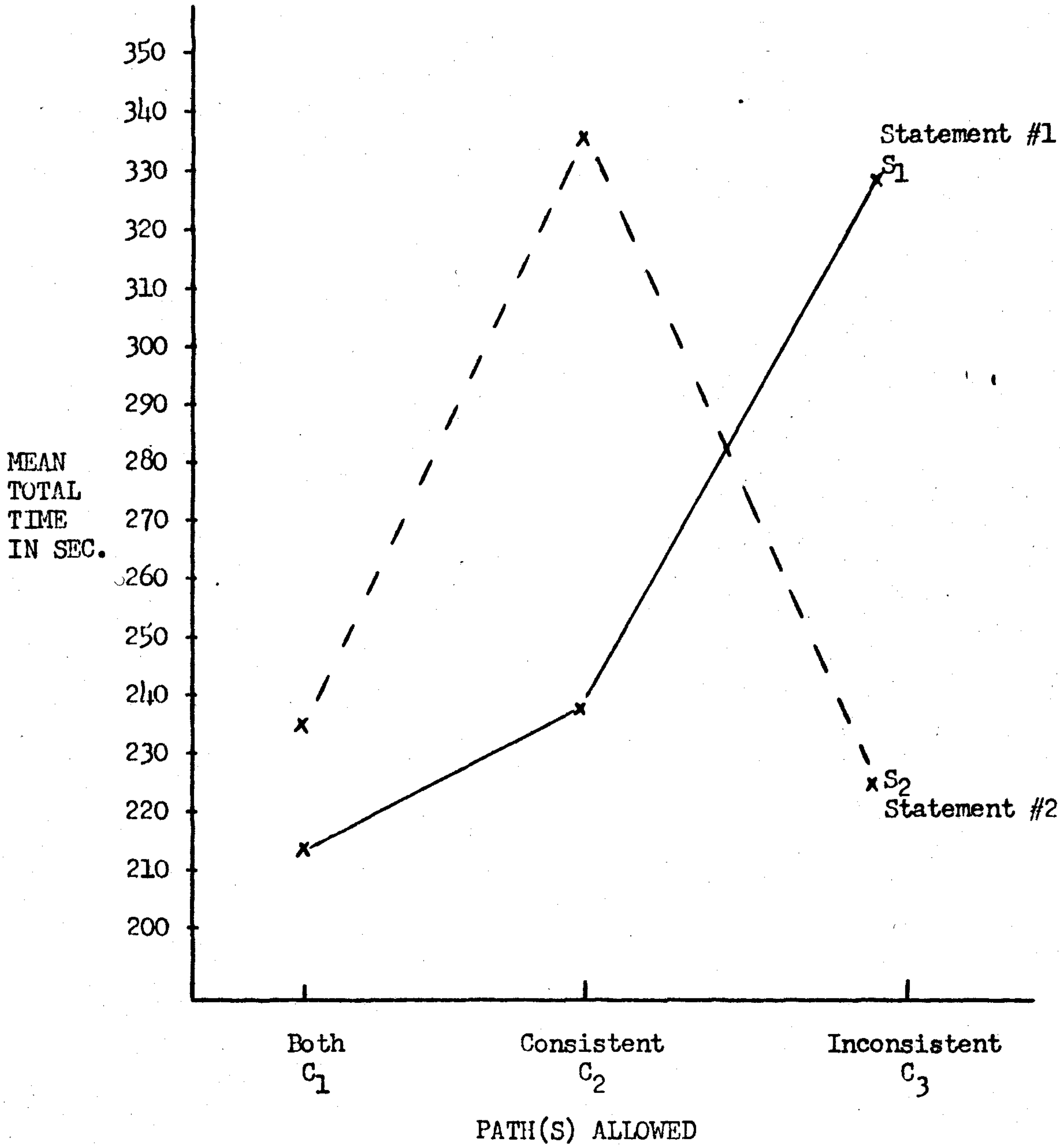

Fig. 6. The consistency by statement interaction for the total time data.

path allowed (i.e., mean total time = 234.69 sec.) than if path 2 is the only permissible path (i.e., mean total time = 330.27 sec.). In fact, the performance of those Ss who were only allowed to use path 1 is not significantly different from the performance of those Ss who were allowed to use either of the paths to the solution [$t(62) = 0.82$, $p > .20$].

The highly significant ($p < .001$) organization effect is in the predicted direction. The increased complexity due to the lack of organization in the randomly organized problem statements resulted in much more total time being spent on the problem by those Ss who were presented the randomly organized problem statements than by those Ss who were presented the hierarchically organized problem statements. The mean total time spent on the problem by each of these groups of Ss was 329.32 sec. and 197.50 sec., respectively.

The significant ($p < .05$) effect of the value factor is in the predicted direction. Those Ss who were required to find the total value solution spent a mean total time of 236.49 sec. The mean total time spent by those Ss who were required to find the additive value solution was 290.32 sec.

The total time spent in solving the problem can be divided into two separate sets of intervals, the response latency and the inter-probe latency. The response latency is the time which elapsed between the presentation of the problem to S and S's first selection of an interrogative probe. The inter-probe latency is the time which elapsed between the selection of one interrogative probe by S and his selection of the next interrogative probe. The inter-probe latencies were used

to analyze Ss' individual responses when interpreting the data. Response latency was analyzed to determine what proportion of the total time was used to organize the problem materials, and to evaluate the effect of this organizing activity upon problem-solving efficiency. Johnson and his associates (Johnson & Hall, 1961; Johnson, 1961; Johnson & Jennings, 1963) and Simon and Barenfeld (1969) reported that in problem-solving tasks Ss spend an initial preparatory period examining and organizing the problem materials which are presented. In the present experiment, those Ss who were presented the hierarchically organized problem statements displayed significantly shorter response latencies than did those Ss who were presented the randomly organized problem statements [$t(94) = 2.27$, $p < .05$]. A Pearson product-moment correlation between the response latencies and the ESs for those Ss who were presented the hierarchically organized problem statements indicated almost no relationship between these two variables [$r = 0.01$, $t(46) = 0.07$, $p > .70$]. For those Ss who were presented the randomly organized problem statements, however, a correlation between the response latencies and the ESs yielded a significant correlation coefficient [$r = -0.39$, $t(46) = -2.24$, $p < .05$]. These analyses indicate that when the problem materials are randomly organized, problem-solving efficiency will improve as the amount of time spent organizing the material increases. However, when the problem materials are hierarchically organized, problem-solving efficiency is unrelated to the initial organizing time. In an effort to account for these unusual results, a closer inspection of the data was conducted. Response latency was transformed to the proportion

of the total time which was spent by each S in organizing the problem materials. A correlation between these proportions and the ESs for those Ss who were presented the randomly organized problem statements yielded a highly significant correlation coefficient [$r = -0.67$, $t(46) = -3.52$, $p < .002$]. Similarly, a correlation between these proportions and the ESs for those Ss who were presented the hierarchically organized problem statements yielded a product-moment coefficient of -0.70 [$t(46) = -3.65$, $p < .001$]. As the proportion of the total time which is spent organizing the problem materials increases, the ES improves. Thus, regardless of whether the problem materials are randomly organized or hierarchically organized, the amount of time spent in the initial preparatory period in which the problem materials are examined and structured is crucial to problem-solving efficiency. In fact, nearly 50% of the variance in the ES measure is accounted for by the proportion of the total time which is spent organizing the problem materials.

Simple chi-square tests were planned to evaluate the effect of the organization and the value variables upon the accuracy data. However, the solution rates approached unity, which resulted in expected frequencies too small for legitimate tests. Of the 48 Ss who were presented the hierarchically organized problem statements, 44 Ss solved the problem accurately; and of the 48 Ss who were presented the randomly organized problem statements, 42 Ss solved the problem accurately. Similarly, 44 of the 48 Ss who were required to solve the problem for the total value solution solved the problem accurately, while 42 of the 48 Ss who were required to solve the

problem for the additive value solution solved the problem accurately.

CHAPTER IV

GENERAL DISCUSSION

Although complete accuracy in prediction was not achieved in this experiment, two predicted effects were observed. The effect of the organization of the problem statements is highly significant in the predicted direction in both the ES data and in the total time data. As was expected, the increased complexity and the heightened informational and organizational requirements brought about by the random presentation of the problem situation resulted in poorer problem-solving performance by those Ss who were presented the randomly organized problem statements than by those Ss who were presented the hierarchically organized problem statements.

The second predicted result which was observed is the differential effect of the required solution upon the total time needed to solve the problem. Those Ss who were required to solve the problem for the total value solution needed significantly less time than did those Ss who were required to solve the problem for the additive value solution. Despite the fact that these data are in agreement with the findings of Peterson and Aller (1971), the interpretation of the present results is vastly different from that offered by Peterson and Aller. Whereas these latter authors attributed the superior performance of Ss who were required to solve a total value solution equation to a greater accessibility in memory

of the facts needed to solve such an equation, in the present study an inspection of the inter-probe latencies for each S indicated that these data are attributable to differences in the number of organizational categories into which the information needed to achieve each solution may be grouped. In the case of the total value solution, there are essentially two categories into which the information needed to solve the problem may be grouped, regardless of whether path 1 or path 2 is the path to the solution which is used. In the case of path 1, these two categories are: a) those car makes which are presented as totals apart from any car body types (i.e., Fords and Buicks), and b) the third car make, the total of which may be obtained by combining the three car body types of that make (i.e., Chevrolet compacts, Chevrolet sedans, and Chevrolet station wagons); for path 2 these two categories consist of: a) those car body types which are presented as totals apart from any car makes (i.e., sedans and compacts), and b) the third car body type, the total of which may be obtained by combining the three car makes with that body type (i.e., Ford station wagons, Buick station wagons, and Chevrolet station wagons). However, in solving for the additive value solution there are three categories into which the information needed to solve the problem may be grouped, regardless of the path used. In the case of path 1, these three categories are: a) the total number of cars, b) those car makes which are presented in totals apart from any car body types (i.e., Fords and Buicks), and c) the third car make, which is presented with the two car body types that are not required by the additive value solution (i.e., Chevrolet compacts and

Chevrolet sedans); in the case of path 2, these three categories consist of: a) the total number of cars, b) those car body types which are presented as totals apart from any car makes (i.e., compacts and sedans), and c) the third car body type, which is presented with the two car makes that are not required by the additive value solution (i.e., Ford station wagons and Buick station wagons). Therefore, while attempting to solve the problem by searching through the available information, S needed to locate only two groups of related pieces of information when solving for the total value solution. However, when solving for the additive value solution, S was forced to locate three distinct groups of related pieces of information. The difference in the total time spent on the problem by the two groups has been attributed to this extra group of information required of those Ss who solved the problem for the additive value solution.

Although unpredicted, two further effects stand out from the rest. The more apparent of these is the effect of the required path upon problem-solving performance. The required use of path 1 consistently maximized performance, while the required use of path 2 generally hindered performance. There are at least two plausible explanations for these data. The first of these explanations is based upon the fact that in this problem the car makes are capitalized while the car body types are not. This capitalization may have caused the car makes to be more noticeable, or conspicuous. If this is the case, then performance by those Ss who were allowed to achieve the solution by first organizing the car makes and then structuring the

car body types within these makes (as in path 1) should be superior to the performance by those Ss who were only allowed to obtain the solution by structuring the car body types first with a subsequent organization of the car makes within the car body types (as in path 2). A second explanation which might account for the obtained data is based upon the contention that the category of car makes may simply be a more superordinate categorical structure than is the category of car body types. In other words, individuals may just naturally think of cars in terms of their makes rather than in terms of their body types. If this is the case, then one would expect that a superordinate organization of the car makes with a subsequent subordinate organization of the car body types under the car makes (as in path 1) would result in better performance than would a situation in which the car makes are relegated to a subordinate organizational position under the car body types (as in path 2).

A simple test of these possible explanations could be implemented through a replication of this experiment in which neither the car makes nor the car body types are capitalized, or in which both the car makes and the car body types are capitalized. In this way the capitalization variable could be eliminated as a possible explanation for any subsequent accentuation of the car makes. The similarity of the data from such a replication to the results of the present experiment would indicate which of these possible explanations is more accurate, i.e., the greater the similarity of the replication data to the present results, the greater the influence of the superordinate-subordinate variable.

Regardless of which of these explanations is correct, however, it is obvious that the characteristics of the paths themselves have overcome whatever effects there might have been due to the consistency of the paths with the problem statements. This fact has prevented the testing of the two remaining hypotheses in this study since any evaluation of these hypotheses is contingent upon the consistency of the solution paths with the problem statements. A test of these hypotheses by means of a replication of this experiment would necessitate the construction of a problem (or problems) whose attribute values are equivalent in organizational priority, thus eliminating any effects due to path dominance.

The second unpredicted effect which stands out from these data is the wording effect. As was pointed out above, the car makes appear to be more noticeable than the car body types, which has resulted in inferior performance when path 2 is the only path allowed. This is due to the fact that the use of path 2 requires that S organize the more accessible group, the car makes, within the less accessible group, the car body types. It seems reasonable to expect, therefore, that anything which would enhance the noticeability of the car body types would aid in the efficient use of path 2. Word order 2 does just that, i.e., enhances the noticeability of the car body types, by listing the body types before the car makes. The presentation of word order 2 therefore aided those Ss who were required to use path 2, improving their performance so that it did not differ significantly from that of those Ss who were required to use path 1. Apparently the compatibility of wording 2 with path 2 was tapped by those Ss who

were required to solve the problem by using path 2.

These data suggest that the effective variable here is not the relative organization among the input stimuli, as determined by the organization of the elements in the problem statement, but rather the organization of the input stimulus itself, i.e., the wording of the interrogative probes. In other words, it appears that the Ss did not use the ordering of the attribute values presented in the statement of the problem situation, but they did utilize the ordering of the attribute values presented in the wording of the interrogative probes. This is in agreement with the encoding specificity principle of Thomson and Tulving (1970), which asserts that no cue can be effective in retrieval unless the specific item of interest is encoded with that cue at the time of storage. Thus the organization of the problem statement was an ineffective cue for solving the problem since it was encoded prior to the input of the items of interest, the interrogative probes. The wording of the interrogative probes, however, was encoded at the time of the input of the interrogative probes, and was therefore an effective cue for solving the problem.

Although this discussion has gone well beyond the intended scope of this study, it has pointed out several fruitful areas of investigation which may be implemented through modifications and/or extensions of the present experiment.

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APPENDIX I

The following two statements are the hierarchically organized statements of the experimental problem situation.

Statement #1:

Mr. Jones went shopping for a new car for his wife. After a month's time, Mr. Jones had looked at several cars. Some of these cars were Fords, some were Chevrolets, and some were Buicks. Some of the Fords that Mr. Jones looked at were station wagons, some were compacts, and some were sedans. Some of the Chevrolets that Mr. Jones looked at were station wagons, some were compacts, and some were sedans. Some of the Buicks that Mr. Jones looked at were station wagons, some compacts, and some were sedans.

Statement #2:

Mr. Jones went shopping for a new car for his wife. After a month's time, Mr. Jones had looked at several cars. Some of these cars were station wagons, some were compacts, and some were sedans. Some of the station wagons that Mr. Jones looked at were Fords, some were Chevrolets, and some were Buicks. Some of the compacts that Mr. Jones looked at were Fords, some were Chevrolets, and some were Buicks. Some of the sedans that Mr. Jones looked at were Fords, some were Chevrolets, and some were Buicks.

APPENDIX II

The following two statements are the randomly organized statements of the experimental problem situation.

Statement #3:

Mr. Jones went shopping for a new car for his wife. After a month's time, Mr. Jones had looked at several cars. Some of the Fords that Mr. Jones looked at were compacts. Some of the sedans that Mr. Jones looked at were Buicks. Some of the Chevrolets that Mr. Jones looked at were sedans. Some of the station wagons that Mr. Jones looked at were Fords. Some of the Chevrolets that Mr. Jones looked at were compacts. Some of the station wagons that Mr. Jones looked at were Buicks. Some of the Fords that Mr. Jones looked at were sedans. Some of the compacts that Mr. Jones looked at were Buicks. Some of the Chevrolets that Mr. Jones looked at were station wagons.

Statement #4:

Mr. Jones went shopping for a new car for his wife. After a month's time, Mr. Jones had looked at several cars. Some of the compacts that Mr. Jones looked at were Fords. Some of the Buicks that Mr. Jones looked at were sedans. Some of the sedans that Mr. Jones looked at were Chevrolets. Some of the Fords that Mr. Jones looked at were station wagons. Some of the compacts that Mr. Jones looked at were Chevrolets. Some of the Buicks that Mr. Jones looked at were station wagons. Some of the sedans that Mr. Jones looked at were Fords. Some of the Buicks that Mr. Jones looked at were compacts. Some of the station wagons that Mr. Jones looked at were Chevrolets.

APPENDIX III

The following four sets of informative items were employed to obtain measures which could be used in scoring Ss' problem-solving performances. Within each set there were three distinctly different sequences in which these items of information could be obtained. Each judge was instructed to rank a particular set of three sequences according to the established criterion of efficiency.

Set 1: Sequences consisting of the information needed when the total value solution is required, and when the solution may be reached only by considering the car body types structured within the car makes:

Sequence A: Mr. Jones looked at 21 Fords.

Mr. Jones looked at 14 Buicks.

Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 6 Chevrolet sedans.

Mr. Jones looked at 10 Chevrolet station wagons.

Sequence B: Mr. Jones looked at 21 Fords.

Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 6 Chevrolet sedans.

Mr. Jones looked at 10 Chevrolet station wagons.

Mr. Jones looked at 14 Buicks.

Sequence C: Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 21 Fords.

Mr. Jones looked at 6 Chevrolet sedans.

Mr. Jones looked at 14 Buicks.

Mr. Jones looked at 10 Chevrolet station wagons.

Set 2: Sequences consisting of the information needed when the total value solution is required, and when the solution may be reached only by considering the car makes organized within the car body types:

Sequence A: Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 10 Chevrolet station wagons.

Mr. Jones looked at 5 Buick station wagons.

Mr. Jones looked at 18 sedans.

Mr. Jones looked at 21 compacts.

Sequence B: Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 18 sedans.

Mr. Jones looked at 21 compacts.

Mr. Jones looked at 10 Chevrolet station wagons.

Mr. Jones looked at 5 Buick station wagons.

Sequence C: Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 18 sedans.

Mr. Jones looked at 10 Chevrolet station wagons.

Mr. Jones looked at 21 compacts.

Mr. Jones looked at 5 Buick station wagons.

Those judges who were first asked to rank the three sequences in Set 1 were asked to rank the three sequences in Set 2 once the initial rankings had been completed. Similarly, once the judges who had first been asked to rank the sequences in Set 2 had completed this request, they were then asked to rank the sequences in Set 1.

Set 3: Sequences consisting of the information needed when the additive value solution is required, and when the solution may be achieved only by considering the car body types structured within the car makes:

Sequence A: Mr. Jones looked at 21 Fords.

Mr. Jones looked at 14 Buicks.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 6 Chevrolet sedans.

Sequence B: Mr. Jones looked at 21 Fords.

Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 6 Chevrolet sedans.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 14 Buicks.

Sequence C: Mr. Jones looked at 21 Fords.

Mr. Jones looked at 9 Chevrolet compacts.

Mr. Jones looked at 14 Buicks.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 6 Chevrolet sedans.

Set 4: Sequences consisting of the information needed when the additive value solution is required, and when the solution may only be reached by considering the car makes organized within the car body types:

Sequence A: Mr. Jones looked at 21 compacts.

Mr. Jones looked at 18 sedans.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 5 Buick station wagons.

Sequence B: Mr. Jones looked at 21 compacts.

Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 5 Buick station wagons.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 18 sedans.

Sequence C: Mr. Jones looked at 21 compacts.

Mr. Jones looked at 6 Ford station wagons.

Mr. Jones looked at 18 sedans.

Mr. Jones looked at 60 cars altogether.

Mr. Jones looked at 5 Buick station wagons.

Those judges who first ranked the three sequences in Set 3 were then asked to rank the sequences in Set 4, and similarly, those judges who ranked the Set 4 sequences initially were then asked to rank the three sequences in Set 3.

APPROVAL SHEET

The thesis submitted by John R. Buri has been read and approved by the following Committee:

Dr. Frank L. Slaymaker, Chairman
Assistant Professor, Psychology, Loyola

Dr. Eugene B. Zechmeister
Associate Professor, Psychology, Loyola

Dr. Robert L. Solso
Professor, Psychology, Loyola

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

December 6, 1977
Date

Frank L. Slaymaker
Director's Signature