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Effects of practice group size and stimulus variables on the use of unfamiliar problem-solving strategies

Bertha Hoffman Cunin
The University of Montana

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EFFECTS OF PRACTICE, GROUP SIZE AND STIMULUS VARIABLES ON THE USE OF UNFAMILIAR PROBLEM-SOLVING STRATEGIES

By

Bertha Hoffman Cunin

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Approved by:

[signature]
Chairman, Board of Examiners

[signature]
Dean, Graduate School

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INTRODUCTION

An Approach to the Study of Problem-Solving

A science of human behavior would be incomplete without an understanding of problem-solving. But in a world that is marked by a wealth of inadequately solved and unsolved personal, social and scientific problems, such an understanding becomes imperative. At the same time, it is important that psychologists begin to develop methods for maximizing the employment of human capacities for such behavior.

One approach that researchers can take in investigating problem-solving behavior is that of exploring the patterns (Restle, 1962) or sequences of responses made by humans who are presented with problem-solving situations. Such patterns have been called strategies (Corts, 1966; Bruner, Goodnow & Austin, 1956; Bruner, *et al.*, 1966; Restle, 1962). They also have been described by investigators as work methods (Ruger, 1910; Sargent, 1940; Seashore, 1939), sets (Ammons & Ammons, 1959a; Ammons & Ammons, 1959b; Seashore, 1939) and hypotheses (Ammons & Ammons, 1959a; Ammons & Ammons, 1959b; Rhine, 1959).

The investigation of strategies in problem-solving would seem to be a potentially useful way in which to study complex behavior. Already, for example, strategies have been identified in performance of a wide variety of tasks, from the relatively simple stylus maze (Husband, 1931; Warden, 1924) and paired-associate (Bugelski, 1962; Martin, Boersman & Cox, 1965) situations to the most complex behaviors. Among the latter have been 3-choice discrimination tasks (Odom, 1967; Weir, 1964), Vigotski blocks (Johnson, 1944) and concept attainment tasks (Bruner, Goodnow & Austin, 1956; Bruner, et al., 1966) as well as such problem-solving situations as construction (Durkin, 1937) and mechanical (Ruger, 1910) puzzles and multiple (Ammons & Ammons, 1959a; Ammons & Ammons, 1959b; Corts, 1966) and single-solution (Rhine, 1959; Sargent, 1940) anagrams. Use of strategies has also been found to vary as a function of such identifiable parameters as age (Mosher & Hornsby, 1966; Odom, 1967; Weir, 1964), intelligence (Klausmeier & Loughlin, 1961; Warden, 1924), problem-solving ability (Rhine, 1959) and socioeconomic class (Odom, 1967).

But, it is another series of findings which perhaps most points up the value of studying strategies in problem-solving. This group of results, obtained from work with simple and complex tasks, indicates that success at many tasks is dependent on both the number (Corts, 1966) and the kinds of strategies used (Bruner, Goodnow & Austin, 1956; Bruner, et al., 1966; Husband, 1931; Odom, 1967; Rhine, 1959; Ruger, 1910; Seashore, 1939; Warden, 1924; Weir, 1964). Warden (1924), for example, found that Ss who rely on verbalization learn a stylus maze more quickly than those who use motor cues. Rhine (1959), in his work with single solution anagrams, also noted the importance of type of strategies when he reported that Ss who use "part" hypotheses are the only Ss who solve difficult problems. For Rhine, as for Sargent (1940), the part hypotheses are ones by which trial and error manipulations of letters are made. They are also ones which can be contrasted to the "whole" approaches, by which letters are read and looked at, with no attempt apparently made to form syllables or combinations.

The reported relationships between strategy and performance suggest that the exploration of strategies can lead to a better understanding of characteristics of successful and unsuccessful problem-solving behavior. They also indicate that perhaps human problem-solving behavior can be made more effective by the development of techniques by which Ss can acquire unfamiliar but potentially highly useful strategies.

As one step, then, toward the understanding and development of techniques for the modification of problem-solving strategies, a series of five experiments have been conducted.

The Development of a Procedure by which Ss Adopt an Unfamiliar Strategy

The first four studies were designed to deal with one basic problem, the development of a procedure by which Ss would be led to adopt and use efficiently a newly presented strategy. Materials such as a problem-solving task, strategies and specific sets of problems also had to be selected or developed. The fifth study, the thesis experiment proper, used a modified version of the procedure and, in addition, investigated several questions suggested by data obtained in Studies 1 through 4.

The problem-solving task.—All five studies used the Standard Anagram Task (SAT) as the problem-solving situation (Ammons & Ammons, 1959a; Ammons

& Ammons, 1959b). This is a task, developed and described in detail by Ammons and Ammons (1959a), for the systematic study of problem-solving, in which _S_s are presented with multiple-solution anagram problems. A problem consists of a set of letters (basic letter combination with which each _S_ is instructed to construct as many words (solutions) as possible, using any or all of the letters. A _S_, however, may use each letter only once in each word that he constructs.

The SAT is a task appropriate for the experimental study of complex problem-solving behavior since it has been shown to be similar in many respects to "real-life" problem situations (Ammons & Ammons, 1959b). For example, _S_s generally find the task highly motivating. The SAT also has the advantage of ease of manipulation of variables important in most forms of problem-solving (Ammons & Ammons, 1959a), such as the objective control of the similarity and difficulty of problems which can easily be achieved.

The SAT is particularly useful for the study of strategy acquisition or modification. This became apparent during preliminary planning stages of the present research when it was noted that there were many known SAT strategies, strategies which had already been compiled by Corts (1966) in the form of a 41-item SAT strategy-checklist. It was especially important that many of these strategies permitted the development and use of objective indices, a prime requisite for their systematic study. The importance of availability of objective indices seems especially great in light of the many broad and often vague definitions of strategies and work methods which have come to be used by different investigators. Among such definitions are those of Seashore (1939), Durkin (1937), Sargent (1940) and Rhine (1959). For Seashore, for example, work methods include "any variation in set, attitude, approach, trick of the trade, adjustment mechanism. . ." (p. 124). Durkin, in investigating three basic "modes of attack," differentiates among trial and error, insight, and gradual analysis; and Sargent and Rhine speak in terms of whole and part methods or hypotheses.

The multiple-solution anagram task strategies summarized by Corts (1966) were classified roughly into three categories: (1) strategies involving the manipulation of letters or manipulation of sounds, (2) strategies involving whole word approaches (such as changing the tense of verb solutions), and (3) more general strategies (such as concentrating on the basic letter combination (BLC) until the "solutions come spontaneously" (Corts, 1966, Appendix)).

From category 2, two strategies were selected and used in the present five studies: (1) constructing solutions that begin with a consonant which is followed by a pair of vowels and another consonant (CVVC), and (2) constructing solutions that begin with two consonants (CC). Each of these obviously task-specific strategies easily met the primary criterion of allowing for the development of objective indices of strategy use. They also had proven to be ones for which problems could be specifically created for which a considerable number of appropriate solutions could be made available. The need for such specifically created problems had become apparent when it was found that neither the E, nor any of 16 pilot Ss taking part in a preliminary study, could construct more than six solutions per problem with any of four strategies selected from Corts' checklist and many already available problems.

The problems used in studies 1 through 4 and the thesis experiment were two sets of five specifically designed anagrams, with one set appropriate with use of strategy 1 (CVVC) and the other with use of strategy 2 (CC). For set 1, a mean of 30.2 solutions (strategy-relevant solutions) per problem have been constructed with the use of the CVVC strategy by at least one S (in any of the five studies) or the E. For set 2, the mean number of solutions (strategy-relevant solutions) per problem constructed by at least one S (in any of the five studies) or the E has been 27.6. A third set of problems, appropriate to the specific strategy of constructing solutions by adding a single consonant to small solutions beginning with a vowel was also constructed. As yet, however, it has not been used in any of the five experiments conducted.

Studies 1 - 4.—A brief look at the results obtained with the first four of the five studies conducted indicates that the materials developed for the study of strategy modification were satisfactory. In addition, the findings suggested that it would be well worth exploring a great many different kinds of problems with the materials at hand. However, they also indicated that the goal of developing a procedure by which Ss adopt and efficiently use an unfamiliar strategy was an unexpectedly difficult one to attain. This can be seen in the more detailed reports of the problems and results of studies 1 to 4 which now follow.

Study 1 attempted to determine if Ss not specifically instructed to work with a particular task-specific strategy could learn to use it by working 10 minutes on each of five problems, in which many specific solutions could be constructed using this strategy (CVVC or CC). Ten-minute work periods were selected since Corts (1966) had previously written that use of trials longer than five or six minutes would force Ss presented with multiple-solution anagrams to work beyond the time when solutions came ready to them. Furthermore, brief work that the present E conducted with one pilot S had suggested that it was not very easy to construct many CVVC or CC solutions. It was thought, therefore, that Ss working beyond the time when "easy" solutions were available might be more likely to come upon the CVVC or CC solutions.

In Study 1, 24 college students working individually in groups of three to eight solved one of two sets of five specially constructed problems which were presented in counterbalanced order. It was found that almost all the solutions specific to the strategies being studied (strategy-relevant solutions) were constructed by one or more Ss. However, a mean number of less than half the possible strategy-relevant solutions (ss) was constructed to each problem. There was no consisten increase with practice in solutions appropriate to the strategy. These findings suggested that the Ss did not use the strategies for which the sets of problems had been developed.

This hypothesis was supported by a careful inspection of the S worksheets, which were made in an attempt to understand why so few ss were constructed. An average of 43% of the solutions constructed for all of the CVVC problems and an average of 56% of those for all CC problems were short (three letters or less). It was also found that many of the solutions constructed began with a consonant followed by a vowel and then another consonant (CVC pattern). An average of 52% of the solutions constructed for all of the CVVC problems and 55% of those for all the CC problems were of this CVC pattern and thus differed from the strategy relevant CVVC or CC solutions.

An examination was then made of all of the worksheets for the 24 Ss for one problem and about 60% of the Ss for each of the other problems. This was done in an attempt to determine the conditions under which solutions four letters or more in length, and in particular ss, (all CVVC ss and the great majority of CC (95.7%) ss are at least four letters in length) were constructed.

Inspection of the data indicated that solutions consisting of four or more letters appeared to have been constructed most often when certain stimulus conditions were present in the original problem. A solution seemed to have a maximum probability of being constructed when its component letters were found very near each other and in the same order in the problem itself (BLC). The construction of solutions at least four letters in length appeared to be associated with S's use of particular response patterns. Among these were various directional patterns. The direction of the scanning pattern in forming a particular solution, for example, maximized the possibility of constructing a particular solution as the next solution. The last letter of a solution often appeared to affect the construction of the next. In some cases, it was evident, the last letter became the first letter and in others, the last letter apparently led to a backward scanning pattern in the solution just constructed. There also were general forward and backward patterns of movement in the selection of letters within the problem, with the selection of consecutive consonants of the problem placed at the beginning of a "root" group of letters. The ss and other long solutions also were constructed when building from previous solutions was possible, as in rhyming, adding to common solutions, and changing vowel sounds. There was less opportunity for the influence of such rhyming and change in sound responses in the construction of CC ss. In summary, these data gathered through the inspection of the work-sheets suggested that strategies of constructing short solutions and CVC solutions were used and that ss were often simply solutions constructed incidentally during S's use of such strategies as rhyming and making letter substitutions and directional movements.

The next step in the search for a method for the modification of specific strategy behavior was taken in Study 2. This experiment attempted to determine if the number of appropriate solutions found by Ss instructed to use a task-specific strategy (CVV or CC), when its successful utilization was reinforced, would increase on successive problems. Twenty Ss, working individually in groups of six to nine, were instructed to use one of two strategies (CVVC or CC) as much as possible in constructing solutions to the appropriate group of five 10-minute problems. They also received knowledge of results as well as differential point reward after each problem through a self-scoring technique by which ss were given ten points and non-ss, one point. Differential point reward, it was hoped, in addition to making task requirements evident (Ammons, 1956), would increase motivation (Ammons, 1956) for the adoption of the new strategy and promote the construction of increasing numbers of ss. It was found that: almost all of the possible ss were constructed by one or more Ss; the mean number of ss per problem was greater than in Study 1; a mean of less than half of the possible ss was constructed to each problem; no systematic change with practice was found in the number of ss constructed.

Additional data regarding strategies used and errors made were also obtained and suggested several questions and problems that should be further explored. These data, consisting of answers to several questions presented to the students immediately after they had served as Ss, indicated that there were two basic verbalizable strategies, besides working with the letter combinations (CVVC or CC), which were most frequently reported as being used. They were rhyming and constructing short, simple words, two strategies whose use had been inferred to be frequent in Study 1. This finding is an interesting and potentially important one since it suggests that strategies or classes of strategies can be classified along various dimensions of similarity. One possible dimension relevant to strategies of rhyming and constructing short, simple words is amount of manipulation that must be made with a strategy in constructing a solution.

Other results from the exploratory analysis of the errors made in Study 2, as well as those in the prior study (Study 1), can perhaps also lead to a greater understanding of strategy characteristics and differences. It was found that:

(1) many more errors were made with the CVVC problems than the CC problems (Study 1: 367% more errors(CVVC = 42, CC = 9); Study 2: 185% more errors (CVVC = 57, CC = 20), (2) most of the errors (Study 1: 67% of the total number of errors; Study 2: 65% of the total number of errors) made with the CVVC problems fell into two out of ten possible classes of errors, spelling errors and repetitions, (3) inspection of the data suggested that these errors were apparently frequently caused by a hasty use of rhyming or sounding out techniques, two strategies which were used more often by Ss working on CVVC problems than CC problems. The data were interpreted as supporting the hypothesis that the occurrence of particular classes of errors is made likely by the use of particular strategies.

The next experiment, Study 3, attempted to determine if even Ss presented with an incentive for performing well would adopt and use efficiently an effective strategy called to their attention. This question was important, since neither Ss left to discover the most effective strategy themselves (Study 1), nor Ss given differential-point incentives for use of a strategy (Study 2) had shown any consistent increase in its use over a series of problems. In Study 3, therefore, 26 college students tested 7 to 10 at a time, worked for either 5 (7 Ss), 10 (10 Ss), or 15 (8 Ss) minutes on each of five problems with which they had been instructed to use either the CVVC or CC strategy as much as possible. Five-minute work periods were selected for use in hope that practice effects might become evident with work periods shorter in time than 10 minutes. Fifteen-minute work periods were used with other Ss since it was thought that Ss might become more skilled in strategy use with a greater amount of practice on each problem. Ss scored their performance after the time limit on each problem had been reached, with each strategy-relevant solution receiving 10 points and each non-strategy-relevant solution, one point. This time groups were told that individuals could leave the experiment early by achieving a high score two times in a row. A statistically significant increase in the number of ss was found for one (CVVC) of the two strategies suggested to the Ss.

Increases in production of ss, ranging from 36% to 100%, were found with three (BLCs, AFRILSTE, BDAEROMN, LOMASETR) of the five CVVC 10-minute problems when the performance of Ss (3) on the first problem on which they worked was compared with the performance of Ss (3) solving the corresponding problems as their fifth or last problem. The numbers of ss constructed to these three problems when presented as problem 1 were combined and then compared to the numbers of ss constructed to the same problems when presented as problem 5. Results of a randomization test for two independent samples (Siegel, 1965, pp. 152-156) revealed that the mean number of ss constructed to problems presented in position 5 (15.0) was significantly larger ($p < .01$) than the mean number constructed to problems presented in position 1 (9.7). The apparent increase in strategy use was also found with three (BLCs, APDILENR, LOMASETR, MIEDALNH) of the five CVVC problems on which Ss worked five minutes (+40%, +133%, +600%). Again, data to the three problems presented as the first problem on which Ss (3) worked were compared to the data to the same problems when presented as the fifth problem which Ss (3) solved. Results from a randomization test for two independent samples (Siegel, 1956, pp. 152-156) indicated that the mean number of ss constructed to problems presented in position 5 (9.0) was significantly greater ($p < .05$) than the mean number constructed to problems presented in position 1 (4.3). For the two other problems on which Ss worked five minutes, as well as for all the problems on which Ss worked 15 minutes, data were not available for all of the five positions in which a particular problem could be presented. This was due to the fact that a total of nine Ss in these conditions achieved the required high scores and left the experiment before all five problems had been presented. It now appeared that with further modification of motivational procedure, most Ss might reasonably be expected to adopt and learn to use effectively a strategy suggested to them.

Study 4. It had been found that some of the Ss, offered an incentive for achieving high scores (Study 3) clearly increased their use of one suggested strategy (CVVC). No such increase, however, had been found in use of the CC strategy under the same circumstances. It was therefore necessary to determine if conditions could be found under which individually-run Ss would construct increasing numbers of ss with practice in using the CC strategy. It was hoped that by working with Ss individually, their motivation could be maintained at more nearly an optimum level, while detailed information about their use of strategies could be obtained from their comments and answers to questions, immediately after working on a problem.

In Study 4, then, three college students naive to the anagram task were instructed to use, as much as possible, the strategy (CC) for which no increase had previously (Study 3) been found in the number of ss constructed with reinforced practice over a series of five problems. They were told that they could leave the experiment early by achieving high scores and shown how high scores could be attained by using the specified strategy. Between problems, these Ss scored their responses, giving 10 points to each strategy-relevant solution and 1 point to each non-strategy-relevant solution constructed. It was found that all the Ss showed a great increase with practice in the number of ss they produced when their performance was compared to the mean number of CC ss constructed with the corresponding problems in Study 2. The binomial test was applied to the result that a predicted outcome was obtained three out of three times and yielded $p < .125$. The Ss showed a mean increase of 160% in the number of ss constructed on the fifth problems (ordinal-position 5) on which they worked as compared to that number constructed on the first problems (ordinal-position 1) on which they worked.

Various other results were also attained through analysis of S reports and solutions produced. All Ss reported that some letter pairs were more familiar than others and that ease of construction of solutions was dependent on the degree of familiarity with them. This finding is similar to one reported by Mayzner and Tresselt (1962a, 1962b, 1963): solutions to single solution anagrams whose bigrams (letter pairs) occur with high frequency in the English language are easier to find than those whose bigrams occur with low frequency.

Evidence from S reports and performance also suggested some reasons for the poor performance shown by Ss presented with the CC strategy and the absence of any practice effect in previous studies. It became clear, for example, that the CC strategy was a highly nonpreferred and difficult work method for them. Further, the Ss believed that they were successful in meeting the demands of the task by simply constructing as many solutions as possible, whether or not related to the strategy being learned.

Poor performance also appeared to be caused by the responses that Ss may make after initial failure at a task. It was found that a S required to use a difficult strategy may retreat from the demands of the task and cease attempting to use it if he performs poorly initially. One S was able to do this by minimizing the importance of the problem-solving situation and also by substituting his criteria of a good performance for that of the E. After being informed that he had not achieved a high score, this S emphatically stated that he didn't have to do well, that "getting many CC words" wasn't indicative of "success in life," and that English was not his "forte." Later, he pointed out that his performance had been good since he "still" did "make up many words." Another S believed that there was no possibility that he could become a high performer. Thus, he too was able to consider his decreased efforts at constructing many CC solutions an acceptable response to initial failure. This was apparent when he stated that studies had indicated, according to a sociology teacher, that perfomance on early tests is very indicative of performance on later tests.

In Study 5, the thesis experiment to be reported in detail, college students were again advised of the importance of using a task-specific (CVVC or (CC) strategy in solving multiple-solution anagrams. For this experiment, further changes in the instructions and experimental design were made which would, it was hoped, minimize the occurrence of some of the problems found to have hindered the increase (Study 4) in the use of a new strategy. (See Procedure.).

Statement of the Problems

Study 5, with these revised instructions and design, investigated three specific problems:

(1) Can strategy behavior be modified over a series of problems so that Ss working under standard experimental conditions adopt and increase their effective use of a designated task-specific strategy?

(2) Do Ss taking part in a problem-solving experiment one at a time differ from Ss, also working individually but participating in small groups (five at a time), in the use of a task-specific strategy which has been presented to them?

This problem is an obviously important one, for practical problems of limitations in time, trained personnel and funds, both in the experimental and educational spheres, demand that techniques for the development of problem-solving skills should bring about such changes within as many people as possible at one time.

(3) Do various stimulus dimensions, as indicated by the auxiliary findings of the previous studies (Study 1, Study 2, Study 4) affect the use of task-specific

problem-solving strategies? The basic question is: Is the probability that four-letter ss will be constructed a function of the distance between the letters of a consonant or vowel pair, their direction and their bigram frequency?

Bigram distance is defined as the number of letters which in the problem (BLC) appear between the two letters of the vowel or consonant pairs. The specific hypothesis was: The probability that four-letter ss will be constructed is a decreasing function of the distance between the letters of a consonant or vowel pair.

A positive bigram direction is defined as the presence of the vowel or consonant letter pairs in the problem (BLC) in the same direction as in the constructable solutions. A negative bigram direction is defined as the presence of the letter pairs in the problem (BLC) in the opposite direction to that found in the constructable solutions. The specific hypothesis was: The probability that four-letter ss will be constructed is greater for ss with a positive direction consonant or vowel pair than for ss with a negative direction consonant or vowel pair.

Bigram frequency is defined as the frequency with which the vowel pairs of the CVVC ss appear as the second and third letter and the consonant pairs of the CC ss appear as the first and second letters within the four-letter words which were sampled by Mayzner and Tresselt (1965). These researchers arrived at these frequencies in their sampling of 20,000 English words which varied in length from three to seven letters. The specific hypothesis was: The probability that four-letter ss will be constructed is an increasing function of the bigram frequency of a consonant or vowel pair.

Problem 3, with its three hypotheses, was posed as an initial step in the study of some of the stimulus determinants of strategy responses.

METHOD

Design

The experiment used a 5 x 5 Latin square design in which columns, rows and Latin letters represent three major sources of variation. Each column corresponds to one of the five ordinal-positions in which the five strategy-relevant problems (BLCs, CVVC or CC) were presented and each row, to a single S, who received the treatments in one of five possible orders. These treatments or Latin letters represent the five strategy-relevant problems (CVVC or CC) presented to each S. Columns, rows and letters were randomly arranged from a randomly selected 5 x 5 standard square (Fisher & Yates, 1948). This 5 x 5 square was replicated eight times, so that a total of 40 Ss participated in the experiment. Four of the eight squares represent experimental procedures in which Ss were presented with the CVVC strategy and the five appropriate or strategy-specific problems. The remaining four represent experimental procedures in which Ss were presented with the CC strategy and its five strategy-specific problems. Two of each set of four squares also correspond to experimental procedures in which the Ss participated in the study one at a time. The other two of each set of four squares correspond to experimental procedures in which Ss, also working individually at the experimental task, participated in the study five at a time. In effect, then, the Latin square design was also a 2 x 2 x 5 factorial, with task specific problem-solving strategy to be used (CVVC, CC), experimental setting (individual, group), and order of problem presentation (the five orders in which problems could be presented for the five Ss of each square), the three variables manipulated. This design provided for 20 experimental conditions, in each of which two Ss participated.

Subjects

Ss were 40 college students (22 males, 18 females) who were experimentally naive, i.e., reported that they had never participated in any prior study in which anagrams had been used. One of these 40 Ss, however, participated in the study only after the data of another S had to be discarded because of her failure to follow instructions on the first problem on which she worked. Since the original S had participated in one of the 5-S group conditions (group setting, CVVC strategy), another 5 Ss also took part in the study and were presented with the CVVC strategy in a group setting. However, only the data produced by the one S who had been randomly assigned to the same one of the 20 possible experimental conditions (same order of problem presentation, in addition to CVVC strategy and group setting) as the original S were included in the data to be analyzed.

Materials

Mimeographed booklets containing typed preliminary instructions, two pages of Standard Anagram Task (SAT) instructions, and five eight-letter basic letter combinations (BLCs) consisting of five consonants and three vowels were used. Page 2 of the SAT instructions included statements on the use of either the CVVC or CC strategy. Both the preliminary instructions and page 2 of the SAT instructions had been revised after Study 4. They were designed to heighten the game-like and competitive aspects of the task and make the construction of many ss a more integral aspect of its requirements. The set of five BLCs was one of the two sets of strategy-relevant problems used. One set of five problems, presented to one-half of the Ss, consisted of the ones which had been specifically designed by the E to allow for the construction of many solutions beginning with a consonant followed by two vowels and another consonant (CVVC). The other set of five problems had been specifically designed to allow for the construction of many solutions beginning with two consonants (CC). The overlapping of letters within the set of five CVVC problems and within the set of five CC problems was minimized as much as possible. The CVVC problems were: AFRILSTE, APDILENR, BDAEROMN, LOMASETR and MIEDALNH. The CC problems were ARHCTNEI, APOSDCIL, IGARDPEB, TORSECPA and WEHTNGIA. Three additional problems were presented at the end of each experimental booklet. For each booklet, these problems were repetitions of the first three which had been presented. A set of CVVC and CC problems and their ss are given in Appendix A.

Procedure

Prior to the study, Ss were randomly assigned to one of the 20 experimental conditions. Each of the Ss, in both the 10 individual and 10 five-subject group conditions, was initially presented with his booklet upon being seated. The sets of strategy-relevant problems (CVVC or CC) presented were the same (the order in which problems were presented differed for each S, however) for all five-subject group Ss participating in the experiment at any one time. Ss in the group conditions were seated in desk-chairs prearranged in the shape of a circle with a diameter of approximately three yards, so that no S could see the problems on which any other S was working. After reading the instructions, which included the information that Ss could leave the experiment early by receiving a high performance score on each of four problems, and being asked if there are any questions, the Ss then worked for 10 minutes on each of the problems. After every minute during each of the 10-minute work periods, all the Ss were instructed to write down the number called to them (1, 2, 3, 4, 5, 6, 7, 8, or 9) and to keep working.

After the 10 minutes allowed for work on each of the problems, Ss were told to stop, draw a line after the last solution and score their papers. Ss gave themselves 10 points for each strategy-relevant solution and 1 point for each other acceptable solution. Each S then showed to the E the problem on which he had worked. E scanned the problem for scoring accuracy, pointing out any "gross" error that may have been present and called for rescoring, and then told the S if he had attained a high performance score (h.p.s.). Brief comments such as "very, very good" and "great" were made to each S when he reached a h.p.s., or if told that he had not reached such a level, comments such as "no . . . you didn't make it" and "but, now really dig in . . ." were made. (See Appendix A.)

Ss received high performance scores regardless of actual performance level and every S was informed after at least one of the first four problems that he had done very well. Every S also failed to attain the h.p.s. on at least one of the first four problems so that every S had to solve the complete set of five problems presented. All of the five Ss represented by the rows of any one Latin square, however, did not receive the same number of high performance scores. In this way, all five Ss taking part in any of the five-subject group conditions did not leave the experiment at the same time.

A more detailed view (See Table 1.) of the procedure shows that two randomly selected Ss of every five received a h.p.s. on four of the first five problems. These Ss did not receive a h.p.s. on one of the first four problems. Two other randomly selected Ss of every five received a h.p.s. on three of the first five problems, and therefore did not receive this reported proficiency level (h.p.s.) on two of the first four problems. The remaining randomly selected single S out of every five received the h.p.s. after two of the first five problems and failed to attain the h.p.s. after three of the first four problems.

The specific problems after which each S received the predetermined h.p.s. which had been assigned were randomly determined. S received information regarding his performance on the basis of a code number assigned to each S. Each code number appeared on the table of the assigned high performance scores held by the E, as well as on the experimental booklet pages of the corresponding S.

Ss not receiving four high performance scores by the completion of problem 5 were told that the rules of the game would remain the same but that the performance standards had been set a little lower.

Table 1

Sample Table of the Assignment of High Performance Scores

To One Group of Five Ss

S No.	Code letter	Problems					Additional repeat problems		
		1	2	3	4	5	6	7	8
1	d	H	NH	NH	H	H	H	-	-
2	b	NH	H	H	H	H	-	-	-
3	a	H	NH	H	H	H	-	-	-
4	c	H	H	NH	NH	H	H	-	-
5	e	NH	NH	H	NH	H	H	H	-

Note. —The code letters were assigned (randomly) for each group of five Ss. For each S, the specific problems (ordinal position 1, 2, 3, 4) after which he received the preassigned h.p.s. was randomly determined.

Legend:

H = h.p.s.

NH = non-attainment of h.p.s.

S a, b = h.p.s. on four of first five problems. (S leaves after problem 5.)

S c, d = h.p.s. on three of first five problems. (S leaves after problem 6.)

S e = h.p.s. on two of first five problems. (S leaves after problem 7.)

Because of the predetermined assignment of attainment of high performance scores, two Ss out of every five left the experiment after the fifth problem, two others after the sixth, and one other after the seventh. No S worked on all eight problems presented in each experimental booklet. (See Table 1.)

Effects of experimenter bias.—Throughout the study the E was aware of the hypotheses being tested and the conditions to which Ss were assigned. Results obtained with the design and procedure used may in part be due to effects of E bias or hypothesis communication (Rosenthal, 1967). To control for possible effects of E bias, the major portion of the instructions was therefore presented to the S in written form. In addition, the E sat back in her chair while Ss were working so that the E was unable to see either the problems which Ss were solving or the solutions being produced.

The principle of E communication of hypotheses or expectancies was used positively, however, to maximize the probability that Ss would remain at a difficult experimental task. Ss were therefore told that they were capable of constructing many ss and would become successful at the problem-solving game. (See Appendix A.)

RESULTS

Effects of Practice

S use of a designated task-specific strategy (CVVC or CC) was measured by the number of ss constructed to a problem. The number constructed by each *S* to each of the five problems on which he worked was calculated. The scores were then subjected to three sets of analyses (analyses 1, 2 and 3) to assess effects of practice on the use of a task-specific strategy (CVVC or CC).

An analysis of variance of the numbers of ss constructed was made for each of the eight 5 x 5 Latin squares (analysis 1). Table 2 shows that there was a significant columns (five ordinal positions in which problems were presented) effect for three squares (p .01). The presence of a columns or ordinal position effect indicated that amount of practice in the use of a strategy was a significant source of variation in these three squares. The columns or ordinal-position (practice) effect approached significance for two other Latin squares ($p < .1$, $p < .25$).

For each square of five *Ss* the mean number of ss constructed for problems presented in the fifth ordinal-position (the maximum amount of practice) was then compared to the mean number for problems presented in the first ordinal-position (no prior practice). As can be seen in Table 3 (summary of analysis 2), *Ss* in each of the eight squares produced a greater mean number of ss for the ordinal-position 5 than for the ordinal-position 1 problems. The binomial test was applied to the finding that a predicted result was obtained eight out of eight times. It indicated

Table 2

Latin Square Analyses of Variance

Source	df	Variance estimate	F
Group I - 1 (CVVC - individually-run *S*s)			
Columns (practice)	4	25.9	7.4****
Rows (subjects)	4	10.3	2.9**
Treatments (problems)	4	25.2	7.2***
Error (residual)	12	3.5	
Group I - 2 (CVVC - individually-run *S*s			
Columns (practice)	4	46.1	7.1****
Rows (subjects)	4	86.6	13.3****
Treatments (problems)	4	40.3	6.2****
Error (residual)	12	6.5	
Group II - 1 (CVVC - group-run *S*s)			
Columns (Practice)	4	17.8	2.0*
Rows (subjects)	4	28.5	3.2**
Treatments (problems)	4	30.4	3.4***
Error (residual)	12	8.9	

Table 2 - cont'd.

Group II - 2 (CVVC - group-run Ss)			
Columns (practice)	4	8.7	
Rows (subjects)	4	194.5	19.8****
Treatments (problems)	4	12.7	
Error (residual)	12	9.8	
Group III - 1 (CC - individually-run Ss)			
Columns (practice)	4	3.8	
Rows (subjects)	4	33.7	7.8****
Treatments (problems)	4	6.9	1.6*
Error (residual)	12	4.3	
Group III - 2 (CC - individually-run Ss)			
Columns (practice)	4	51.8	12.6****
Rows (subjects)	4	35.9	8.8****
Treatments (problems)	4	3.5	
Error (residual)	12	4.1	

Table 2 - cont'd.

Group IV - 1 (CC - group-run Ss)			
Columns (practice)	4	10.0	
Rows (subjects)	4	24.9	2.0*
Treatments (problems)	4	15.9	
Error (residual)	12	12.2	

Group IV - 2 (CC - group-run Ss)			
Columns (practice)	4	18.2	2.5**
Rows (subjects)	4	57.0	7.8****
Treatments (problems)	4	23.7	3.2**
Error (residual)	12	7.3	

* $p < .25$

** $p < .1$

*** $p < .05$

**** $p < .01$

Table 3

Comparison of Position 5 Mean Number of ss with

Position 1 Mean Number of ss

Group	Percentage change
I - 1 (CVVC problems)	+ 90.9
I - 2 (CVVC problems	+ 100.0
II - 1 (CVVC problems)	+ 45.5
II - 2 (CVVC problems)	+ 1.9
III - 1 (CC problems)	+ 30.7
III - 2 (CC problems)	+ 159.3
IV - 1 (CC problems)	+ 23.9
IV - 2 (CC problems)	+ 87.5

that the predicted outcome occurred more frequently than could be expected by chance ($\underline{p}$ = .004).

The third set of analyses made was directed to the question: did strategy performance level consistently increase with practice? In the optimum (performance level an increasing function of amount of practice) situation, the mean performance scores would be ordered so that the mean number of ss constructed was greatest for the problems presented in ordinal-position 5. It would be next greatest for the problems presented in ordinal-position 4, next for those presented in ordinal-position 3, then for those presented in ordinal-position 2 and finally, smallest for the problems presented in ordinal-position 1. This optimum and improbable (1/5!, $\underline{p}$ = .008) ordering or arrangement of mean scores did not occur with any of the eight squares. However, the arrangements of mean scores which were found generally deviated only slightly from the optimum ordering of ordinal-position mean performance scores. This can be seen in Table 4, which indicates that for seven of the eight Latin squares the mean numbers found only have to be moved a total of either one or two places so that the optimum arrangement or ordering of ordinal-position mean performance scores could be obtained. The probability of attaining these or more extreme arrangements of scores by chance is $\underline{p}$ = .04 for four of these seven squares and $\underline{p}$ = .14 for the other three. The first $\underline{p}$ was computed by the dividing of the number of possible cases in which a total of a one-position move or less of a mean performance score (5) is necessary for arriving at the optimum arrangement by the total number of possible arrangements (5!). The latter $\underline{p}$ was computed by dividing the number of possible cases in which a total of two possible moves or less of mean performance scores (17)

Table 4

Obtained Arrangements of Performance Scores

Group	Mean no. ss for 5 ordinal-positions 1	2	3	4	5	No. position moves necessary for optimum arrangement	p	Combined p
I - 1	6.6	10.2	10.0	11.6	12.6	1	.04	
I - 2	8.2	14.0	11.8	13.4	16.4	2	.14	
II - 1	11.0	13.6	15.0	14.2	16.0	1	.04	
II - 2	10.6	10.2	9.2	12.8	10.8	5	.38	
III - 1	7.8	8.6	8.8	8.6	10.2	2[a]	.14	
III - 2	5.4	8.8	11.6	9.4	14.0	1	.04	
IV - 1	9.2	7.8	10.6	10.6	11.4	2[a]	.14	
IV - 2	4.8	8.4	8.8	9.6	9.0	1	.04	
								.01[b]

a Tie between 2 means considered as 1 mean out of optimum place.

b x^2 = 39.32; d.f. = 16.

is necessary for arriving at the optimum arrangements by the total number of possible arrangements (5!). For the eighth square (group 11-2), p = 38, computed by dividing 45 (number of possible cases in which a total of five position moves or less are necessary for arriving at the optimum arrangement) by 120 (5!).

As is evident, the probability that the arrangement of mean scores found was attained by chance was less than .05 ($p = .04$) for four of the eight squares. The p's from the eight independent tests of significance were then combined by a procedure in which the x^2s computed for each probability were added into a composite x^2 and then evaluated, with degrees of freedom being twice the number of probabilities combined (Lindquist, 1940). The x^2 indicated (See Table 4.) that the occurrence of the eight obtained arrangements, with their generally slight deviations from the optimum arrangement or ordering of ordinal position mean performance scores, was statistically significant ($p < .01$).

Effect of Size of Experimental Group and Other Factors

The effect of size of experimental group was examined in two ways. For the first approach, the number of ss constructed for all five problems was counted for each S and subjected to a 2 x 2 x 5 analysis of variance. Neither experimental group size (1 S vs v Ss) nor order of presentation was a statistically signiticant source of variation. (See Table 5.) The effect of strategy was significant ($p < .05$), with the greater mean number of ss constructed by the Ss using the CVVC strategy greater than the number constructed by Ss using the CC strategy. (See Table 5.) None of the interactions were significant.

The effect of group size was also examined in terms of differences in effects of practice on the construction of ss. This was done because no statistically significant ordinal-position or practice effect had been found with any of the four squares which represented Ss working individually in groups of five. For two of these squares, however, the practice effect did approach significance ($p < .1$, $p < .25$). In contrast, a statistically significant ($p < .01$, $p < .05$) ordinal-position or practice effect had been found with three of the four squares representing individually-run Ss.

For the second analysis of group size effects, then, scores were not summed over the five ordinal-positions in which problems were presented. Instead the number of ss that each S constructed on the fifth problem on which he worked was compared to the number he constructed on the first and the difference noted. Table 6 (as well as Table 3) shows that both Ss presented with the CVVC problems and Ss presented with the CC problems constructed more ss on the fifth problem than the first problem on which they worked. However, Ss working in the individual conditions showed a greater mean difference or increase (See Fig. 1.) than did Ss working in the group conditions. This was found with both the Ss presented with the CVVC problems ($p < .05$, two-tailed test) and those presented with the CC problems ($p < .01$, two-tailed test).

Table 5

Analysis of Variance

Source of variance estimate	*df*	Variance estimate	*F*
Between Pairs	(19)	(3353.7)	
Size of group (A)	1	19.6	
Strategy (B)	1	1876.9	5.7*
Order (C)	4	372.2	
A x B	1	84.1	
A x C	4	284.9	
B x C	4	351.1	
A x B x C	4	364.9	
Within Pairs	20	330.6	

* $p < .05$

Table 6

Comparison of Practice Effect in Individual Conditions with Practice Effect in Group Conditions

Type of problem	Mean difference in no. ss constructed to problems in ordinal-position 5 with no. to problems in ordinal-position 1			
	Individual conditions	Group conditions	*t*	*df*
CVVC	8.1	2.6	2.89*	9
CC	5.5	3.2	3.89**	9

Note.—Both tests of statistical significance were *t* tests for correlated scores. Ordinal-position 5 - ordinal-position 1 scores were blocked, with each block derived from data from *Ss* whose problems had been presented in identical order. The fifth and first problems presented were therefore identical for each block of *Ss*.

*$p < .05$ (two-tailed test)

**$p < .01$ (two-tailed test)

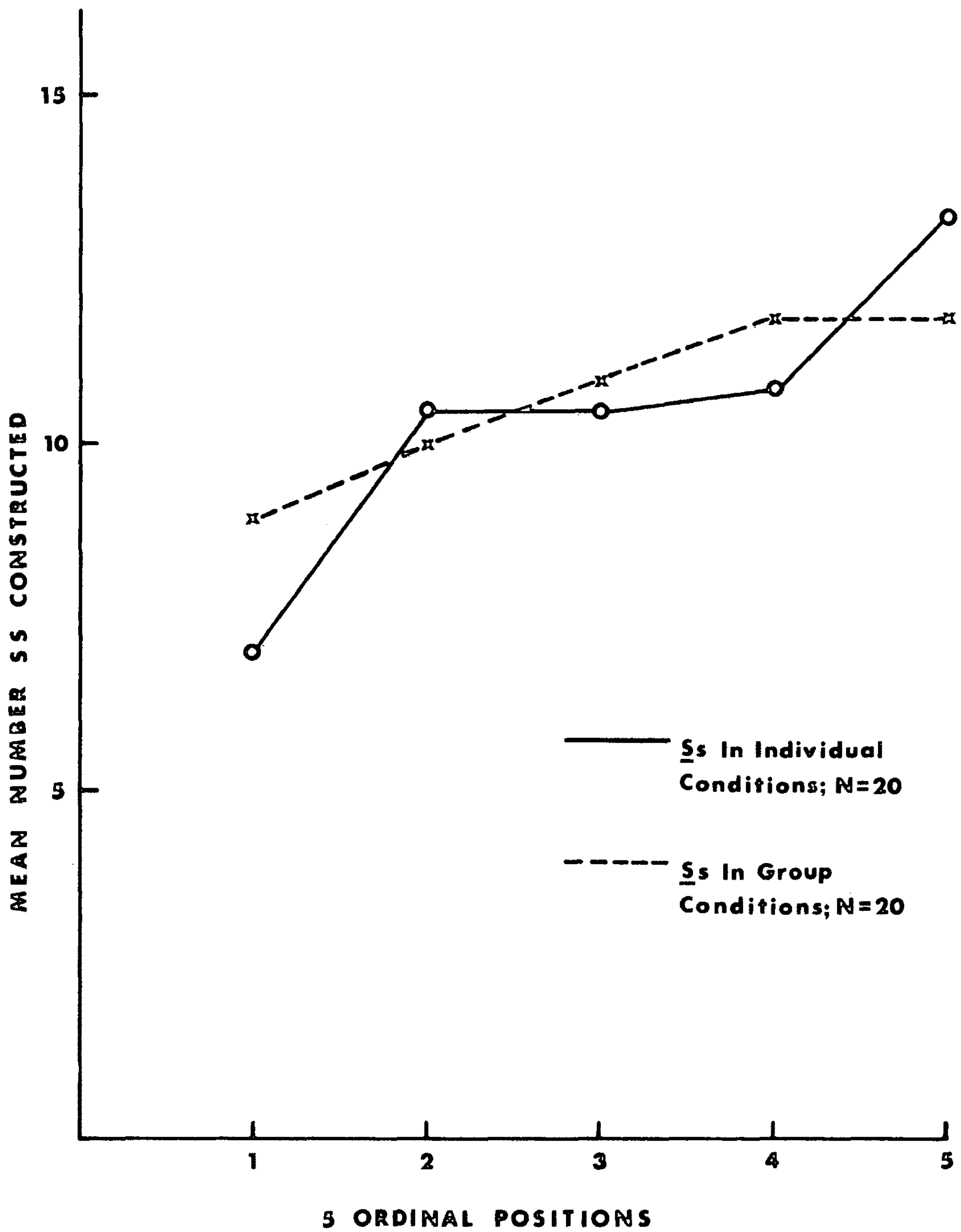

FIG. 1 MEAN NUMBER SS CONSTRUCTED AS A FUNCTION OF ORDINAL POSITION IN WHICH PROBLEMS WERE PRESENTED.

Three Stimulus Dimensions which Define Solution Classes and Use of the CVVC and CC Strategies

Effects of bigram distance, direction and frequency on strategy use were analyzed after all four-letter ss for both the CVVC and CC problems were categorized into ss classes.

For investigation of the stimulus dimension of bigram (vowel or consonant pairs) distance, all the constructable four-letter ss for each of the problems were categorized into one of seven (0, 1, 2, 3, 4, 5, or 6) possible bigram distance ss classes. (See Table 7 and Appendix B.) Bigram distance class 0 was composed of ss whose vowel or consonant bigrams had the least possible bigram distance, that is, no letters appearing in the problem (BLC) between the two letters of the vowel or consonant pairs. Bigram distance class 6 was composed of ss whose vowel or consonant bigrams had the greatest possible bigram distance, that is, six letters appearing in the problem between the two letters of the vowel or consonant pairs. Bigram distance classes 1 through 5 fell in between the two extremes.

For investigation of the stimulus dimension of bigram direction (vowel or consonant pairs), all the constructable (four letters in length) ss for each of the problems were recategorized into one of two possible direction classes (See Table 8 and Appendix B.) The positive bigram direction class was made up of ss whose vowel or consonant bigrams appeared in the problem in the same direction as in the ss themselves. The other class, the negative bigram direction class, was composed of ss whose vowel or consonant bigrams appeared in the problem in opposite direction to that found in the constructable ss themselves.

Table 7

Mean Percentage of Class ss Constructed

Problems	Distance classes						
	0	1	2	3	4	5	6
CVVC							
APDILENR		(EI, IE)	(AI, IA)		(EA)		
		10.0	53.1		50.0		
LOMASETR	No comparisons possible						
MIEDALNH	(IE)	(EA)	(AI, IA)				
	30.0	63.3	51.3				
BDAEROMN	(EA)	(OE)	(OA)				
	62.7	10.0	52.0				
AFRILSTE			(IA, AI)	(IE)			(EA)
			45.0	12.5			48.3
CC							
WEHTNGIA	(TH, GN)	(WH)	(TW)				
	48.3	52.0	42.5				

Table 7 - cont'd.

	0	1	2	3	4	5	6
APOSDCIL		(CL)		(SL)		(PL)	
		SC)					
		28.3		65.0		70.0	
TORSECPA		(TR,	(ST,				
		SC)	CR,				
			SP)				
		43.3	36.7				
IGARDPEB	(DR)	(GR,		(BR)			
		PR)					
	50.0	57.5		32.5			
ARHCTNEI	(CH)	(TH)					
	60.0	63.3					

Note. —No comparisons were made with the solutions produced to a problem whose ss could not be classified into at least two distance ss classes.

The number of ss and the ss themselves in each of the distance classes are given for each of the problems in Appendix B.

Table 8

Mean Percentage of Class ss Constructed

Problems	Direction classes	
	Positive	Negative
CVVC		
APDILENR	(AI, IE) 46.2	(EA, EI, IA) 44.7
LOMASETR	(OA) 50.0	(EA) 52.1
MIEDALNH	(EA, IA, IE) 53.1	(AI) 47.1
BDAEROMN	No comparisons possible	
AFRILSTE	(AI, IE) 41.1	(EA, IA) 43.1
CC		
WEHTNGIA	(WH) 52.0	(TH, GN, TW) 38.8
APOSDCIL	No comparisons possible	
TORSECPA	(TR, SC, SP) 31.4	(ST, CR) 50.0
IGARDPEB	(GR) 73.3	(BR, DR, PR) 36.7
ARHCTNEI	No comparisons possible	

Note. —No comparisons were made with the solutions produced to a problem whose ss could not be classified into two direction ss classes.

The number of ss and the ss in each of the direction classes are given for each of the problems in Appendix B.

The third stimulus dimension was studied after all the four-letter constructible ss for each of the problems were again reclassified into one of four (1, 2, 3, 4) possible frequency ss classes. (See Table 9 and Appendix B.) These classes were derived from the bigram frequencies reported by Mayzner and Tresselt (1965) in their sampling of 20,000 English words. For the thesis experiment, bigram frequency class 1 consisted of ss containing the consonant bigram (TH), found by Mayzner and Tresselt to have a frequency of 847. Bigram frequency class 2 consisted of ss containing the vowel or consonant bigrams found by them to have frequencies in the 100's. Bigram frequency class 3 was defined as a class consisting of ss containing the vowel or consonant bigrams reported to have frequencies in the 20's (19 - 26). Class 4 was defined as a class of ss containing the vowel or consonant bigrams which were reported to have frequencies equal to 11 or less among the four-letter words sampled by Mayzner and Tresselt (1965).

After all constructible four-letter ss had been categorized into classes, the relationship between the three stimulus dimensions and use of the CVVC and CC strategies was examined in terms of two measures. The measures were: (1) the mean percentage of solutions constructed from each particular class of ss being considered and (2) the number of Ss who constructed at least one solution from it.

Measure 1. For each of the stimulus dimensions (bigram distance, direction and frequency), the mean percentage of solutions constructed from each class of ss is reported in Tables 7, 8 and 9 for each problem on which Ss worked. For each stimulus dimension, a separate analysis of variance was conducted for each

Table 9

Mean Percentage of Class ss Constructed

Problems	Frequency classes 1	2	3	4
CVVC				
APDILENR		(EA,AI) 43.6	(IE) 13.3	(EI, IA) 30.0
LOMASETR		(EA) 52.1	(OA) 50.0	
MIEDALNH		(EA,AI) 62.2	(IE) 30.0	(IA) 75.0
BDAEROMN		(EA) 62.7	(OA, OE) 46.7	
AFRILSTE		(EA,AI) 50.6	(IE) 12.5	(IA) 15.0
CC				
WEHTNGIA	(TH) 60.0	(WH) 52.0		(GN, TW) 33.8
APOSDCIL	No comparisons possible			
TORSECPA			(ST, TR) 67.5	(CR, SC, SP) 25.0
IGARDPEB	No comparisons possible			
ARHCTNEI	(TH) 63.3			(CH) 60.0

Note. —No comparisons were made with the solutions produced to a problem whose ss could not be classified into at least two frequency ss classes.

The number of ss and the ss in each of the frequency classes are given for each of the problems in Appendix B.

problem (if possible) on the percentage of ss from each class that each S constructed. No analysis of variance to determine effects of one of the stimulus dimensions was conducted where the ss to a problem could not be classified into at least two ss classes of that stimulus dimension. For example, no analysis of the effect of bigram distance class could be carried out with the ss constructed to problem, LOMASETR since all the constructible ss (containing either the vowel bigram EA or OA) were classified as bigram distance class 1 ss. (See Appendix B.)

Inverse sine transformations were made to correct for skewness prior to any of the analyses of variance made on data which included mean percentages smaller than 25% or greater than 75%. Values were taken from Snedecor's (1956) reproduction of Bliss's tables.

1). Bigram distance. Table 10 shows the results from the analyses of variance made to assess effects of bigram distance class. Four of the four analyses made with the ss constructed to the CVVC problems showed a statistically significant classes effect ($p < .01$). No consistent relationship was found, however, between distance class and the mean percentage of the class ss constructed. (See Table 7.) No statistically significant classes effect was found with three of the five analyses made with the percentages of distance class ss constructed to the CC problems. With the other two analyses (for solutions to problems, APOSDCIL and IGARDPEB), a significant classes effect was found. Inspection of the data summarized in Table 7 shows that again there was no consistent relationship

Table 10

Analyses of Variance

Problems	Mean percentage of distance class ss constructed		
	df	Variance estimate	F
CVVC			
APDILENR			
Source of variation			
Classes	2	7,508.2	28.2****
Rows (Ss)	19	442.5	1.7**
Residual	38	266.2	
LOMASETR	No comparisons possible		
MIEDALNH			
Source of variation			
Classes	22	9,938.1	18.1****
Rows (Ss)	19	772.1	1.4*
Residual	38	550.0	
BDAEROMN			
Source of variation			
Classes	2	11,162.2	20.2 ****
Rows (Ss)	19	598.3	1.1
Residual	38	533.1	

Table 10 - cont'd.

	df	Variance estimate	F
AFRILSTE			
Source of variation			
Classes	2	6,286.0	31.4****
Rows (Ss)	19	399.7	2.0***
Residual	38	200.0	
CC			
WEHTNGIA			
Source of variation			
Classes	2	361.3	
Rows (Ss)	19	1,197.2	1.9****
Residual	38	623.4	
APOSDCIL			
Source of variation			
Classes	2	8,565.1	4.1***
Rows (Ss)	19	865.6	
Residual	38	1,835.0	
TORSECPA			
Source of variation			
Classes	1	444.8	
Rows	19	739.2	1.6*
Residual	19	458.3	

Table 10 - cont'd.

	df	Variance estimate	F
IGARDPEB			
Source of variation			
Classes	2	3,573.0	4.4***
Rows (Ss)	19	778.5	
Residual	38	809.8	
ARHCTNEI			
Source of variation			
Classes	1	108.5	
Rows (Ss)	19	1,416.7	1.6*
Residual	19	908.3	

*$p < .25$

**$p < .1$

***$p < .05$

****$p < .01$

between distance class and the mean percentage of class ss constructed.

2). Bigram direction. With the dimension of direction, no analyses of variance were conducted with the percentages of class ss constructed to the CVVC problems since inspection of the data indicated that the differences in the mean percentages of class ss were very small ones. (See Table 8.) An analysis of variance was applied, though, to the percentages of class ss constructed to each of three of the five CC problems. (See Table 11 which notes that no analyses were possible with the data to the other two problems.) Each of the three analyses yielded a significant classes effect ($p < .01$). For two of the three problems, a greater mean percentage of the positive direction class of ss than of the negative direction class of ss was constructed. (See Table 8.)

3). Bigram frequency. Table 12 summarizes the analyses of variance carried out with the percentages of class ss constructed to the CVVC and CC problems. A significant classes effect was found for the data to three of the five CVVC problems ($p < .01$). A classes effect also approached significance ($p < .1$) for the data to one other CVVC problem (problem, BDAEROMN). For this problem, a greater mean percentage of the most frequent class of ss (class 2, see problem BDAEROMN in Table 9) than of the remaining and less frequent bigram frequency class of ss (class 3, see problem, BDAEROMN in Table 9) was constructed. In two of the three cases in which statistical significance had been reached, a greater mean percentage of the most frequent bigram frequency class of ss (class 2, see Table 9) than of either of the other bigram frequency classes of ss (class 3 and

Table 11

Analyses of Variance

Problems	Mean percentage of direction class ss constructed		
	df	Variance estimate	F
CC			
WEHTNGIA			
Source of variation			
Classes	1	1,155.7	28.1**
Rows (Ss)	19	893.8	21.7**
Residual	19	41.1	
APOSDCIL	No comparisons possible		
TORSECPA			
Source of variation			
Classes	1	3,339.7	12.1**
Rows (Ss)	19	684.7	2.5*
Residual	19	274.6	
IGARDPEB			
Source of variation			
Classes	1	12,303.5	17.5
Rows	19	668.2	
Residual	19	704.3	
ARHCTNEI	No comparisons possible		

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

Table 12

Analyses of Variance

Problems	Mean percentage of frequency class ss constructed		
	df	Variance estimate	F
CVVC			
APDILENR			
Source of variation			
Classes	2	6,112.3	21.6****
Rows (Ss)	19	507.1	1.8
Residual	38	282.6	
LOMASETR	No statistical analysis carried out (differences among classes small).		
MIEDALNH			
Source of variation			
Classes	2	11,806.6	22.9****
Rows (Ss)	19	1,105.2	2.1***
Residual	38	516.2	
BDAEROMN			
Source of variation			
Classes	1	2,572.8	3.3**
Rows (Ss)	19	634.3	
Residual	19	768.4	

Table 12 - cont'd.

	df	Variance estimate	F
AFRILSTE			
Source of variation			
Classes	2	6,697.9	24.7****
Rows (Ss)	19	438.9	1.6*
Residual	38	271.3	
CC			
WEHTNGIA			
Source of variation			
Classes	2	3,345.4	6.7****
Rows	19	1,002.5	2.0***
Residual	38	501.6	
APOSDCIL	No comparisons possible		
TORSECPA			
Source of variation			
Classes	1	17,765.7	39.8****
Rows (Ss)	19	887.3	2.0**
Residual	19	446.5	
IGARDPEG	No comparisons possible		
ARHCTNEI			
Source of variation			
Classes	1	108.5	
Rows (Ss)	19	1,416.7	1.6*
Residual	19	908.3	

*$p < .25$ **$p < .1$ ***$p < .05$ ****$p < .01$

class 4, see Table 9) was also constructed. Application of Duncan's New Multiple Range test (Edwards, 1960) revealed that the differences were significant ($p < .005$). (See Table 13.) Results from the test indicated, however, that a greater mean percentage of the least frequent bigram frequency class of ss (class 4, see Table 9.) than of the next to the least frequent class of ss (class 3, see Table 9) was constructed to problem, APDILENR.

Table 12 also shows that there was a significant classes effect (p .01) for the data to two of the three CC problems in which the ss could be classified into two (TORSECPA) or more (WEHTNGIA) bigram frequency ss classes. A greater mean percentage of the more frequent bigram frequency class of ss (class 3, see Table 9) than of the remaining and less frequent bigram frequency class of ss (class 4, see Table 9) was constructed to problem, TORSECPA. Results from Duncan's New Multiple Range test (Edwards, 1960) indicated that a greater mean percentage of the most frequent bigram frequency class of ss (class 1, see Table 9) than of the least frequent bigram frequency class of ss (class 4, see Table 9) was constructed ($p < .005$) to problem, WEHTNGIA. (See Table 14.) With $\alpha = .05$, application of Duncan's New Multiple Range test revealed that a significantly greater mean percentage of the next to the most frequent bigram frequency class of ss (class 2, see Table 9) than of the least frequent bigram frequency class of ss (class 4, see Table 9) was constructed to problem, WEHTNGIA ($p < .05$). (See Table 14.)

Measure 2.—Table 15 shows, for each of the bigram frequency classes of ss to each of the problems, the number of Ss who constructed at least one solution.

Table 13

Duncan's New Multiple Range Test

Applied to differences between mean percentages of frequency classes ss constructed to problem, APDILENR

	(1) A	(2) B	(3) C	(4)
Mean percentage[a]	13.3 (11.5)	30.0 (27.8)	43.6 (46.5)	Shortest significant ranges
A 13.3 (11.5)		16.3	35.0	R_2= 15.61
B 30.0 (27.8)			18.7	R_3= 16.23

A B C

Applied to differences between mean percentages of frequency classes ss constructed to problem, AFRILSTE

	(1) A	(2) B	(3) C	(4)
Mean percentage[a]	12.5 (12.0)	15.0 (13.5)	50.6 (44.4)	Shortest significant ranges
A 12.5 (12.0)		1.5[b]	32.4	R_2= 15.61
B 15.0 (13.5)			30.9	R_3= 16.23

<u>A B</u> C

Table 13 - cont'd.

Note. —Any two bigram frequency class mean percentages not underscored by the same line are significantly different ($\underline{p} < .005$). Any two bigram frequency class mean percentages underscored by the same line are not significantly different ($\underline{p} < .005$).

[a]Mean percentages within the parentheses were derived from transformed (arc sine) data and were subjected to Duncan's test.

[b]R_2 was calculated for $\alpha = .05$ ($R = 10.60$), A and B were not significantly different ($\underline{p} < .05$).

Table 14

Duncan's New Multiple Range Test

Applied to differences between mean percentages of frequency classes ss constructed to problem, WEHTNGIA

	(1)	(2)	(3)	(4)
	A	B	C	
Mean percentage	33.8	52.0	60.0	Shortest significant ranges
A 33.8		18.2[a]	26.2	$R_2 = 21.10$
B 52.0			8.0	$R_3 = 21.93$

A B C (A and B underscored by one line; B and C underscored by another line)

Note. —Any two bigram frequency class mean percentages not underscored by the same line are significantly different ($p < .005$). Any two bigram frequency class mean percentages underscored by the same line are not significantly different ($p < .005$).

[a]R_2 was calculated for $\alpha = .05$ ($R = 14.32$). B (class 2) and A (class 4) were significantly different ($p < .05$).

Table 15

No. of Ss Who Constructed at Least One Solution

from Frequency Classes

Problems	Classes			
	1	2	3	4
CVVC				
APDILENR		19	6	13
LOMASETR		19	15	
MIEDALNH		20	9	15
BDAEROMN		19	18	
AFRILSTE		19	7	6
CC				
WEHTNGIA	19	19		14
APOSDCIL	No comparisons possible			
TORSECPA			19	18
IGARDPEB	No comparisons possible			
ARHCTNEI	16			19

Note.—N = 20

The summarized data indicated that for each of the five CVVC problems, a greater number of Ss constructed at least one solution from the class of ss with the greatest bigram frequency than from those with the smaller bigram frequencies. A predicted outcome therefore occurred five out of five times, more frequently than could be expected by chance (binomial test, $p = .031$). The predicted finding, however, was obtained with only one of the three CC problems for which ss could be classified into two or more bigram frequency classes. For only one CC problem did a greater number of Ss construct at least one solution from the ss class with the greatest bigram frequency than from those with smaller bigram frequencies. The data from both the five CVVC and three CC problems were also combined. Results from the binomial test (Siegel, 1956) indicated that the probability that a predicted result would occur six out of eight times was .145.

No statistically significant relationship was found between the number of Ss constructing at least one solution from a ss class and either bigram distance or bigram direction.

DISCUSSION

Effects of Practice

Analysis of the results has indicated that the problem-solving strategy behavior of college students can be modified under standard and controlled experimental conditions. Ss allowed to practice with one of two unfamiliar, nonpreferred and difficult strategies were able to adopt them in finding solutions to multiple-solution anagram problems. Furthermore, Ss became more proficient in their use with increasing amounts of practice. A significant practice effect was evident even in the performance of Ss working with the CC strategy, the more difficult of the two strategies and the one for which earlier studies in the current series had revealed no practice effect under standard experimental conditions. The positive findings imply that procedures can be developed to greatly improve the performance of Ss who are working on complex tasks for which successful performance is dependent on the efficient use of particular specific strategies.

In spite of the positive findings, however, it is clear that the strategy behavior of all Ss did not show a positive practice effect. Many of the Ss who performed very poorly and showed little increase with practice in the number of ss constructed were Ss who made self-depracatory statements. (See Appendix C.) One S who worked in one of the group conditions, for example, made several comments upon entering the room and sitting down in which he "predicted" that his performance would be one of the worst. Later, upon hearing that he had not received a h.p.s., this S emphatically said: "I knew it! I knew it!" Remarks like these may reflect feelings of low esteem and little confidence in intellectual ability. Such feelings probably reduced S motivation for remaining with the difficult task of using the non-preferred CVVC or CC strategy after many initial attempts in working with it had proven unsuccessful. They may also have depressed performance by eliciting frequently reinforced response habits of "leaving" situations which threaten to bring about failure at a task.

Other Ss who showed little improvement with practice were ones who were subjected to a feature of the experimental design. This aspect of the design, the fact that some Ss did not receive a h.p.s. on three successive problems and others on the first two, may have hindered improvement by greatly reducing S expectation of successful performance and S motivation for remaining at a difficult task. This hypothesis was suggested when it was noted that several Ss receiving such scores sighed, pushed away their experimental booklets slightly, or angrily labeled the task "impossible!"

Effects of Group Size

Ss working individually in groups of five showed smaller practice effects than did Ss who participated in the study one at a time. One factor which can account for this result was the absence of highly motivated, task-involved Ss in one group. Instead, the majority of Ss in this all male experimental group, the poorest performing group of Ss (Group II - 2), responded laughingly to the frequent remarks and laughter of one of the five Ss. It seemed at times as if the remarks of this "wise-cracking" S, who frequently asked when he could leave, had greater reinforcing properties than those of the E.

Absence of large practice effects for this as well as the other groups of Ss working individually in groups of five can perhaps also be explained by an aspect of the experimental design. This feature was that Ss first had to wait for each other to complete scoring their performance and in addition, had to wait for the E to come and scan their papers before they received knowledge of their performance (h.p.s. or lack of h.p.s.). The effectiveness of the design in bringing about improvement with practice may therefore have been reduced through a delay of reinforcement effect.

Three Stimulus dimensions and Use of the CVVC and CC Strategies

Bigram distance.—The results indicate that bigram distance does not affect use of CVVC and CC strategies. The probability that a strategy-relevant solution would be constructed did not vary as a function of bigram distance class.

The evidence from this experiment, therefore, does not support the hypothesis, suggested by auxiliary findings obtained in Study 1, that the probability that a solution will be constructed varies as an inverse function of its vowel or consonant bigram distance. The results, however, were not actually contrary to those obtained in Study 1, for as it has been recently realized by the E, the hypothesized important role played by distance was based on observations in which three out of four letters of solutions were found either directly or nearly directly next to each other in the problem presented. For example, three of the four letters of the solution DIAL are found directly adjacent to each other in problem, MIEDALNH.

Failure to obtain any bigram distance classes effect can also be attributed to the analyses that were chosen for use. These analyses did not take into account that Ss solving multiple-solution anagrams look back at the solutions they have already constructed (Study 1), as well as to the problem itself. The bigram distance for a particular solution that a S constructs, therefore may not be determined by the distance between the vowel or consonant pair in the problem. Instead, it may be determined by its distance in one of the previous solutions, one of the solutions already constructed.

Bigram direction.—The data to some of the problems show that bigram direction affects the use of the CVVC and CC strategies. With most of the problems, the probability that a strategy-relevant solution would be constructed did not vary as a function of bigram direction class.

Interpretation of these results is difficult, though, because: 1) the analyses made did not take into account that Ss look back at solutions they have already constructed and 2) neither bigram distance no direction were held constant in the analyses conducted. (See Appendix D.)

Bigram frequency.—The evidence from the experiment is that bigram frequency affects use of the CVVC and CC strategies. The probability that a strategy-relevant solution would be constructed varied as an increasing function of bigram frequency.

The results can be understood in terms of frequently reinforced language habits. An obvious conclusion that can be drawn is that the past experience of an S plays an important role in the attaining of problem solutions. For example, the bigrams most frequently appearing in written and spoken English probably served as cues most likely to elicit solution words. Ss manipulating letters so as to discover vowel or consonant bigrams also probably more often formed the most common bigrams.

The responses that Ss made in constructing solutions with highly frequent bigrams may also have been an aspect of a more general strategy, used by humans in the solution of wide varieties of problems. The strategy is that of solving problems by attending the most usual kinds of stimuli and by making common responses. This strategy, if it is actually held by humans, would seem to be one with a long history of reinforcement, both in the history of the human species as well as the life of the individual. It may be a most efficient strategy for most responses which have to be made and most simple problems which have to be solved. But, it also would appear to be a quite useless strategy for the solution of long standing or new but very difficult problems.

In the experiment conducted, the hypothesized strategy may have served to help set a ceiling on performance and the positive effect of practice. Thus, Ss probably did not use the skills they have for the forming of solutions with low probabilities of construction. Nor did they probably develop new skills or capacities.

One implication that the hypothesized general strategy has for future studies is that Ss can perhaps be introduced to the opposite strategy, that of attaining many solutions by attending to the more uncommon stimuli and stimulus dimensions and by making more uncommon responses. In this way, the performance of Ss using task-specific strategies may be maximized. But even more important, such attempts at modifying general strategies may lead to the development of methods by which Ss can acquire various general problem-solving strategies and other skills with wide transfer to new strategies and different problem situations.

Interpretations of some negative results.—The data indicate that a significant bigram frequency classes effect was not found with the solutions to some of the problems. This was probably due, in part, to the fact that each of many of the bigram frequency as well as the bigram distance and bigram direction classes consisted of a very small number of ss. In effect, the mean percentage of bigram frequency classes constructed was in many cases determined by individual solution peculiarities and not by frequency class. For example, with one problem already discussed (MIEDALNH), the bigram frequency class (class 4) for which a greater than expected mean percentage of ss was constructed consisted of only one solution (DIAL).

Examination of the cases in which significant bigram frequency effects were not evident also reveals that there are aspects to solving multiple-solution anagrams which minimize effects of bigram frequency on the construction of solutions. One factor which apparently maximizes the probability that a solution (four letters in length) will be constructed, regardless of its bigram frequency class, is the presence in the problem itself of three letters in close proximity. For example, three of the four letters in the solution DIAL were found directly next to each other in the problem

MIEDALNH. As it has been previously noted, this was the one solution of the frequency 4 class of ss for which a much greater than expected mean percentage of ss was constructed. Another example, involving the solution ROAM to the problem, BDAEROMN, can also be cited. This is a strategy relevant solution, containing the vowel bigram OA, which was constructed by 75% of the Ss. Each of the other four ss containing the vowel bigram OA, in contrast, was constructed by a mean percentage of less than 50% of the Ss.

This last example also points to another factor which may minimize effects of bigram frequency. This and other examples have suggested that Ss probably hold multiple hypotheses or use several strategies in constructing the restricted kinds of solutions labeled ss. In constructing the strategy-relevant solution, ROAM, from the problem, BDAEROMN, for example, Ss may also have been using the general strategy of sounding out, the strategy found to be a prevalent one in Studies 1 and 2, coming to the solution by sounding out different variations of the O sound.

In constructing ss, Ss may also have been using another strategy, one reinforced along with the specific strategies of forming CVVC or CC solutions. The strategy referred to is that of constructing ss which can be categorized grammatically as nouns or verbs of the present tense. Its use may help to explain the much smaller than expected mean percentage of class ss that was constructed from the bigram frequency 3 class of ss to problem, APDILENR, for in this class, two of the four solutions were verbs of the past tense (LIED, PIED). In contrast, a total of only three solutions can be categorized as verbs of the past tense when all the four-letter ss from all the five CVVC problems are considered. Another example, one involving the solution DOER to the CVVC problem, BDAEROMN, can also be cited in support of the hypothesis that S use of additional strategies minimizes the effect of bigram frequency in the construction of some of the ss. This solution is the only four-letter strategy-relevant solution of any of the solutions possible with the five CVVC problems which can be considered as a noun derived from a verb (DO+ER). This is also one which was constructed by a much fewer number of Ss (10%) than any of the five solutions (a mean percentage of 50% of the Ss) whose OA vowel bigram placed them in the same bigram frequency ss class and the same bigram direction class.

SUMMARY

Forty college students working under conditions designed to maximize performance were instructed to use one of two difficult, task-specific problem-solving strategies. It was found that the strategies were adopted by Ss and became more dominant with reinforced practice on five SAT problems, as evidenced by the consistently increasing numbers of strategy-relevant solutions (ss) constructed. The absence of a positive practice effect with some Ss was noted and factors, involving size of experimental group, individual S differences and an aspect of the experimental design, which may have been responsible for the findings, were noted.

The relationship between three stimulus dimensions and the construction of solutions was evaluated. It was found that bigram frequency, and in some instances bigram direction, affected the probability that a particular strategy-relevant solution would be constructed. No such relationship was found with bigram distance. Results were interpreted in terms of frequently reinforced language habits and several problem-solving strategies which may have been used by Ss.

REFERENCES

Ammons, R. B. Effects of knowledge of performance: A survey and tentative theoretical formulation. Journal of General Psychology, 1956, 54, 279-299.

Ammons, R. B., & Ammons, D. H. A standard anagram task. Psychological Reports, 1959, 5, 654-656. (a)

Ammons, R. B., & Ammons, C. H. Rational evaluation of the "standard anagram task" as a laboratory analogue of "real-life" problem solving. Psychological Reports, 1959, 5, 718-720. (b)

Bruner, J. S., Goodnow, Jacqueline, J., & Austin, G. A. A study of thinking. New York: Wiley, 1956.

Bruner, J. S., Olver, Rose, E., & Greenfield, Patricia, M., et al., Studies in cognitive growth. New York: Wiley, 1966.

Bugelski, B. R. Presentation time, total time, and mediation in paired-associate learning. Journal of Experimental Psychology, 1962, 63, 409-412.

Corts, D. B. Analysis of methods for indicating strategy during the solving of anagram problems. Unpublished Master's thesis, University of Montana, 1966.

Durkin, H. E. Trial-and-error, gradual analysis, and sudden reorganization: An experimental study of problem-solving. Archives of Psychology, 1937, No. 210.

Edwards, A. E. Experimental design in psychological research. New York: Holt, Rinehart and Winston, 1964.

Fisher, R. A., & Yates, F. Statistical tables for biological, agricultural and medical research. Edinburgh: Oliver and Boyd, 1948.

Husband, R. W. Comparative behavior on different types of mazes. Journal of General Psychology, 1931, 5, 234-244.

Johnson, D. M. A modern account of problem solving. Psychological Bulletin, 1944, 41, 201-229.

Klausmeier, H. J., & Loughlin, L. J. Behaviors during problem solving among children of low, average and high intelligence. Journal of Educational Psychology, 1961, 52, 148-152.

Lindquist, E. F. Statistical analysis in educational research. Boston: Houghton Mifflin Co., 1940.

Martin, C. H., Boersma, F. J., & Cox, D. L. A classification of associative strategies in paired-associate learning. Psychonomic Science, 1965, 3, 455-456.

Mayzner, M. S., & Tresselt, M. E. Anagram solution times: a function of word transition probabilities. Journal of Experimental Psychology, 1962, 63, 510-513. (a)

Mayzner, M.S., & Tresselt, M. E. The ranking of letter pairs and single letters to match digram and single-letter frequency counts. Journal of Verbal Learning and Verbal Behavior, 1962, 1, 203-307. (b)

Mayzner, M. S., & Tresselt, M. E. Anagram solution times: a function of word length and letter position variables. Journal of Psychology, 1963, 55, 469-475.

Mayzner, M. S., & Tresselt, M. E. Tables of single-letter and digram frequency counts for various word-length and letter-position combinations. Psychonomic Monograph Supplements, 1965, 1, No. 2.

Mosher, F. A. & Hornsby, Joan, R. On asking questions. In J. S. Bruner, et al., Studies in cognitive growth. New York: Wiley, 1966, Pp. 86-102.

Odom, R. D. Problem-solving strategies as a function of age and socioeconomic level. Child Development, 1967, 38, 747-752.

Restle, F. The selection of strategies in cue learning. Psychological Review, 1962, 69, 329-343.

Rhine, R. J. The relation of achievement in problem solving to rate and kind of hypothesis produced. Journal of Experimental Psychology, 1959, 57, 253-256.

Rosenthal, R. Covert communication in the psychological experiment. Psychological Bulletin, 1967, 67, 356-367.

Ruger, H. The psychology of efficiency. Archives of Psychology, 1910, No. 15.

Sargent, S. S. Thinking processes at various levels of difficulty. Archives of Psychology, 1940, No. 249.

Seashore, R. H. Work methods: an often neglected factor underlying individual differences. Psychological Review, 1939, 46, 123-141.

Snedecor, G. W. Statistical methods applied to experiments in agriculture and biology. Ames, Iowa State College Press, 5th ed. 1956.

Stern, C. Acquisition of problem-solving strategies in young children and its relation to verbalization. Journal of Educational Psychology, 1967, 58, 245-252.

Warden, C. J. The relative economy of various modes of attack in the mastery of a stylus maze. Journal of Experimental Psychology, 1924, 7, 243-275. (b)

Weir, M. W. Developmental changes in problem solving strategies. Psychological Review, 1964, 71, 473-490.

APPENDIX

APPENDIX A

During this experiment you will be playing a problem-solving game. It is important to remember that if you work hard and learn to play well early in the game, you can leave much before the two hours have elapsed and still receive full credit.

When I give the signal, turn the page and read four of the five basic rules of the game. Then go on to the next page and read the most important rule of the game, which tells you how to do really well, if you follow it carefully.

WORD CONSTRUCTION GAME

This is a game in which you will construct words out of a basic letter combination which you will have in front of you while you work. After a few minutes with each letter combination, you will be given a short rest, then you will work on a different letter combination. As you work, you will turn over the pages so that the previous letter combination you have worked on will not be visible.

The rules you should follow are these:

1. Use any number of letters you wish out of the basic letter combination - from one to as many letters as there are in the letter combination.

2. Use each letter only once in a given word. Of course, you can construct many words using the same letter once each time as a part of each single word.

3. Construct only English words. Foreign words do not count. Neither do prefixes or suffixes (e.g., "pre-" or "-ing").

4. Construct no proper nouns, that is, no name whose first letter would be capitalized.

Try the following letter combination: MDEA

Some of the words you could make would be: A, MAD, MA, DAM, DAME and ME. DE would not be usable under the rules because it is a foreign word meaning "of" in several languages, and not an English word. MAE also would not count, since it is a proper noun - the name of a specific girl, which name would always have the first letter capitalized. You could not use MADAM because that would mean that you were using the letters "m" and "a" twice in the same word. Remember, use each letter only once in each word you construct, use no proper nouns, and use no foreign words. These words would not count and would just slow you down.

Rules of the WORD CONSTRUCTION GAME page 2

5. For all words that you construct that begin with a consonant which is followed by a pair of vowels and another consonant (CVVC), you receive ten (10) points. Vowels, as you will remember, are the letters A, E, I, O, or U and consonants are all other letters. With the vowel pair AI, for example, words such as bAIt and sAIl can be constructed. The words hEArd and rEAch contain the vowel pair EA.

All other acceptable words that you construct without an initial consonant which is followed by a pair of vowels and another consonant, such as BAND and SUN, receive one (1) point.

Some of the basic letter combinations will be easier and some more difficult than others. You will score yourself at the end of each basic letter combination. Then, when I ask, you will show me the basic letter combination on which you have worked and the score you've attained and I will scan your scoring for accuracy. I will then be able to compare your performance on that basic letter combination with that of previous high scoring college students who have constructed many ten-point words on that particular problem, and will let you know if you have reached a high performance score.

Just as soon as you reach a high performance score on four basic letter combinations, you will be able to leave with full credit for the session.

Rules of the WORD CONSTRUCTION GAME page 2

5. For all words that you construct that begin with two consonants (CC), you receive ten (10) points. Consonants, as you will remember, are all letters besides A, E, I, O, or U. S and T are two consonants. The words STem and STamp, for example, begin with this consonant pair. With B and L, two other consonants, words such as BLue and BLond can be formed.

All other acceptable words that you construct without an initial two consonants, such as BAND and SUN, receive (1) point.

Some of the basic letter combinations will be easier and some more difficult than others. You will score yourself at the end of each basic letter combination. Then, when I ask, you will show me the basic letter combination on which you have worked and the score you've attained and I will scan your scoring for accuracy. I will then be able to compare your performance on that basic letter combination with that of previous high scoring college students who have constructed many ten point words on that particular problem, and will let you know if you have reached a high performance score.

Just as soon as you reach a high performance score on four basic letter combinations, you will be able to leave, with full credit for the session.

Comments Made by E between Problems

To high scorers:

1.	Very good. Very, very good	(after either problem 1 or 2, and problem 5 or 6)
2.	Keep it up. Keep after those high point words.	(after either problem 1 or 2)
3.	Great!	(after either problem 3 or 4, and problem 5 or 6)
4.	You got it. . . you made a high performance score.	(after either problem 3 or 4)

To low scorers:

1.	No . . . you didn't make it.	(after either problem 1 or 2, and problem 5 or 6)
2.	And go after those 10-point words . . . that's the only . to get those high performance scores quickly.	(after either problem 1 or 2, and problem 5 or 6)
3.	But now really dig in, everyone can become a high scorer.	(after either problem 3 or 4)
4.	You can still make it. You still have an excellent chance.	(after either problem 3 or 4)

To those Ss working on problems after problem 5:

The rules of the game are still the same. The performance standards, though, have been set a little lower.

Note. — E did not repeat the same comment to a S after two consecutive problems.

Basic letter combination:

AFRILSTE

Solutions:

No. of CVVC Solutions x 10 __________
No. of other Solutions x 1 __________
Score = __________

Basic letter combination:

APDILENR

Solutions:

No. of CVVC Solutions x 10 __________
No. of other solutions x 1 __________
Score = __________

Basic letter combination:

BDAEROMN

Solutions:

No. of CVVC Solutions x 10 ________
No. of other Solutions x 1 ________
Score = ________

Basic letter combination:

LOMASETR

Solutions:

No. of CVVC Solutions x 10 __________
No. of other Solutions x 1 __________
Score = __________

Basic letter combination:

MIEDALNH

Solutions:

No. of CVVC Solutions x 10 ________
No. of other Solutions x 1 ________
Score = ________

Basic letter combination:

ARHCTNEI

Solutions:

No. of CC Solutions x 10 ________
No. of other Solutions x 1 ________
Score = ________

Basic letter combination:

APOSDCIL

Solutions:

No. of CC solutions x 10 __________
No. of other Solutions x 1 __________
Score = __________

Basic letter combination:

IGARDPEB

Solutions:

No. of CC Solutions x 10 __________
No. of other Solutions x 1 __________
Score: = __________

Basic letter combination:

TORSECPA

Solutions:

No. of CC Solutions x 10 ________

No. of other Solutions x 1 ________

Score = ________

Basic letter combination:

WEHTNGIA

Solutions:

No. of CC Solutions x 10 ________
No. of other Solutions x 1 ________
Score = ________

CVVC Problems and their ss

APDILENR

DEAL	LAIN	LIAR	NEAR	PEAR	RAINED
DEAN	LAIR	LIED	PAID	PEARL	READ
DEAR	LEAD	LIEN	PAIL	PIED	REAL
DIAL	LEAN	NAIL	PAIN	PIER	REAP
DIALER	LEAP	NAILED	PAIR	RAID	REIN
DIAPER	LEAR	NAILER	PAIRED	RAIL	
LAID	LEARN	NEAP	PEAL	RAIN	

AFRILSTE

FAIL	FEAST	LEAST	REAL	SEAR	TEARS
FAILS	FEAT	LIAR	REALS	SEAT	TIER
FAIR	FEATS	LIEF	REALIST	TAIL	TIES
FAIRS	LAIR	LIES	REAP	TAILER	
FEAL	LEAF	RAIL	RIAL	TAILS	
FEAR	LEAR	RAILS	SAIL	TEAL	
FEARS	LEARS	RAISE	SEAL	TEAR	

BDAEROMN

BEAD	BEAR	BOARD	DOER	MOANED	ROAD
BEAM	BEARD	DEAN	MEAD	NEAR	ROAM
BEAN	BOAR	DEAR	MEAN	READ	ROAMED
			MOAN	REAM	ROAN

LOMASETR

LEAR	MEAN	REALM	ROAMER	SEAR	TEAMS
LEAST	MEAT	REAM	ROAMS	SEAT	TEAR
LOAM	MOAT	REAMS	ROAST	SOAR	TEARS
MEAL	MOATS	MEATS	SEAL	TEAL	TEAS
MEALS	REAL	ROAM	SEAM	TEAM	TOES

MIEDALNH

DEAL	HEAD	LAIN	LIEN	MAILED	MEAN
DEAN	HAILED	LEAD	MAID	MAIN	MIEN
DIAL	HEAL	LEAN	MAIDEN	MEAD	NAIL
HAIL	LAID	LIED	MAIL	MEAL	NAILED

CC Problems and their ss

WEHTNGIA

GNAT	THE	THING	TWIN	WHAT	WHIG
GNAW	THEN	TWAIN	TWINE	WHEAT	WHINE
THAN	THIN	TWANG	TWINGE	WHEN	WHIT
THAW	THINE	TWIG	WHANG	WHET	WHITE
					WHITEN

APOSDCIL

CLAD	CLIP	CLOP	PLAIDS	SCALD	SLID
CLAP	CLIPS	CLOPS	PLOD	SCALP	SLIP
CLASP	CLOD	PLACID	PLODS	SCOLD	SLOP
CLAPS	CLODS	PLAID	SCAD	SLAP	SPA
					SPOIL

TORSECPA

CRAP	PRATE	SCAT	SPAR	SPORE	STOP
CRAPS	PREST	SCOPE	SPARE	SPORT	STORE
CRAPE	PRO	SCORE	SPARSE	SPOT	STRAP
CRATE	PROSE	SCRAP	SPAT	STAR	STREP
CREPT	SCAPE	SCRAPE	SPEAR	STARE	STROP
CREST	SCAR	SPA	SPIRE	STEAR	TRACE
CROP	SCARE	SPACE	SPIT	STEP	TRAP
					TRAPS

IGARDPEB

BRA	BREAD	BRIG	DREG	GRAPE	PRIDE
BRAD	BRED	DRAB	DRIP	GRID	PRIG
BRAG	BRIDE	DRAG	GRAB	GRIP	
BRAID	BRIDGE	DRAPE	GRADE	GRIPE	

ARHCTNEI

CHAIN	CHART	CHINA	CRATE	THEN	THRICE
CHAIR	CHAT	CHINE	CRETIN	THEIR	TRACE
CHANT	CHEAT	CHIT	THAN	THIN	TRAIN
CHAR	CHIN	CRANE	THE	THING	TRANCE

Note. —Acceptability and spelling of CVVC and CC ss checked with Webster's seventh new collegiate dictionary (1967).

APPENDIX B

4-Letter CVVC ss Categorized into Classes

Distance Classes

APDILENR

0 (0 ss)
1 (5 ss)
REIN
LIED
LIEN
PIED
PIER
2 (13 ss)
LAID
LAIN
LAIR
NAIL
PAID
PAIL
PAIN
PAIR
RAID
RAIL
RAIN
DIAL
LIAR
3 (0 ss)
4 (14 ss)
DEAL
DEAN
DEAR
LEAD
LEAN
LEAP
LEAR
NEAP
NEAR
PEAL
PEAR
READ
REAL
REAP
5 (0 ss)
6 (0 ss)
6 (0 ss)

LOMASETR
0 (0 ss)
1 (18 ss)
LEAR
MEAL
MEAN
MEAT
REAL
REAM
SEAL
SEAM
SEAR
SEAT
TEAL
TEAM
TEAR
TEAS
LOAM
MOAT
ROAM
SOAR
2 (0 ss)
3 (0 ss)
4 (0 ss)
5 (0 ss)
6 (0 ss)

MIEDALNH
0 (3 ss)
LIED
LIEN
MIEN
1 8 (ss)
DEAL
DEAN
HEAD
LEAD
LEAD
MEAD
MEAL
MEAN
2 (8 ss)
HAIL
LAID
LAIN
MAID
MAIL
MAIN
NAIL
DIAL
3 (0 ss)
4 (0 ss)
5 (0 ss)
6 (0 ss)

BDAEROMN
0 (11 ss)
BEAD
BEAM
BEAN
BEAR
DEAN
DEAR
MEAD
MEAN
NEAR

READ
REAM
1 (1 ss)
DOER
2 (5 ss)
BOAR
MOAN
ROAD
ROAM
ROAN
3 (0 ss)
4 (0 ss)
5 (0 ss)
6 (0 ss)

AFRILSTE
0 (0 ss)
1 (0 ss)
2 (7 ss)
FAIL
FAIR
RAIL
SAIL
TAIL
LIAR
RIAL
3 (3 ss)
LIEF
LIES
TIER
4 (0 ss)
5 (0 ss)
6 (12 ss)
FEAL
FEAR
FEAT
LEAF
LEAR
REAL
REAP
SEAL
SEAR
SEAT
TEAL
TEAR

Direction Classes

APDILENR
- Positive (15 ss)
  - LAID
  - LAIN
  - LAIR
  - NAIL
  - PAID
  - PAIL
  - PAIN
  - PAIR
  - RAID
  - RAIL
  - RAIN
  - LIED
  - LIEN
  - PIED
  - PIER
- Negative (17 ss)
  - DEAL
  - DEAN
  - DEAR
  - LEAD
  - LEAN
  - LEAP
  - LEAR
  - NEAP
  - NEAR
  - PEAL
  - PEAR
  - READ
  - REAL
  - REAP
  - REIN
  - DIAL
  - LIAR

LOMASETR
- Positive (4 ss)
  - LOAM
  - MOAT
  - ROAM
  - SOAR
- Negative (14 ss)
  - LEAR
  - MEAN
  - MEAL
  - MEAT
  - REAL
  - REAM
  - SEAL
  - SEAM
  - SEAR
  - SEAT
  - TEAL
  - TEAM
  - TEAR
  - TEAS

MIEDALNH
- Positive (13 ss)
  - DEAL
  - DEAN
  - HEAD
  - HEAL
  - LEAD
  - LEAN
  - MEAD
  - MEAL
  - MEAN
  - DIAL
  - LIED
  - LIEN
  - MIEN
- Negative (7 ss)
  - HAIL
  - LAID
  - LAIN
  - MAID
  - MAIL
  - MAIN
  - NAIL

BDAEROMN
- Positive (0 ss)
- Negative (17 ss)
  - BEAD
  - BEAM
  - BEAN
  - BEAR
  - DEAN
  - DEAR
  - MEAD
  - MEAN
  - NEAR
  - READ
  - REAM
  - BOAR
  - MOAN
  - ROAD
  - ROAM
  - ROAN
  - DOER

AFRILSTE
- Positive (8 ss)
  - FAIL
  - FAIR
  - LAIR
  - RAIL
  - SAIL
  - TAIL
  - LIES
  - TIER
- Negative (13 ss)
  - FEAL
  - FEAR
  - FEAT
  - LEAF
  - LEAR
  - REAL
  - REAP
  - SEAL
  - SEAT
  - TEAL

LIAR
RIAL

Frequency Classes

APDILENR
1 (0 ss)
2 (25 ss)
LAID
LAIN
LAIR
NAIL
PAID
PAIL
PAIN
PAIR
RAID
RAIL
RAIN
DEAL
DEAN
DEAR
LEAD
LEAN
LEAP
LEAR
NEAP
NEAR
PEAL
PEAR
READ
REAL
REAP
3 (4 ss)
LIED
LIEN
PIED
PIER
4 (3 ss)
REIN
DIAL
LIAR

LOMASETR
1 (0 ss)
2 (14 ss)
LEAR
MEAL
MEAN
MEAT
REAL
REAM
SEAL
SEAM
SEAR
SEAT
TEAL
TEAM
TEAR
TEAS
3 (4 ss)
LOAM
MOAT
ROAM
SOAR
4 (0 ss)

MIEDALNH
1 (0 ss)
2 (15 ss)
HAIL
LAID
LAIN
MAID
MAIL
MAIN
NAIL
DEAL
DEAN
HEAD
LEAD
LEAN
MEAD
MEAL
MEAN

3 (3 ss)
LIED
LIEN
MIEN
4 (1 ss)
DIAL

BDAEROMN
1 (0 ss)
2 (11 ss)
BEAD
BEAM
BEAN
BEAR
DEAN
DEAR
MEAD
MEAN
NEAR
READ
REAM
3 (6 ss)
BOAR
MOAN
ROAD
ROAM
ROAN
DOER
4 (0 ss)

AFRILSTE
1 (0 ss)
2 (17 ss)
FAIL
FAIR
RAIL
SAIL
TAIL
FEAL
FEAR
FEAT
LEAF

LEAR
REAL
REAP
SEAL
SEAR
SEAT
TEAL
TEAR
3 (3 ss)
LIEF
LIES
TIER
4 (2 ss)
LIAR
RIAL

4-Letter CC as Categorized into Classes

<u>Distance Classes</u>

WEHTNGIA
0 (6 ss)
GNAT
GNAW
THAN
THAW
THEN
THIN
1 (5 ss)
WHAT
WHEN
WHET
WHIG
WHIT
2 (2 ss)
TWIG
TWIN
3 (0 ss)
4 (0 ss)
5 (0 ss)
6 (0 ss)

APOSDCIL
0 (0 ss)
1 (5 ss)
CLAD
CLAP
CLIP
CLOD
CLOP
SCAD
2 (0 ss)
3 (4 ss)
SLAP
SLID
SLIP
SLOP
4 (0 ss)
5 (1 ss)
PLOD
6 (0 ss)

TORSECPA
0 (0 ss)
1 (3 ss)
SCAR
SCAT
TRAP
2 (9 ss)
CRAP
CROP
SPAR
SPAT
SPIT
SPOT
STAR
STEP
STOP
3 (0 ss)
4 (0 ss)
5 (0 ss)
6 (0 ss)

IGARDPEB
- 0 (4 ss)
  - DRAB
  - DRAG
  - DREG
  - DRIP
- 1 (4 ss)
  - GRAB
  - GRID
  - GRIP
  - PRIG
- 2 (0 ss)
- 3 (4 ss)
  - BRAD
  - BRAG
  - BRED
  - BRIG
- 4 (0 ss)
- 5 (0 ss)
- 6 (0 ss)

ARHCTNEI
- 0 (4 ss)
  - CHAR
  - CHAT
  - CHIN
  - CHIT
- 1 (3 ss)
  - THAN
  - THEN
  - THIN
- 2 (0 ss)
- 3 (0ss)
- 4 (0 ss)
- 5 (0 ss)
- 6 (0 ss)

Direction Classes

WEHTNGIA
- Positive (5 ss)
  - WHAT
  - WHEN
  - WHET
  - WHIG
  - WHIT
- Negative (8 ss)
  - GNAT
  - GNAW
  - THAN
  - THAW
  - THEN
  - THIN
  - TWIG
  - TWIN

APOSDCIL
- Positive (11 ss)
  - CLAD
  - CLAP
  - CLIP
  - CLOD
  - CLOP
  - PLOD
  - SCAD
  - SLAP
  - SLID
  - SLIP
  - SLOP
- Negative (0 ss)

TORSECPA
- Positive (7 ss)
  - SCAR
  - SCAT
  - SPAR
  - SPAT
  - SPIT
  - SPOT
  - TRAP
- Negative (5 ss)
  - CRAP
  - CROP
  - STAR
  - STEP
  - STOP

IGARDPEB
  Positive (3 ss)
    GRAB
    GRID
    GRIP
  Negative (9 ss)
    BRAD
    BRAG
    BRED
    BRIG
    DRAB
    DRAG
    DREG
    DRIP
    PRIG

ARHCTNEI
  Positive (0 ss)
  Negative (7 ss)
    CHAR
    CHAT
    CHIN
    CHIT
    THAN
    THEN
    THIN

Frequency Classes

WEHTNGIA
  1 (4 ss)
    THAN
    THAW
    THEN
    THIN
  2 (5 ss)
    WHAT
    WHEN
    WHET
    WHIG
    WHIT
  3 (0 ss)
  4 (4 ss)
    GNAT
    GNAW
    TWIG
    TWIN

APOSDCIL
  1 (0 ss)
  2 (0 ss)
  3 (0 ss)
  4 (11 ss)
    CLAD
    CLAP
    CLIP
    CLOD
    CLOP
    PLOD
    SCAD
    SLAP
    SLID
    SLIP
    SLOP

TORSECPA
  1 (0 ss)
  2 (0 ss)
  3 (4 ss)
    STAR
    STEP
    STOP
    TRAP
  4 (8 ss)
    CRAP
    CROP
    SCAR
    SCAT
    SPAR
    SPAT
    SPIT
    SPOT

IGARDPEB
  1 (0 ss)
  2 (0 ss)
  3 (0 ss)
  4 (12 ss)
    BRAD
    BRAG
    BRED
    BRIG
    DRAB
    DRAG
    DREG
    DRIP
    GRAB
    GRID
    GRIP
    PRIG

ARHCTNEI
  1 (3 ss)
    THAN
    THEN
    THIN
  2 (0 ss)
  3 (0 ss)
  4 (4 ss)
    CHAR
    CHAT
    CHIN
    CHIT

APPENDIX C

Summary of Self-deprecatory Comments Made by some of the S Participating in the Thesis Experiment

Some of the Ss who took part in the thesis experiment performed very poorly and showed little increase with practice in the number of ss constructed. Many of these Ss made statements which were thought to reflect feelings of low esteem and little confidence in intellectual ability. These feelings probably depressed performance by reducing S motivation for remaining with the experimental task and by eliciting habits of "leaving" situations which threaten to bring about failure.

The remarks are as follows:

1. A male S, working in one of the 5-S group conditions.

a. Upon entering the room, he said to E: "I'd like you to know -- I'm stupid."

b. While awaiting the instructions of the E, he said to two of the other Ss: "Don't worry, you'll do better than me. I'll be one of the worst."

c. After he was informed that he had not received a h.p.s. for problem 1, he said: "I knew it! I knew it!"

2. A female S, working in one of the individual conditions.

a. Many of the Ss were telephoned by the E the night before the S was scheduled to take part in the experiment, and briefly reminded of the previously agreed upon time and place. During this conversation, the S said:

(1) "My mother is in psychological work too."

(2) "My brother is doing research . . ."

(3) The S also mentioned that her brother was in Princeton and had won a fellowship (it may have been a Wilson).

b. The first sentence spoken by S upon entering the room included the following remark: "I hated being in my Mom's I.Q. experiment."

c. After the experiment was conducted and a brief questioning period occurred, E began to gather up her materials.

(1) At this time the S spontaneously spoke of the many intellectual and academic successes of her mother (has received a Master's in counseling; was apparently made chairman of a department at a small college at a young age) and brother (high marks, fellowship recipient).

(2) She also said: "I did very poorly in school; that's why I left for one year. I went to Seattle and worked as a telephone operator."

3. A female, working in one of the 5-S group conditions.

a. When she began work on the first problem, the S said: "Oh! I'm not going to do well."

b. After hearing that she had not received a h.p.s. on problem 1, she said: "I just can't do this! I just can't."

4. A male S, working in one of the 5-S group conditions. The S wore a short beard, long unkempt hair, shabby clothing and sneakers.

a. While signing up for the experiment, he said: "I won't have to do things in front of people will I?"

(S also made a statement to the E while awaiting the arrival of the other Ss which perhaps more reflected dislike of the university as a whole than feelings of low esteem. He said: "I love it up here!" (The art studio and floor of the Find . Arts Building.) It's the only part of the campus I like."

APPENDIX D

Additional Results

Data produced by Ss were subjected to several additional analyses. The results, however, have as yet not been subjected to statistical tests of significance. They were, therefore, not included in the main body of the thesis.

Three Stimulus Dimensions which Define Solution Classes and Use of the CVVC and CC Strategies

Bigram Frequency.—The effect of bigram frequency class on the construction of ss was further evaluated after the data from all CVVC problems presented in ordinal-position one were combined. It was therefore possible to learn if the differences apparently associated with vowel bigram frequency class would be found with solutions produced by Ss who had as yet not had the opportunity to practice on all five problems. This was thought important since the five problems contained a total of only seven vowel bigrams (AI, EA, IE, OA, OE, EI, IA). Furthermore, the mean number of problems in which the most frequent vowel bigrams appeared (class 2) was greater (four problems) than the mean number in which any of the other vowel bigrams appeared (2 problems). The differences already found, it was thought, could therefore be attributed to the greater opportunity that Ss had in practicing with the most frequent vowel bigrams as they solved anagrams.

Table 16 shows that Ss solving ordinal-position 1 problems constructed a greater mean percentage of the most frequent bigram frequency class of ss than of either of the two other bigram frequency classes. A greater mean percentage of the most frequent bigram frequency class of ss than of either of the two other bigram frequency classes was also constructed to the problems presented in ordinal-position 5.

The ordinal-position 1 and 5 data, summarized in Table 16, also indicate that the percentage of Ss constructing at least one strategy-relevant solution was greatest with the class of ss containing the vowel bigrams of greatest frequency.

Effects of each of the three stimulus dimensions after one or both of the others have been held constant.—For each of the three stimulus dimensions, the mean percentage of solutions constructed from each class of ss for each problem (where possible) is reported after each and both of the two other stimulus dimensions were held constant. (See Tables 17, 18, 19.)

With the distance dimension, five comparisons were made with the data to the CVVC problems after direction had been held constant. (See Table 17.) In holding direction constant, the E first compared only those solutions whose bigrams (CVVC or CC) were classified as being positive in direction. She then compared only the solutions with bigrams classified as being negative in direction. For four of these comparisons, summarized in Table 17, a smaller mean percentage of the smallest distance class of ss than of any of the other distance classes of ss was constructed. After bigram-frequency had been kept constant, five comparisons

TABLE 16

CVVC ss Constructed

Probability of construction	Frequency classes		
	2 (EA, AI)	3 (IE, OA, OE)	4 (EI, IA)
Performance with problems presented in ordinal-position 1			
Mean percentage of class ss constructed	41.1	22.7	25.0
Percentage of <u>S</u>s who constructed at least 1 solution from class	95.0	45.0	41.7
Performance with problems presented in ordinal-position 5			
Mean percentage of class ss constructed	63.7	31.8	37.5
Percentage of <u>S</u>s who constructed at least 1 solution from class	100.0	70.0	58.3

were made with the CVVC problems. (See Table 17.) E first compared only those solutions whose bigrams (CVVC or CC) were classified as bigram frequency 2, then only those solutions with bigrams classified as bigram frequency 3 and finally, those solutions classified as bigram frequency 4. With three of these comparisons, made with classes of ss in which the vowel bigrams were categorized as frequency 2 (the most frequent vowel bigram), little difference was found among classes of ss. With the other two comparisons, made with classes of ss in which the vowel bigrams were categorized as being less frequent than class 2 (3 and 4), a smaller mean percentage of the smaller distance classes of ss than of other distance classes of ss was constructed. After bigram direction and frequency had been held constant in the same way, two additional comparisons were made with CVVC problems. The distance ss classes were again classes in which the vowel bigrams were categorized as being less frequent than class two. In each case, a smaller mean percentage of the smaller distance class of ss than of the other distance class of ss was constructed. Similar comparisons were made with the CC problems. No consistent relationship was found, however, between distance class and the mean percentage of the class ss constructed. (See Table 17.)

With the dimension of direction, four comparisons were made with the CVVC problems after distance had been held constant. (See Table 18.) In this way, the E first compared ss with bigrams classified as bigram distance 1, and then those with bigrams classified as bigram distance 2. Table 18 indicates that with distances 0, 3, 4, 5 and 6, no comparisons were possible between the mean percentages of

Table 17

Mean Percentage of Distance Class ss Constructed with One or More other Stimulus Classes Held Constant

Stimulus class held constant	Distance Classes 0	1	2	3	4	5	6
			CVVC problems				
Direction							
Positive							
APDILENR		(IE)	(AI)				
		13.3	55.5				
		(4)	(11)				
LOMASETR	No comparisons possible						
MIEDALNH	(IE)	(EA)					
	20.0	63.0					
	(3)	(8)					
BDAEROMN	No comparisons possible						
AFRILSTE	No comparisons possible						
Negative							
APDILENR		(EI)	(IA)				
		10.0	40.0				
		(1)	(2)				
LOMASETR	No comparisons possible						

Table 17 - cont'd.

	0	1	2	3	4	5	6
MIEDALNH	No comparisons possible						
BDAEROMN	(EA)	(OE)	(OA)				
	62.7	10.0	52.0				
	(11)	(1)	(5)				
AFRILSTE			(IA)				(EA)
			15.0				48.3
			(2)				(12)
Frequency							
2							
APDILENR			(AI)		(EA)		
			56.4		50.0		
			(11)		(14)		
LOMASETR	No comparisons possible						
MIEDALNH		(EA)	(AI)				
		63.3	48.6				
		(8)	(7)				
BDAEROMN	No comparisons possible						
AFRILSTE			(AI)				(EA)
			55.0				49.2
			(5)				(12)

Table 17 - cont'd.

	0	1	2	3	4	5	6
3							
APDILENR	No comparisons possible						
LOMASETR	No comparisons possible						
MIEDALNH	No comparisons possible						
BDAEROMN		(OE)	(OA)				
		10.0	52.0				
		(1)	(5)				
AFRILSTE	No comparisons possible						
4							
APDILENR		(EI)		(IA)			
		10.0		37.5			
		(1)		(2)			
LOMASETR	No comparisons possible						
MIEDALNH	No comparisons possible						
BDAEROMN	No comparisons possible						
AFRILSTE	No comparisons possible						
Direction and Frequency							
Positive-2	No comparisons possible						
Positive-3	No comparisons possible						
Positive-4	No comparisons possible						
Negative-2	No comparisons possible						

Table 17 - cont'd.

	0	1	2	3	4	5	6
Negative-3	No comparisons possible						
APDILENR	No comparisons possible						
LOMASETR	No comparisons possible						
MIEDALNH	No comparisons possible						
BDAEROMN		(OE)	(OA)				
		10.0	52.0				
		(1)	(5)				
AFRILSTE	No comparisons possible						
Negative-4							
APDILENR		(EI)	(IA)				
		10.0	37.5				
		(1)	(2)				
LOMASETR	No comparisons possible						
MIEDALNH	No comparisons possible						
BDAEROMN	No comparisons possible						
AFRILSTE	No comparisons possible						
	CC problems						
Direction							
Positive							
WEHTNGIA	No comparisons possible						

Table 17 - cont'd.

	0	1	2	3	4	5	6
APOSDCIL		(CL, SC) 28.3 (6)		(SL) 65.0 (4)		(PL) 70.0 (1)	
TORSECPA		(TR, SC) 43.3 (3)	(SP) 18.0 (4)				
IGARDPEB	No comparisons possible						
ARHCTNEI	No comparisons possible						
Negative							
WEHTNGIA	(TH, GN) 48.3 (6)		(TW) 42.5 (2)				
APOSDCIL	No comparisons possible						
TORSECPA	No comparisons possible						
IGARDPEB	(DR) 50.0 (4)	(PR) 10.0 (1)		(BR) 32.5 (4)			

Table 17 - cont'd.

	0	1	2	3	4	5	6
ARHCTNEI	(CH)	(TH)					
	60.0	63.3					
	(4)	(3)					
Frequency							
1	No comparisons possible						
2	No comparisons possible						
3							
WEHTNGIA	No comparisons possible						
APOSDCIL	No comparisons possible						
TORSECPA		(TR)	(ST)				
		70.0	65.0				
		(1)	(3)				
IGARDPEB	No comparisons possible						
ARHCTNEI	No comparisons possible						
4							
WEHTNGIA	(GN)		(TW)				
	25.0		42.5				
	(2)		(2)				
APOSDCIL		(CL, SC)		(SL)		(PL)	
		36.0		65.0		70.0	
		(6)		(3)		(1)	

Table 17 - cont'd.

	0	1	2	3	4	5	6
TORSECPA		(SC)	(CR, SP)				
		30.0	22.5				
		(2)	(6)				
IGARDPEG	(DR)	(GR, PR)		(BR)			
	50.0	57.5		32.5			
	(4)	(4)		(4)			
ARHCTNEI	No comparisons possible						
Direction and Frequency							
Positive-1	No comparisons possible						
Positive -2	No comparisons possible						
Positive-3	No comparisons possible						
Positive-4							
WEHTNGIA	No comparisons possible						
APOSDCIL		(CL, SC)		(SL)		(PL)	
		36.0		65.0		70.0	
		(6)		(3)		(1)	
TORSECPA		(SC)	(SP)				
		30.0	22.5				
		(2)	(4)				

Table 17 - cont'd.

	0	1	2	3	4	5	6
IGARDPEB	No comparisons possible						
ARHCTNEI	No comparisons possible						
Negative-1	No comparisons possible						
Negative-2	No comparisons possible						
Negative-3	No comparisons possible						
Negative-4							
WEHTNGIA	(GN)		(TW)				
	25.0		42.5				
	(2)		(2)				
APOSDCIL	No comparisons possible						
TORSECPA	No comparisons possible						
IGARDPEG	(DR)	(PR)		(BR)			
	50.0	10.0		32.5			
	(4)	(1)		(4)			
ARHCTNEI	No comparisons possible						

Note. —The number of ss which comprise a class is given below the mean percentage of ss constructed from the class.

solutions constructed from the positive direction classes of ss and the mean percentages from the negative direction classes. In each of the comparisons that were made, a greater mean percentage of the positive direction class of ss than of the negative direction class of ss was constructed. Three comparisons were then made with the CVVC problems after bigram frequency had been held constant. (See Table 18.) E compared only those ss whose bigrams were classified as bigram frequency 2. No comparisons were possible with ss classified as class 3 or 4. In each case, again, a greater mean percentage of the positive direction class of ss than of the negative direction class of ss was constructed. Differences between classes of ss were generally small, however, in these seven comparisons. No comparisons were possible after both vowel bigram distance and frequency had been held constant. Six comparisons were also made with the CC problems after distance, direction and both distance and direction had been held constant. (See Table 18.) No consistent relationship, however, was found between direction class and the mean percentage of class ss constructed.

With the bigram frequency dimension, five comparisons were made with the solutions constructed to the CVVC problems after distance had been held constant (See Table 19.) E first compared only the ss with bigrams classified as distance 1, then only the ss with bigrams classified as distance 2 and lastly, the ss with bigrams classified as distance 3. No comparisons were possible with bigram distance 4. For four of the five comparisons, a greater mean percentage of the more frequent bigram frequency class of ss than of the other bigram frequency classes of ss was constructed.

Table 18

Mean Percentage of Direction Class ss Constructed with One or More Other Stimulus Classes Held Constant

Stimulus class held constant	Direction Classes Positive	Direction Classes Negative
	CVVC problems	
Distance		
0	No comparisons possible	
1		
APDILENR	(IE)	(EI)
	12.5	10.0
	(4)	(1)
LOMASETR	(OA)	(EA)
	50.0	52.1
	(4)	(14)
MIEDALNH	No comparisons possible	
BDAEROMN	No comparisons possible	
AFRILSTE	No comparisons possible	
2		
APDILENR	(AI)	(IA)
	56.4	45.0
	(11)	(2)

Table 18 - cont'd.

LOMASETR	No comparisons possible	
MIEDALNH	(IA)	(AI)
	80.0	47.1
	(1)	(7)
BDAEROMN	No comparisons possible	
AFRILSTE	No comparisons possible	
3	No comparisons possible	
4	No comparisons possible	
5	No comparisons possible	
6	No comparisons possible	
Frequency		
2		
APDILENR	(AI)	(EA)
	56.4	50.0
	(11)	(15)
LOMASETR	No comparisons possible	
MIEDALNH	(EA)	(AI)
	63.3	47.1
	(8)	(7)
BDAEROMN	No comparisons possible	

Table 18 - cont'd.

AFRILSTE	(AI)	(EA)
	55.0	48.3
	(5)	(12)
3	No comparisons possible	
4	No comparisons possible	
Distance and frequency	No comparisons possible	
	CC problems	
Distance		
0	No comparisons possible	
1		
WEHTNGIA	No comparisons possible	
APOSDCIL	No comparisons possible	
TORSECPA	No comparisons possible	
IGARDPEB	(GR)	(PR)
	73.3	10.0
	(3)	(1)
ARHCTNEI	No comparisons possible	
2		
WEHTNGIA	No comparisons possible	
APOSDCIL	No comparisons possible	

Table 18 - cont'd.

TORSECPA	(SP)	(ST, CR)
	23.8	48.0
	(4)	(5)
IGARDPEB	No comparisons possible	
ARHCTNEI	No comparisons possible	
3	No comparisons possible	
4	No comparisons possible	
5	No comparisons possible	
6	No comparisons possible	
Frequency		
1	No comparisons possible	
2	No comparisons possible	
3		
WEHTNGIA	No comparisons possible	
APOSDCIL	No comparisons possible	
TORSECPA	(TR)	(ST)
	70.0	66.0
	(1)	(3)
IGARDPEB	No comparisons possible	
ARHCTNEI	No comparisons possible	
4		
WEHTNGIA	No comparisons possible	

Table 18 - cont'd.

APOSDCIL	No comparisons possible	
TORSECPA	No comparisons possible	
IGARDPEB	(GR)	(BR, DR, PR)
	73.3	36.7
	(3)	(9)
ARHCTNEI	No comparisons possible	
Distance and Frequency		
0		
1-1	No comparisons possible	
1-2	No comparisons possible	
1-3	No comparisons possible	
1-4		
WEHTNGIA	No comparisons possible	
APOSDCIL	No comparisons possible	
TORSECPA	No comparisons possible	
IGARDPEB	(GR)	(PR)
	73.3	10.0
	(3)	(1)
ARHCTNEI	No comparisons possible	
2-1	No comparisons possible	
2-2	No comparisons possible	

Table 18 - cont'd.

2-3	No comparisons possible	
2-4		
WEHTNGIA	No comparisons possible	
APOSDCIL	No comparisons possible	
TORSECPA	(SP)	(CR)
	23.8	27.5
	(4)	(2)
IGARDPEB	No comparisons possible	
ARHCTNEI	No comparisons possible	
3	No comparisons possible	
4	No comparisons possible	
5	No comparisons possible	
6	No comparisons possible	

Note. —The number of ss which comprise a class is given below the mean percentage of ss constructed from the class.

Table 19

Mean Percentage of Frequency Class ss Constructed with One or More Other Stimulus Classes Held Constant

Stimulus class held constant	Frequency classes 1	2	3	4
		CVVC problems		
Distance				
0	No comparisons possible			
1				
APDILENR			(IE)	(EI)
			13.3	10.0
			(4)	(1)
LOMASETR		(EA)	(OA)	
		52.1	50.0	
		(14)	(4)	
MIEDALNH	No comparisons possible			
BDAEROMN	No comparisons possible			
AFRILSTE	No comparisons possible			
2				
APDILENR		(AI)		(IA)
	55	55.5		37.5
		(11)		(2)

Table 19 - cont'd.

	LOMASETR	No comparisons possible			
	MIEDALNH		(AI)		(IA)
			48.6		75.0
			(7)		(1)
	BDAEROMN	No comparisons possible			
	AFRILSTE	No comparisons possible			
3					
	APDILENR	No comparisons possible			
	LOMASETR	No comparisons possible			
	MIEDALNH	No comparisons possible			
	BDAEROMN	No comparisons possible			
	AFRILSTE		(AI)	(IE)	
			55.0	12.5	
			(5)	(3)	
4		No comparisons possible			
5		No comparisons possible			
6		No comparisons possible			
Direction					
Positive					
	APDILENR		(AI)	(IE)	
			56.4	13.3	
			(11)	(4)	

Table 19 - cont'd.

LOMASETR	No comparisons possible			
MIEDALNH		(EA)	(IE)	(IA)
		63.3	30.0	75.0
BDAEROMN	No comparisons possible			
AFRILSTE		(AI)	(IE)	
		55.0	12.5	
		(5)	(3)	
Negative				
APDILENR		(EA)		(EI, IA)
		50.0		30.0
		(14)		(5)
LOMASETR	No comparisons possible			
MIEDALNH	No comparisons possible			
BDAEROMN		(EA)	(OA, OE)	
		62.7	46.7	
		(11)	(6)	
AFRILSTE		(EA)		(IA)
		48.3	15.0	
		(12)	(2)	
Distance and directions	No comparisons possible			

Table 19 - cont'd.

CC problems			
Distance			
0			
WEHTNGIA	(TH)		(GN)
	60.0		25.0
	(4)		(2)
APOSDCIL	No comparisons possible		
TORSECPA	No comparisons possible		
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
1			
WEHTNGIA	No comparisons possible		
APOSDCIL	No comparisons possible		
TORSECPA		(TR)	(SC)
		70.0	30.0
		(1)	(2)
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
2			
WEHTNGIA	No comparisons possible		
APOSDCIL	No comparisons possible		

Table 19 - cont'd.

TORSECPA		(ST)	(CR, SP)
		65.0	23.3
		(3)	(6)
IGARDPEG	No comparisons possible		
ARHCTNEI	No comparisons possible		
3	No comparisons possible		
4	No comparisons possible		
5	No comparisons possible		
6	No comparisons possible		
Direction			
Positive			
WEHTNGIA	No comparisons possible		
APOSDCIL	No comparisons possible		
TORSECPA		(TR)	(SC, SP)
		70.0	24.2
		(1)	(6)
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
Negative			
WEHTNGIA	(TH)		(GN, TW)
	60.0		33.8
APOSDCIL	No comparisons possible		

Table 19 - cont'd.

TORSECPA		(ST)	(CR)
		65.0	25.0
		(3)	(2)
IGARDPEB	No comparisons possible		
ARHCTNEI	(TH)		(CH)
	63.3		60.0
	(3)		(4)
Distance and Direction			
0-Positive	No comparisons possible		
0-Negative			
WEHTNGIA	(TH)		(TW, GN)
	60.0		33.8
	(4)		(4)
APOSDCIL	No comparisons possible		
TORSECPA	No comparisons possible		
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
1-Positive			
WEHTNGIA	No comparisons possible		
APOSDCIL	No comparisons possible		

Table 19 - cont'd.

TORSECPA		(TR)	(SC)
		70.0	30.0
		(1)	(2)
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
1-Negative	No comparisons possible		
2-Positive	No comparisons possible		
2-Negative			
WEHTNGIA	No comparisons possible		
APOSDCIL	No comparisons possible		
TORSECPA		(ST)	(CR)
		65.0	25.0
		(3)	(2)
IGARDPEB	No comparisons possible		
ARHCTNEI	No comparisons possible		
3	No comparisons possible		
4	No comparisons possible		
5	No comparisons possible		
6	No comparisons possible		

Note. —The number of ss which comprise a class is given below the mean percentage of ss constructed from the class.

Six comparisons were made with the data to the CVVC problems after direction had been held constant. (See Table 19.) First only the solutions with bigrams classified as positive in direction were evaluated. Subsequently the ss with bigrams classified as being negative in direction were examined. For five of the comparisons, a greater mean percentage of the more frequent bigram frequency class of ss than of the remaining bigram frequency class of ss was constructed. No comparisons were possible with the ss to the CVVC problems after both the distance and direction of the vowel bigrams had been held constant. With this bigram frequency dimension, three comparisons with the data to the CC problems were then made after distance again had been held constant. Solutions with distance 0 were compared and then those with distance 1. Solutions with distance 2 bigrams were then considered. Table 19 indicates that no comparisons were possible with bigram distances of 3, 4, 5 or 6. Four other comparisons were then made after direction had been held constant (comparisons made first with ss containing positive direction bigrams, followed by comparisons with ss containing negative direction bigrams) and three after both distance and direction again had been held constant. With each of these ten, it was found that a greater mean percentage of the more frequent bigram frequency class of ss than of the other bigram frequency class of ss was constructed. (See Table 19.)

APPENDIX E

Summary of the Major Results of Studies 1 - 4

Study 1

The study attempted to determine if Ss not specifically instructed to work with a particular task-specific strategy could learn to use it by working on each of five multiple-solution anagrams, in which many specific solutions could be constructed using this strategy (CVVC or CC). Ss took part in Study 1 in small groups. Each S, however, worked individually in solving the problems.

Analysis of results indicated that almost all the solutions specific to the strategies being studied (ss) were constructed by one or more Ss. However, a mean number of less than half the possible ss was constructed to each problem. There was no consistent increase with practice in the number of ss produced. Inspection of the worksheets suggested that the ss constructed were often simply solutions constructed incidentally during S's use of such response patterns or strategies as rhyming, and making letter substitutions and directional movements.

Study 2.

The experiment attempted to determine if the number of ss produced by Ss instructed to use a task-specific strategy (CVVC or CC) and reinforced for its successful use would increase on successive problems. Ss worked individually in small groups.

The results showed that almost all of the possible ss were constructed by one or more Ss and that the mean number of ss per problem was greater than in Study 1. It was also found that a mean of less than half of the possible ss was constructed to each problem and that no systematic change with practice was found in the number of ss constructed.

Additional data, regarding strategies used and errors made, were also obtained, suggesting several questions that should be further explored.

Study 3

The experiment investigated whether even Ss presented with an incentive for performing well would adopt and use efficiently an effective strategy called to their attention. Ss again worked individually, but participated in the study in small groups.

Analysis of the data indicated that there was a statistically significant increase in the number of ss constructed with one (CVVC) of the two strategies suggested to the Ss.

Study 4

Study 4 attempted to determine if conditions could be found under which individually-run Ss would construct increasing numbers of ss with practice in using the more difficult CC strategy. It was found that all Ss showed a great increase with practice in the number of ss produced. The results approached statistical significance.

Evidence from S reports and performance also suggested some reasons for the poor performance shown by Ss presented with the CC strategy and the absence of a practice effect in the previous studies.