THE EFFECT OF TRANSITION PROBABILITY AND PROBLEM-SOLVING METHODS ON ANAGRAM PROBLEM SOLVING

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ABSTRACT

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PROBLEM-SOLVING METHODS ON
ANAGRAM PROBLEM SOLVING

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A 2 x 2 factorial design was employed in which anagram form and problem-solving method was manipulated in order to test the hypotheses that (1) solution times for nonsense anagrams are significantly shorter than those for word anagrams, and (2) irrespective of the anagram form, subjects provided with paper and pencil will have shorter solution times than those who are instructed to solve all the anagrams without the aid of paper and pencil. The methods and materials employed to test these two hypotheses were those of Beilin and Horn (1962), with slight modifications. Sixty students in the introductory psychology course at Michigan State University served as subjects.

A fixed-effects analysis of variance of solution times and the number of anagrams solved correctly significantly support the first hypothesis. There is no evidence to indicate that anagram solution time or the number of anagrams solved correctly is a function of problem-solving methods thus, the second hypothesis cannot be confirmed. To determine the relationship between intelligence (verbal scores) and the ability to solve anagrams (anagram solution time and the number of anagrams solved correctly), scatter plots and correlation coefficients were computed for each of the

four treatment conditions. None of the correlation coefficients approached significance.

A study of the verbal reports of the subjects suggests that (1) subjects initially attempt to solve anagrams by a whole approach and if they are unsuccessful, they use a trial-and-error method, (2) the major source of difficulty in reaching a solution is in the reorganization of letter groups, and (3) subjects are aware of the frequency of letter pairs and the likelihood of their occurrence in particular letter positions.

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INTRODUCTION

The Anagram as a Problem-Solving Task

It is difficult to conceive of an adequately functioning individual who does not daily encounter situations in which he must make a choice between alternatives and then act according to his decision. The problem facing this person may be simply one of deciding when he should have the snowtires put on or whether Answer A is better than Answer C on the history exam, or it may be a more serious problem involving the lives of many people. Disregarding the nature of the choice and the degree of conscious effort expended in making the decision, it is still extremely unlikely that anyone can regularly avoid being confronted with a problem-solving situation. It is due to this universal nature of problem-solving that it is an important area of research.

According to Johnson (1951, p. 259) all problem-solving, whether it be verbal, numerical or spatial in content, consists of "(1) survey of the problem and analysis of the goal, (2) production of promising solution attempts, and (3) judgment or evaluation of the attempts." In the case of problems involving verbal material, the individual is faced with manipulating and reorganizing the given information in such a way as to construct an appropriate solution. In seeking this solution such things as past experience, persistence of set, complexity of the material, lack of understanding of or unfamiliarity with the problem, and affective components in the material may aid or obstruct the person. It seems possible then, that with an adequate knowledge of the processes involved in problem-solving and through careful control of the above mentioned factors, one can construct an experiment that explores a problem-solving situation in depth and that explains with greater clarity the reasons why individuals differ when given identical tasks.

The anagram, i.e., "the change of one word or phrase into another by the transposition of its letters,"[1] is one example of a problem-solving task, verbal in content, that has been recently explored in depth. There are numerous reasons why the anagram has been thought of as an advantageous method of studying problem-solving behavior, some of which are reviewed by Ammons and Ammons (1959a). Though these authors present a slightly different definition of the anagram from the one above, several of their conclusions are also relevant to the anagram as presently defined. Some of the advantages they list are: (1) responses can be recorded by the subject or the experimenter, (2) the task can be an individual or a group task, (3) the requirements of the experiment are readibly understandable to literate subjects, (4) subjects find the problem interesting, (5) the experiment is easily replicable, and (6) difficulty can be identified by pretesting and thus, controlled. In another study by Ammons and Ammons (1959b) in which they compare the

[1] Webster's New International Dictionary, 1956, p. 94.

anagram task with everyday problems gained from students, they conclude that the anagram task is a laboratory analogue of "real-life problem solving."

Accepting the anagram as an appropriate method for studying problem solving, investigators have sought to explore various aspects of the situation. Of major importance to this study is the research centered around the question of why some anagrams are more difficult to solve than others. With this question in mind, the history of problem-solving tasks using anagrams will be reviewed.

Early Research in Anagram Problem-Solving

According to the Gestalt conception, words are recognized as wholes that have meaning attached to them. Given a word that has a missing letter or an incorrect letter, the meaning of the word may still arise to such an extent that an individual supplies the correct letter or overlooks errors in spelling. To the Gestaltists this was a demonstration of the principle that the whole determines the part. Hollingworth (1935) reasoned that if words are configurations they should follow the laws of configuration. To test this assumption he disarranged words into loosely patterned groups (ungestalted) and well-patterned groups (gestalted). For example, he hypothesized that the word INTELLECTUAL would be more easily formed from ALINLETLUETC than from ALL IN LETTUCE. The results did not confirm the hypothesis that words act as a constraining influence over the letters within the word. Hollingworth (1938) replicated this experiment using children of eight to ten years of age, instead of college students, and again there was no significant difference in the number of words made from gestalted than from ungestalted letter groups.

Hollingworth recorded the number of words formed to test the principle of configuration. Devnich (1937) repeated his experiment, but instead of noting the number of words constructed she used the number of errors or omissions made in generating a word. Her results are contradictory to those of Hollingworth's in that she found that well-patterned letter groups resist change to a greater extent than loosely patterned letter groups.

Both Hollingworth (1935, 1938) and Devnich (1937) attempted to correlate a subject's ability to solve anagrams with various measures of intelligence. The former investigator compared Alpha Test intelligence scores with the total number of words correctly built by each subject, whereas Devnich correlated the final grades in a general psychology course and the raw scores from intelligence tests of each subject with the number of errors in building words. Neither experimenter was able to conclude that there is a correlation between intelligence and the ability to solve anagrams· although, Hollingworth did suggest that there was a tendency for the brighter subjects (Alpha scores of 140 or above) to profit from having the anagrams presented in word form. Due to the somewhat unsystematic design of his experiment, it seems unwise to accept this statement without further investigation.

Thus, early in the history of the anagram as a method of studying verbal problem solving, the contradictory results of the aforementioned investigators acted as a catalyst for further research in this area. A number of criticisms were directed at the studies by Hollingworth and Devnich. In these investigations the experimenter presented a definite class of words, e.g., names of cities, birds, psychological terms. Nissenson and Sargent (1941) suggest that this introduces a factor of differential knowledge. Also, it seems likely that when a subject is informed that the solution word is of a particular class he will mentally list all the words of that class that he knows and compare each with the given anagram rather than focusing upon the anagram itself. Having corrected for this factor by creating words not relevant to one particular class, e.g., DO RUN, HOT TAR, Nissenson and Sargent were unable to support the Gestalt principle that words are configurations and as such resist change.

Sargent (1940), studying the changes in the thinking processes as task difficulty is increased, obtained results similar to those of Hollingworth's. He concludes that the degree of difficulty of a disarranged word is greatly dependent upon the pattern of letter presentation, i.e., when the first and last letters of the disarranged word are the same as those letters necessary for the solution word, the anagram is more easily solved than when they are placed in other letter positions. He also noted, from his observations of the subjects and comments from them, that in general, the college students first attempted to solve the anagram by the whole approach, i.e., looking at the letters as a whole. If they were unsuccessful, they then proceeded to try various letter combinations, i.e., part or trial-and-error approach, until they arrived at the correct solution or failed to do so in the time alloted. In a much later study, Rhine (1959) asked subjects to list the hypotheses used in solving anagrams. Like Sargent, he also found that the college students used the whole and/or the trial-and-error approach. He concludes that those employing the latter method are superior at anagram problems and suggests that the method used may be a determiner of achievement in problem-solving.

The Work of Mayzner and Tresselt

For the past seven years Mayzner and Tresselt have dominated the field of verbal problem-solving using anagrams. In their effort to explain solution time variability they have identified a number of factors which play major roles in determining the ease with which anagrams are solved. Before beginning a discussion of the specific experiments conducted by these investigators it is important to note that their research is centered around a S-R mediational model. According to Mayzner and Tresselt (1964, p. 263), "an anagram constitutes a problem whose stimulus properties evoke a variety of implicit responses in the subject and the variables anagram letter order, word frequency, anagram transition probability and word transition probability are related to the processes underlying the production of such implicit responses." From these implicit responses, introspective reports and language behavior arise. It is assumed that when a subject is given an anagram problem he begins by rearranging the letters in the anagram in accordance with their frequency of occurrence in the English language. These implicit responses continue to occur until the subject recognizes the correct solution. The results of a study by Mayzner, Tresselt and Helbock (1964) in which they attempted to investigate mediational responses strongly supports their model.

In 1958, these investigators studied the effects of anagram letter order, i.e., the rearrangement of letters from their correct position in the word, and word frequency on anagram solution times. According to their hypotheses, an anagram with a letter order of 52413 (hard letter order) will be more difficult to solve than one with an order of 23451 (easy letter order). Similarly, anagrams of words with low Thorndike-Lorge (1944) frequency counts, e.g., peony, would be more difficult than ones of words that occur very frequently in the English language, e.g., chair. The results of the experiment are in accord with their hypotheses. Hunter (1959) confirms Mayzner and Tresselt's results in regard to letter order affecting solution times. Using high scrambled anagrams, i.e., the letter order of the anagram and solution word are maximally dissimilar, and low scrambled ones, i.e., three consecutive letters are in the same order as in the solution word, Hunter concludes that the ease of solution is dependent upon the number of letters that must be rearranged, the distance the letter(s) must be moved, and whether or not the letter is shifted from an end position to a middle location or the reverse.

Taking into account the function of letter order and word frequency on anagram solution times, in their next experiment Mayzner and Tresselt (1959) investigated the effect of transition probability on anagram problem-solving. Transition probability (TP) refers to the number obtained when summing the digram frequencies for all sequential pairs of letters in a single anagram. For example, the TP of the anagram IHRAC is 0 + 3 + 5 + 20, or 28. The letters of any given word can be rearranged to form an anagram with a high TP or a low TP. This was done by Mayzner and Tresselt when testing the hypothesis that anagrams with low TP totals should be solved faster than those with high TP totals. They base this hypothesis on the assumption that in solving an anagram, the subject tries various letter combinations and those combinations having low digram frequencies will be more easily rearranged than those of high digram frequency. The results of this study are in agreement with their proposition; anagrams having high TP totals produce significant increases in anagram solution times.

Stachnik (1963) attempted to duplicate the aforementioned study in a group situation, but his results were non-significant. He suggests that when attempting to solve an anagram without the use of paper and pencil (as in the Mayzner and Tresselt experiment), each time the subject fails to arrange the letters correctly he returns to the anagram to try a new pattern, and thus the TP total remains constant. Given paper and pencil, as in a group setting, with each incorrect rearrangement the individual proceeds from it, rather than returning to the original letter arrangement and therefore the TP total changes and is lowered with each revision.

Having demonstrated that letter order, word frequency, and anagram transition probability have a significant effect on anagram solution times, Mayzner and Tresselt (1962) attempted to determine the effect of a fourth variable: word transition probability. They reason that a subject's initial arrangement of pairs of letters will correspond to pairs of letters having a high frequency of occurrence in the English language. Based on this assumption, they hypothesized that anagrams whose word solutions have high TP totals will be solved faster than those whose word solutions have low TP totals. As an example, they suggest that given the letter H and the letter E, one is more likely to rearrange the two as HE rather than EH. Once again, the results supported their hypothesis beyond the 0.02 level of significance. With the compilation of single letter and digram frequency counts based on word length and letter position, Mayzner and Tresselt (1963) suggest that the subject not only produces letters with high frequency totals first, but that he also takes into account the word length and letter position in solving the anagram.

It is obvious from the preceding discussion that the work of Mayzner and Tresselt has aided greatly in advancing our knowledge of anagram solution times. Some insight into the significance of their research can be realized just from the fact that at present, there are few studies conducted which do not control for letter order, word frequency, and transition probabilities.

Recent Investigations of Anagram Problem-Solving Tasks

These aforementioned investigations have not gone unnoticed, nor have they been free of criticism. Particularly relevant to this thesis is a study by Beilin and Horn (1962) in which they suggest that it cannot be concluded that the transition probability hypothesis, i.e., anagram solution time is a function of TP, is applicable to word anagrams as well as nonsense anagrams without a test in which both anagram forms are employed. Since Mayzner and Tresselt had used only the latter form of anagram in their studies, Beilin and Horn (1962, p. 514) designed an experiment to test the hypothesis that "solution time differences between highly and loosely patterned anagram letter arrangements are a function of transition probability." Keeping transition probabilities, letter order, and solution-word frequency constant, 10 five-letter "nonsense" anagrams and 10 five-letter "word" anagrams were presented. To one group the nonsense aggregates were given first followed by the word anagrams; the other group received the reverse. It should be noted that subjects were told that in order to obtain the correct solution to any of the anagrams they only needed to interchange two letters. This was not the case in the Mayzner and Tresselt experiments in which all five letters were to be rearranged. In accordance with previous studies, subjects were not permitted to use paper and pencil in seeking a solution. Using a Friedman two-way analysis of variance, the experimenters were able to conclude that word anagrams are solved significantly more slowly than nonsense anagrams ($P < .001$). Since transition probability was held constant it cannot be assumed that the solution time differences for word and nonsense anagrams are a function of TP. As an explanation of their results, Beilin and Horn suggest a word perseveration effect, i.e., subjects fixate on the word anagram, thus hindering them in reaching a solution. These investigators have been criticized by Mayzner and Tresselt (1965) for changing the anagram task from one of rearranging five letters to one necessitating only an interchange of two letters, thus restricting and simplifying the task.

Seeking a more sensitive measure of the production of digrams by a subject, Dominowski (1965) computed the digram ranks (DR) for successive pairs of letters. DR should not be confused with TP. The TP of a contiguous pair of letters indicates the frequency of occurrence of the particular letter pair whereas the rank of a digram denotes the number of more frequent letter pairs with the same initial letter. For example, the digram rank of AN is 1 because it is the most frequent digram beginning with the letter A, while the TP of this letter pair is 2048. In a rather complicated 3 x 3 x 2 factorial design, Dominowski manipulated word frequency, word DR, and anagram DR. Anagrams having a high frequency word solution were solved more often. This finding is similar to that of Mayzner and Tresselt's and it is also consistent with the "spew hypothesis," i.e., emission of verbal units is a function of their frequency of occurrence. Words with low DR totals were easier to solve than the reverse. Given an anagram with a high DR solution word, it is assumed that if the spew hypothesis is correct, the subject will encounter a number of interfering digrams before he obtains the solution. Dominowski also indicates that more solutions are produced from high DR anagrams though the results were small. To him, this suggests that solution of anagram problem-solving tasks is mainly one of word production rather than the generation of letter patterns.

The last study to be discussed is an important one for Ronning's (1965) results indicate that even when taking into account transition probability, variability in solution times is still evident. Given a five-letter anagram, there are 120 permutations that can be made in attempting a solution. But according to Ronning, there are a number of combinations of letters that do not occur in the English language, and thus can be ruled out. As an example, he presents the anagram HIGTL (light). Digrams and trigrams such as HG, HT, HL, GT, TG, TL, LH, LG, LT, GHT, GHL, GLH, GLT, THL, and THG do not occur as the <u>initial</u> group of letters in this language. These combinations rule out 66 of the possible 120 permutations. He adds that since vowels seldom begin a five-letter word, the "I" in the above example can also be ruled out bringing the total number of remaining permutations to 30. Ronning then assumes that as the subject manipulates the letters of an anagram he intuitively takes into account the fact that certain letters are more likely to be arranged in one pattern rather than another, e.g., words usually begin with a consonant followed by a vowel (cv) or with a ccv pattern. To test the rule-out factor, Ronning selected 20 words according to their frequency of occurrence and rule-out totals. Because of his interest in initial digrams and trigrams, he did not control for transition probabilities of anagrams and solution words. Forming four groups of words, he hypothesized that the words should be solved in the following order (from fastest to slowest solution time): (1) high frequency, high rule-out; (2) low frequency, high rule-out; (3) high frequency, low rule-out; (4) low frequency, low rule-out. Ronning's results are in complete agreement with his hypothesis.

In an attempt to see whether or not the TP totals used by Mayzner and Tresselt could predict Ronning's results, this experimenter computed the TP totals from the frequency counts reported in Underwood and Schulz (1960) for both the anagrams and the word solutions. Mayzner and Tresselt's (1959) results indicate that those anagrams having low TP totals will be solved faster than those with high TP totals. Looking only at digram totals in Table 1, the order in which the anagrams should be solved employing TP totals is (from fastest to slowest solution time): (1) low frequency, low rule-out; (2) high frequency, high rule-out; (3) low frequency, high rule-out; and (4) high frequency, low rule-out. This order is not in agreement with Ronning's obtained order in any of the four conditions. Referring to trigram totals, both Ronning's theory and Mayzner and Tresselt's theory posit that the anagrams in the high frequency, high rule-out condition should be solved the fastest. Their predictions do not overlap in any other way.

According to Mayzner and Tresselt's (1962) theory, the solution words having high TP totals will be solved faster than those with low TP totals. Both the rule-out theory and the theory of TP applied to trigram totals predict the same order of solution for the words in Table 2. The same predictions cannot be drawn from looking at the digram totals. The predictions of these two theories over lap in only two conditions (high frequency, low rule-out and low frequency, low rule-out.

Table 1. Digram and Trigram Totals for Individual Anagrams According to Word Frequency and Rule-Out Conditions.

Condition	Anagram		Digram Total		Trigram Total
High Frequency and High Rule-Out	ITLGH		1780		0
	NMTHO		1920		72
	TNDSA		1325		0
	DHCIL		1270		1
	LNTPA		3261		0
		total	9556	total	73
High Frequency and Low Rule-Out	WREAT		6622		786
	HULAG		2585		128
	HIETW		2115		88
	ICREP		4472		163
	RTHIE		2664		254
		total	18458	total	1419
Low Frequency and High Rule-Out	NWGRI		1600		45
	NIFLT		1472		79
	ANCST		5574		217
	RAPCM		1784		135
	BNTUL		6553		78
		total	16983	total	554
Low Frequency and Low Rule-Out	OSHSA		923		0
	HPCOU		2200		14
	ITDYE		826		24
	OCURS		2170		350
	OLBRI		2077		34
		total	8196	total	422

To conclude that Ronning's results can be predicted from TP totals would be fallacious. It should be noted however, that while Mayzner and Tresselt controlled for letter order, Ronning did not. In checking for this

Table 2. Digram and Trigram Totals for Solution Words According to Word Frequency and Rule-Out Conditions.

Condition	Solution Word		Digram Total		Trigram Total
High Frequency and High Rule-Out	LIGHT		2621		931
	MONTH		6394		153
	STAND		6455		797
	CHILD		2865		290
	PLANT		5799		919
		total	24134	total	3090
High Frequency and Low Rule-Out	WATER		7301		1285
	LAUGH		2041		110
	WHITE		3992		174
	PRICE		4181		228
	THEIR		3489		257
		total	21004	total	2054
Low Frequency and High Rule-Out	WRING		6219		889
	FLINT		6016		654
	SCANT		5407		502
	CRAMP		2394		93
	BLUNT		4109		204
		total	24145	total	708
Low Frequency and Low Rule-Out	CHAOS		2290		210
	POUCH		3243		2
	DEITY		2735		275
	SCOUR		3478		194
	BROIL		2281		27
		total	14027	total	708

variable, it was found that not any two anagrams had the same letter order. Another criticism of Ronning's study also seems valid. In looking at the words within each condition it was observed that every word in both high rule-out conditions had one vowel (assuming the vowels to be the letters a, e, i, o, and u) whereas in the low rule-out conditions, every word had two vowels. If it is accepted that most five-letter words begin with a consonant, and therefore vowels may be ruled out as the first letter of the word, this writer is of the opinion that the rule-out factor can be more easily applied to words composed of three consonants, two vowels rather than those containing four consonants, one vowel. But this seems to be a contradiction of Ronning since the words in his High Rule-Out conditions contain four consonants and one vowel. Possibly this paradox could be eliminated if it were more clear as to how Ronning arrived at the conclusion that one word had a higher rule-out than that of another. Future studies should control for vowel variability as well as letter order.

Anagram Problem Solving: A Function of Many Variables

Research on the anagram as a problem-solving task, and in particular, the investigation of solution time variability, has come a long way since the study by Hollingworth (1935). Yet it does not seem valid to conclude that only three or four variables must be taken into account when designing an anagram experiment. The effect of word frequency on solution times seems to be well established, but it cannot be said as emphatically that letter order, transition probability, and the like occupy as sound a position. Nor can the role of set in problem-solving be disregarded. The subject brings to the experimental session his own set, and this may be altered or replaced by a set specified by the experimenter's instructions or by numerous other variables in the testing situation. One need only look at a few studies on set in order to recognize the importance of this feature of behavior in problem-solving tasks (Rees and Israel, 1935; Maltzman (1953); Maltzman and Morrisett, 1952, 1953; Adamson, 1959; Safren, 1962). Investigations thus far have succeeded in identifying a number of variables that affect solution times in anagram problem-solving tasks, but it is still unclear as to how and to what degree these factors interact with each other and what other variables play a significant role in this area of psychology.

Statement of the Problem

The present study was undertaken for two purposes: (1) to re-examine the hypothesis that "solution time differences between highly and loosely patterned anagram letter arrangements are a function of transition probability,"[1] and (2) to explore the heretofore neglected possibility that problem-solving methods are related to anagram solution times.

A review of the literature to date indicates that in all the studies in which subjects were tested individually, the subjects were required to solve the anagrams without the aid of paper and pencil. It has been observed by this

[1] *J. exp. Psychol.*, 1962, *63*, p. 514.

investigator that when given a problem she often attempts to reconstruct the problem on paper in an effort to obtain a solution. This behavior has also been noticed in others, and it suggested the possibility that the difficulty in solving anagrams might be reduced if the subject were permitted to use paper and pencil. It therefore seemed wise to construct an experiment in which problem-solving methods could be varied through task instructions. A review of Beilin and Horn's study suggested that this variable could be tested within their experimental design.

Hypotheses

According to Mayzner and Tresselt (1958), well-patterned letter groups are more difficult to rearrange than loosely-patterned aggregates. They state that the differences in difficulty are a function of transition probability. Then, if this variable were held constant, no differences in solution times between word (well-patterned) and nonsense anagrams (loosely patterned) should be evident. Yet when Beilin and Horn tested this assumption, their data indicated a significant difference in solution times. This suggests that difficulty in solving various forms of anagrams is not a function of transition probability.

Therefore, it was hypothesized that in replicating Beilin and Horn's study, the results would be in accord with theirs, i.e., solution times for nonsense anagrams are significantly shorter than those for word anagrams. It was also hypothesized that, disregarding the form of anagram given, those subjects permitted to use paper and pencil in seeking a solution would have shorter solution times than those who were instructed to solve all the anagrams without the aforementioned aids. These two problem-solving methods, i.e., (1) anagram solving with the aid of paper and pencil, and (2) anagram solving without the aid of paper and pencil, will heretofore be referred to as the "paper method" (P) and the "oral method" (O), respectively. The experiment designed to test these hypotheses attempted to follow Beilin and Horn's methods as closely as possible and any variations will be indicated.

METHOD OF INVESTIGATION

Subjects

The sixty-one subjects used in this experiment were research volunteers enrolled in the Introductory Psychology course during Fall Quarter, 1965 at Michigan State University. Of these, data from one student were discarded because she was unable to solve eight of the ten anagrams. The final sample of sixty included twenty-seven males and thirty-three females, mainly in their second year of college, whose range in age was from seventeen to twenty-three years. Subjects were randomly distributed to one of four groups and each subject was tested individually.

Materials

The stimulus materials consisted of 10 five-letter nonsense anagrams, e.g., TEANM, and 10 five-letter word anagrams, e.g., EMITS. Each anagram was typed in capital letters on a 3 x 5 inch white index card.

Experimental Design

In Beilin and Horn's study one group of subjects were given ten nonsense anagrams followed by ten word anagrams. The second group received the anagrams in the reverse order. Since the present investigation was interested in manipulating a method variable in addition to the form of the anagram presented, it was necessary to alter the experimental design.

A 2 x 2 factorial design was employed in which anagram form and problem-solving method was manipulated. The four different treatment conditions were: (1) nonsense anagram, oral method; (2) nonsense anagram, paper method; (3) word anagram, oral method; and (4) word anagram, paper method. These four groups will heretofore be referred to as N-O, N-P, W-O, and W-P, respectively.

Unlike Beilin and Horn's rotated order of presentation, in this study the anagram order was held constant. In other words, disregarding the method, all subjects receiving nonsense aggregates were first given OBAVE followed by EHECK,...,LEAGL. Those in the word anagram conditions were asked to solve MELON followed by VERSE,...,TRAIL.

In all four conditions the subjects were told that the correct solution could be obtained by interchanging only two letters of the anagram. Since letter order has been shown to be a variable affecting solution times it was necessary to hold it constant across all conditions. Thus, if it was necessary to rearrange the first and third letters to form the correct word in N-O and N-P, there was also an anagram in W-O and W-P that required the interchangement of the first and third letters. It was impossible for a subject to form a successful letter order set, i.e., always switching the same two letters to reach a solution, since the same two letter orders were never applicable to more than one anagram with one exception. Two nonsense anagrams and two word anagrams can be solved correctly if the third and fourth letters are rearranged.

As a result of evidence suggesting that anagram solution times decrease as solution word frequency increases, it was necessary to control for this variable. All solution words were selected from the Thorndike-Lorge (1944) word list. The mean frequency of nonsense anagram solution words is 74.4 as compared with a mean frequency of 74.3 for word anagram solution words.

If it is accepted that as one uses a language in order to communicate he learns that some letters have a tendency to occur together more often than others, it seems reasonable to conclude that transition probability totals should be computed and equated across all conditions. The mean total for nonsense anagrams and word anagrams is 153.8 and 151.7, respectively. The difference between the two is not significant. Beilin and Horn suggest that if a subject has some knowledge of digram frequencies he will most likely be aware of one-, three-, four-, and five-letter arrangements in a similar manner. The mean total of trigram frequencies for both forms of anagrams have been computed and the differences in means is not significant. The mean for nonsense anagrams is 164.8 whereas the mean for word anagrams is 204.2. Nor are the mean differences between initial letter frequencies significant (nonsense mean, 67.4; word mean 63.0). Lastly, the terminal word frequencies were determined yielding a nonsense mean of 72.7 and a word anagram mean of

122.6. These differences are not significant. Pentagram and quadragram frequencies are not available and thus, were not computed. For a further analysis of the variables letter order, solution word frequency, and transition probability as they relate to this experiment, the reader should consult Table 3. This table was taken from an unpublished communnication from Beilin and Horn.

Table 3. A Comparison of Nonsense Anagrams and Word Anagrams According to Letter Order, Solution Word Frequency, and TP Totals.

Nonsense Anagrams	Word Solution	Letter Order	Solution Word Frequency	TP Totals
OBAVE	ABOVE	1-3	100	53
EHECK	CHEEK	1-4	50	163
TEANM	MEANT	1-5	50	169
HNOOR	HONOR	2-3	100	69
BEELD	BLEED	2-4	16	66
HTARE	HEART	2-5	100	167
LERAN	LEARN	3-4	100	245
RAESI	RAISE	3-5	100	89
THERI	THEIR	4-5	100	424
LEAGL	LEGAL	3-4	28	83
Word Anagrams				
MELON	LEMON	1-3	27	129
VERSE	SERVE	1-4	100	170
EMITS	SMITE	1-5	16	81
FROTH	FORTH	2-3	100	250
SLIME	SMILE	2-4	100	68
SLEET	STEEL	2-5	50	131
THERE	THREE	3-4	100	479
UNLIT	UNTIL	3-5	100	86
QUIET	QUITE	4-5	100	35
TRAIL	TRIAL	3-4	50	88

Procedure

Upon entering the testing situation the subject was asked to state his name, age, university status, academic major, and whether or not he regularly attempted to solve anagrams. He was then given a typed sheet of instructions and asked whether he had any questions. The instructions varied according to the condition, but the investigator attempted to make them as identical as possible. For example, a subject in N-O was given the following instructions:

> A five-letter anagram is simply five scrambled letters which when properly rearranged will make a single five-letter word. For example, by rearranging the letters FALSH you can form the word FLASH. Notice that you need only to rearrange two of the five letters in order to form the correct word. You will be given ten anagrams to solve. If after two minutes you cannot find the solution to one, the correct solution will be given to you before going on to the next anagram. Only one correct solution is possible for each anagram. When you think you have the answer, tell the experimenter the word. Do not use paper and pencil in solving the anagrams. Remember, you need only to rearrange two of the five letters, leaving the remaining three in the same location, in order to form the correct word.

The only difference made for an individual in W-O was that the example given was one relevant to the task, e.g., SPOON to SNOOP. The sentence, "Do not use paper and pencil in solving the anagrams," did not appear in the instructions given to N-P and W-P subjects. In place of it, the subjects were told: "You will be given paper and pencil which you may use to help solve the anagram. Write whatever you wish, but when you have the solution, tell the experimenter." Having answered any questions the subject might have, a sample anagram was presented and then the test series. Solution times were recorded with a stop watch. The subject was encouraged to verbalize his problem-solving attempts and major sources of difficulty. No comments or suggestions were provided by the investigator until all anagrams had been presented. At the completion of the experimental session the purpose of the study was explained to the subject and thanks were extended for his participation.

RESULTS

Quantitative Results

Available for purposes of analysis were ten time scores for each subject with each score having a possible range from 1 to 120 seconds. The number of anagrams correctly solved in the allotted time were also recorded for each subject. These raw scores for each subject according to the treatment condition may be found in Appendix 1. Medians were employed rather than means for time scores because of skewed distributions and the artificial ceiling imposed by the 120 second time limit per anagram. Skewness was not apparent in the scores of number of anagrams solved correctly and as a result means were computed. The major results of the study are given in Tables 4 and 5.

Table 4. Solution Times (Sec.) for Nonsense Anagram and Word Anagram Tasks.

Method	Nonsense Anagrams			Word Anagrams		
	N	Median	Range	N	Median	Range
Oral	15	7.5	3.0-19.5	15	25.0	4.0-106.5
Paper	15	8.5	2.5-25.5	15	13.0	3.0-118.5

Table 5. Number of Anagrams Solved Correctly for Nonsense Anagram and Word Anagram Tasks.

Method	Nonsense Anagrams			Word Anagrams		
	N	Mean	Range	N	Mean	Range
Oral	15	9.5	8-10	15	8.0	5-10
Paper	15	9.0	6-10	15	8.9	5-10

To evaluate the effect of anagram form and method on solution times, a fixed-effects two-way analysis of variance was employed. As indicated by Table 6, word anagram solution time was significantly slower than nonsense anagram solution time ($P < .01$). The null hypothesis of no method effect cannot be rejected since the F value is less than unity. Also, there is no significant evidence for interaction effects.

Table 6. Summary Table of the Analysis of Variance of Anagram Solution Times.

Source	SS	df	MS	F
Method	196.202	1	196.202	0.419
Anagram Form	4463.437	1	4463.437	0.540**
Interaction	429.341	1	429.341	0.917
Error (within cells)	26199.570	56	467.849	
Totals	31288.550	59		

**Significant beyond 0.01 level of confidence

The same model of analysis of variance was used to test the two variables according to number of anagrams solved correctly. A summary of this statistical test is presented in Table 7. It would be expected that if word anagrams are more difficult to solve then nonsense anagrams, they should be solved less often. An analysis of the data supports this supposition beyond the 0.05 level of confidence. Assuming that the ratio of MS interaction to MS error remained constant, it would be necessary to have a sample of 400 in order that the interaction effects be significant at the 0.05 level of confidence.

Table 7. Summary Table of the Analysis of Variance of the Number of Anagrams Solved Correctly.

Method	0.60	1	0.60	0.34
Anagram Form	9.60	1	9.60	5.58*
Interaction	6.66	1	6.66	3.87
Error (within cells)	96.54	56	1.72	
Totals	113.40	59		

*Significant beyond 0.05 level of confidence

The hypothesis that solution times for nonsense anagrams is significantly shorter than for word anagrams is substantiated by the data. Although it was not postulated that less word anagrams would be solved than nonsense anagrams, this was shown to be significantly true. Problem-solving methods as employed in this study do not have a significant effect on solution times. Therefore, the second hypothesis cannot be accepted. There is no indication that one problem-solving method rather than another, results in a greater number of anagrams solved correctly.

For an initial inspection of the possible relationships between verbal scores and anagram solution times, scatter plots were constructed. Although the plots did not indicate a relationship between these measures, a correlation coefficient was computed for each of the four treatment conditions. The coefficients for N-O, N-P, W-O, and W-P are +.32, -.38, -.26, and -.01, respectively. None of these correlation coefficients approaches significance. These results are similar to those of Hollingworth (1935, 1938) and Devnich (1937). Neither of these investigators was able to conclude that there was any consistent relationship between intelligence and the ability to solve anagrams. Scatter plots were also constructed to determine the relationships between verbal scores and the number of anagrams solved correctly. Since the distribution of points on these plots was so similar to the aforementioned plots, no further statistical analyses were carried out. The scatter plots for each of the four treatment conditions according to anagram solution time and the number of anagrams solved correctly may be found in Appendix 2 and 3, respectively.

Qualitative Results

A study of the verbal reports of the subjects indicates some of the sources of difficulty and the methods used in solving these anagrams. One of the most interesting findings was the number of incorrect "guesses" the subjects made shortly after being presented with the anagram. Many of them said they gave the first word that "came into my head," and if it was wrong, proceeded to "analyze" the anagram. This behavior was particularly evident in the N-O and N-P conditions in which the aggregate EHECK was called CHECK. This tendency toward immediate verbalization seemed to indicate that subjects attempted to solve the anagrams initially by a whole approach, and indeed, many subjects said they did. This solution method was also evident in the N-P and W-P conditions when the subjects momentarily studied the anagram without writing it, and if immediate insight was not forthcoming, they proceeded to break up the anagram into letter combinations. A third indication of the whole approach was the number of individuals in all conditions who created a word, but in so doing rearranged too many letters. When the experimenter recalled for them that the instructions directed them to rearrange only two letters, while keeping the other three letters in their original position, the subjects' subsequent behavior, as observed in N-P and W-P, was to use the trial-and-error method. The anagrams in which this response was particularly evident were HTARE, incorrectly called EARTH by those in N-O and N-P; and SLIME labelled MILES or LIMES instead of SMILE in the W-O and W-P conditions.

One of the major sources of difficulty reported by those in W-O and W-P was the fact that they were confronted with a word and had to form another word. A common statement was, "I can't think of anything but that word!" This statement also suggests that blocking (interference) occurred, hindering them in breaking up the given letter organization. This difficulty resulting in interference was also applicable to many in the N-O and N-P conditions when they said that after forming an incorrect word they "went blank," i.e., could not think of other letter combinations.

Such comments as, "I know these two letters go together" and "Can a word start with that letter" suggest that the subjects were aware of the frequency of letter pairs and the likelihood of their occurrence in particular letter positions. This knowledge appeared to be helpful to some, but to others it appeared to be a hindrance since they reported that they were hesitant to break-up certain letter groups or to place a specific letter at the beginning or the end of the word. It was surprising to note the large proportion of subjects who said that the easiest anagrams were those whose solution began with the same initial letter as given in the anagram, e.g., HNOOR to HONOR, FROTH to FORTH.

DISCUSSION

The results of this study clearly demonstrate that the differences between nonsense and word anagram solution times are not to be explained by transition probability effects since this variable was held constant. The reason for this difference is as yet debatable. Beilin and Horn (1962) suggest two possibilities to account for the results. The first is a perseveration effect attributed to the sound or meaning of the word anagram. This experimenter questions this proposal because there was nothing in the subjects' reports that indicates that word sound or meaning influenced their production of solutions. Nor is there any evidence in the past literature that supports this proposal. It does seem plausible that a perseveration effect is influencing word solution, but that it is attributable to the letter organization rather than to word sound or meaning. This hypothesis is similar to the second suggestion of Beilin and Horn. If there is such a variable influencing anagram solution that is not an artifact of the experimental design, it seems to be independent of transition probability of successive letter arrangements.

The differences in solution time can be explained by transition probability if the results of Beilin and Horn's study and this investigation are shown to be artifacts of the experimental design. Mayzner and Tresselt (1965) have criticized the aforementioned researchers for altering the anagram problem. It is true that the subject's activity has been restricted by rearranging two letters rather than all five letters. Whether this simplifies the task or makes it more confusing to maintain a set is not yet clear. No study has been attempted to determine whether transition probability effects apply only to the traditional anagram problem and not to other forms. At present there is no evidence that the results obtained are artifacts.

The results of this study do not demonstrate that differences in method have any effect on anagram solution times. Still, this experimenter is of the opinion that task aids may significantly decrease anagram solution times. In support of this hypothesis she suggests that the task was too easy and that possibly, the solution words were too familiar. The subjects thus felt no need to resort to paper and pencil. It does not seem presumptuous to assume that most college students find the task of interchanging two letters not overwhelming, and that the majority of the solution words are encountered frequently in their daily activities. It is proposed that problem-solving methods be varied in an experiment involving anagrams of five letters or more in which all letters must be manipulated, before any conclusions be stated concerning the role of a method in the solution of anagrams. The need for an experiment such as the one described above is based on the assumption that when the task is one in which the number of letter pair combinations is beyond the immediate memory span, and when the solution word is one not readily encountered, the subject will resort to any available aid that will help him recognize the solution.

A number of the qualitative results are consistent with past investigations. Both Sargent (1940) and Rhine (1959) conclude that subjects first attempt to solve an anagram by the whole approach and if they are unsuccessful, they then proceed to a trial-and-error method. Sargent (1940) lists a series of characteristics that he describes as being the behavior of individuals as they solve anagrams. One of the major sources of difficulty in this present experimenter's study was blocking due to the presentation of a word anagram or due to the formation of an incorrect word. Sargent characterizes this behavior as a susceptibility to interference or blocking and defines it as an inability to manipulate or discard letter combinations. The observation that subjects are aware of the frequency of letter pairs and the likelihood of their occurrence in particular letter positions is not a unique discovery. Similar observations have been recorded by Sargent (1940), Hunter (1959), and Mayzner and Tresselt (1959).

SUMMARY AND CONCLUSIONS

Past research has centered around the variables affecting anagram solution times. Of particular significance to this study are the findings of Mayzner and Tresselt (1958, 1959). They conclude that well-patterned letter groups are more difficult to reorganize than loosely patterned letter groups and that the differences in solution times can be explained by transition probabilities. Since they employed only nonsense anagrams in their investigations, it seemed unwise to Beilin and Horn (1962) to offer such a suggestion without first conducting an experiment in which both nonsense anagrams and word anagrams were presented. They designed an experiment to test this aforementioned hypothesis, in which each subject was asked to solve both forms of anagrams without the aid of paper and pencil, by interchanging only two of the five letters. Having held transition probability, solution-word frequency, and letter order constant, they conclude that the significant differences between solution times for nonsense anagrams and word anagrams is not a function of these three variables, and in particular, transition probability.

The present study followed Beilin and Horn's experimental design with slight modifications in order to test two hypotheses: (1) Solution times are significantly shorter for nonsense anagrams than for word anagrams. (2) Irrespective of anagram form, subjects provided with paper and pencil will have shorter solution times than those who are instructed to solve all the anagrams without the aid of paper and pencil. A fixed-effects analysis of variance of solution times and the number of anagrams solved correctly significantly support Hypothesis 1. There is no evidence to indicate that anagram solution time or the number of anagrams solved correctly is a function of problem-solving methods.

To determine the relationships between intelligence (verbal scores) and the ability to solve anagrams (anagram solution time and the number of anagrams solved correctly) scatter plots and correlation coefficients were computed for each of the four treatment groups. None of the correlation coefficients approached significance. These results are similar to those of Hollingworth (1935, 1938) and Devnich (1937).

A study of the verbal reports of the subjects suggests that (1) subjects initially attempt to solve anagrams by a whole approach and if they are unsuccessful, they use a trial-and-error method, (2) the major source of difficulty in reaching a solution is in the reorganization of letter groups, and (3) subjects are aware of the frequency of letter pairs and the likelihood of their occurrence in particular letter positions. These qualitative results are supported by previous investigations.

Since the traditional anagram problem was modified to the rearrangement of two letters, it is possible that the obtained differences in solution times were an experimental artifact, and that in "reality," solution times are a function of transition probability. Further evidence is needed before the present results can be substantially verified. It was also suggested that various problem-solving methods be studied more closely in an experiment involving anagrams of five letters or more in which all letters must be reorganized.

In conclusion, it is the opinion of this experimenter that the methods and sources of difficulty involved in anagram problem-solving can also be applied to many everyday problems. When faced with a problem there seems to be a natural tendency to try and solve it in much the same manner as the whole approach, and if such a solution is not feasible the individual attempts to gradually solve the situation by any method that is applicable and available (trial-and-error approach). It is suggested that an apparent source of difficulty in resolving everyday problems is the degree of familiarity with the problem. At least for this investigator, the less familiar she is with a problem situation the harder it is to solve it. It follows from this that as the frequency of occurrence of this situation increases, the time spent in seeking a solution decreases. Yet it cannot be concluded that problem-solving, whether it be in an experimental setting or in the process of living, involves just the aforementioned activities and a few others such as set and complexity of the problem. As indicated by the sometimes nebulous results of present experiments, other variables await further investigation.

REFERENCES

Adamson, R. Inhibitory set in problem-solving as related to reinforced learning. J. exp. Psychol., 1959, 58, 280-282.

Ammons, R.B. & Ammons, C.H. A standard anagram task. Psychol. Rep., 1959a, 5, 654-656.

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

Beilin, H. & Horn, R. Transition probability effects in anagram problem solving. J. exp. Psychol., 1962, 63, 514-518.

Devnich, G.E. Words as "Gestalten." J. exp. Psychol., 1937, 20, 297-300.

Dominowski, R.L. Anagram solving as a function of bigram rank and word frequency. Proc. 73rd Ann. Conv. APA, 1965, 87-88.

Hollingworth, H.L. The conditions of verbal configuration. J. exp. Psychol., 1935, 18, 299-306.

Hollingworth, H.L. Verbal Gestalt experiments with children. J. exp. Psychol., 1938, 23, 90-95.

Hunter, I.M.L. The solving of five-letter anagram problems. Brit. J. Psychol., 1959, 50, 193-206.

Johnson, D.M. The psychology of thought and judgment. New York, Harper, 1955.

Maltzman, I. Effects of single and compound classes of anagrams on set solutions. J. exp. Psychol., 1953, 45, 345-350.

Maltzman, I. & Morrisett, L., Jr. Different strengths of set in the solution of anagrams. J. exp. Psychol., 1952, 44, 242-246.

Maltzman, I. & Morrisett, L., Jr. Effects of task instructions on solution of different classes of anagrams. J. exp. Psychol., 1953, 45, 351-354.

Mayzner, M.S. & Tresselt, M.E. Anagram solution times: A function of letter order and word frequency. J. exp. Psychol., 1958, 56, 376-379.

Mayzner, M.S. & Tresselt, M.E. Anagram solution times: A function of transition probabilities. J. Psychol., 1959, 47, 117-125.

Mayzner, M.S. & Tresselt, M.E. Anagram solution times: A function of word transition probabilities. J. exp. Psychol., 1962, 63, 510-513.

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

Mayzner, M.S., Tresselt, M.E. & Helbock, H. An exploratory study of mediational responses in anagram problem solving. J. Psychol., 1964, 57, 263-274.

Mayzner, M.S. & Tresselt, M.E. Solving words as anagrams: An issue re-examined. Psychon. Sci., 1965, 3, 363-364.

Nissenson, M. & Sargent, S.S. Words as configurations. J. exp. Psychol., 1941, 28, 85-89.

Rees, H. & Israel, H. An investigation of the establishment and operation of mental sets. Psychol. Monogr., 1935, 46, No. 6 (Whole No. 210).

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

Ronning, R.R. Anagram solution times: A function of the "ruleout" factor. J. exp. Psychol., 1965, 69, 35-39.

Safren, M.A. Association, sets, and the solution of word problems. J. exp. Psychol., 1962, 64, 40-45.

Sargent, S.S. Thinking processes at various levels of difficulty. Arch. Psychol., N.Y., 1940, No. 249.

Stachnik, T. Transition probability in anagram solution in a group setting. J. Psychol., 1963, 55, 259-261.

Thorndike, E.L. & Lorge, I. The teacher's word book of 30,000 words. New York: Bureau of Publications, Teacher's Coll., Columbia Univer., 1944.

Underwood, B.J. & Schulz, R.W. Meaningfulness and verbal learning. Chicago: Lippincott, 1960.

Webster's New International Dict., 2nd ed., Massachusetts: G. & C. Merriam Co., 1956.

APPENDICES

APPENDIX 1

Raw Scores (Sec.) for Each Subject in Treatment Condition N-O

Subject	Anagram 1	2	3	4	5	6	7	8	9	10
1	12	68	21	7	3	6	1	2	1	1
2	24	4	6	7	4	5	9	17	8	92
3	11	9	3	2	10	9	1	69	50	1
4	5	22	17	4	2	62	1	29	5	4
5	9	28	25	8	120*	120*	2	1	5	24
6	27	24	8	102	120*	2	120*	10	3	2
7	28	12	45	2	1	76	1	11	3	7
8	8	70	34	5	72	6	3	11	3	4
9	20	25	12	5	4	5	1	11	1	1
10	5	5	1	1	13	101	1	7	1	1
11	3	8	4	3	120*	18	1	2	1	2
12	120*	25	16	7	5	14	2	7	2	110
13	6	82	22	1	15	9	1	17	1	1
14	5	18	41	21	2	5	26	120*	22	4
15	17	119	17	12	1	35	11	6	23	95

*Unsolved anagram

Raw Scores (Sec.) for Each Subject in Treatment Condition N-P

Subject	Anagram 1	2	3	4	5	6	7	8	9	10
1	16	48	14	7	4	75	21	15	26	5
2	79	10	3	5	5	4	3	57	18	51
3	23	120*	120*	5	4	10	1	4	7	99
4	26	13	10	13	36	120*	20	12	13	9
5	31	11	120*	2	2	120*	1	120*	120*	10
6	7	38	7	1	2	2	50	120*	3	3
7	17	40	31	6	120*	45	22	8	2	3
8	64	120*	14	4	3	120*	1	5	2	81
9	37	27	120*	4	120*	1	29	24	1	1
10	12	5	6	5	31	10	3	13	2	2
11	10	62	6	12	12	4	17	5	5	5
12	8	110	9	3	1	8	45	10	3	9
13	1	14	15	58	18	7	5	7	5	112
14	1	1	3	2	3	3	11	3	1	1
15	120*	55	9	10	5	5	1	34	2	1

*Unsolved anagram

Raw Scores (Sec.) for Each Subject in Treatment Condition W-O

Subject	Anagram 1	2	3	4	5	6	7	8	9	10
1	26	12	99	120*	87	15	4	120*	5	120*
2	5	5	21	74	120*	7	19	105	8	6
3	2	12	120*	120*	1	6	120*	120*	10	120*
4	1	120*	120*	68	3	3	14	1	2	9
5	120*	21	116	40	4	7	4	29	4	120*
6	5	120*	120*	120*	3	31	10	37	12	28
7	5	4	100	87	2	45	13	9	4	1
8	9	11	18	67	16	85	48	73	17	59
9	10	17	120*	120*	120*	93	33	120*	6	120*
10	16	25	60	120*	120*	82	88	120*	7	98
11	6	15	17	57	26	33	41	59	16	30
12	5	3	25	8	2	13	2	1	10	2
13	3	1	39	101	13	22	81	120*	3	11
14	17	15	16	20	7	25	70	120*	5	120*
15	10	18	120*	120*	3	4	8	7	40	24

*Unsolved anagram

Raw Scores (Sec.) for Each Subject in Treatment Condition W-P

Subject	Anagram 1	2	3	4	5	6	7	8	9	10
1	1	1	1	4	10	3	5	36	5	1
2	5	11	3	114	86	19	40	120*	3	105
3	16	5	67	52	4	8	41	10	2	18
4	8	15	50	120*	120*	27	61	120*	70	32
5	3	3	28	120*	1	8	4	10	37	27
6	14	22	22	120*	1	6	10	9	5	17
7	20	95	42	16	120*	120*	7	44	7	120*
8	6	4	25	84	35	11	15	13	2	5
9	117	10	120*	120*	5	53	3	120*	120*	120*
10	7	5	100	72	3	4	5	2	3	3
11	1	2	3	3	1	4	4	8	9	2
12	2	62	11	120*	1	3	1	108	3	13
13	62	7	26	30	1	6	46	112	6	6
14	4	2	10	74	27	120*	91	9	1	16
15	8	5	21	66	6	2	103	5	2	2

*Unsolved anagram

APPENDIX 2

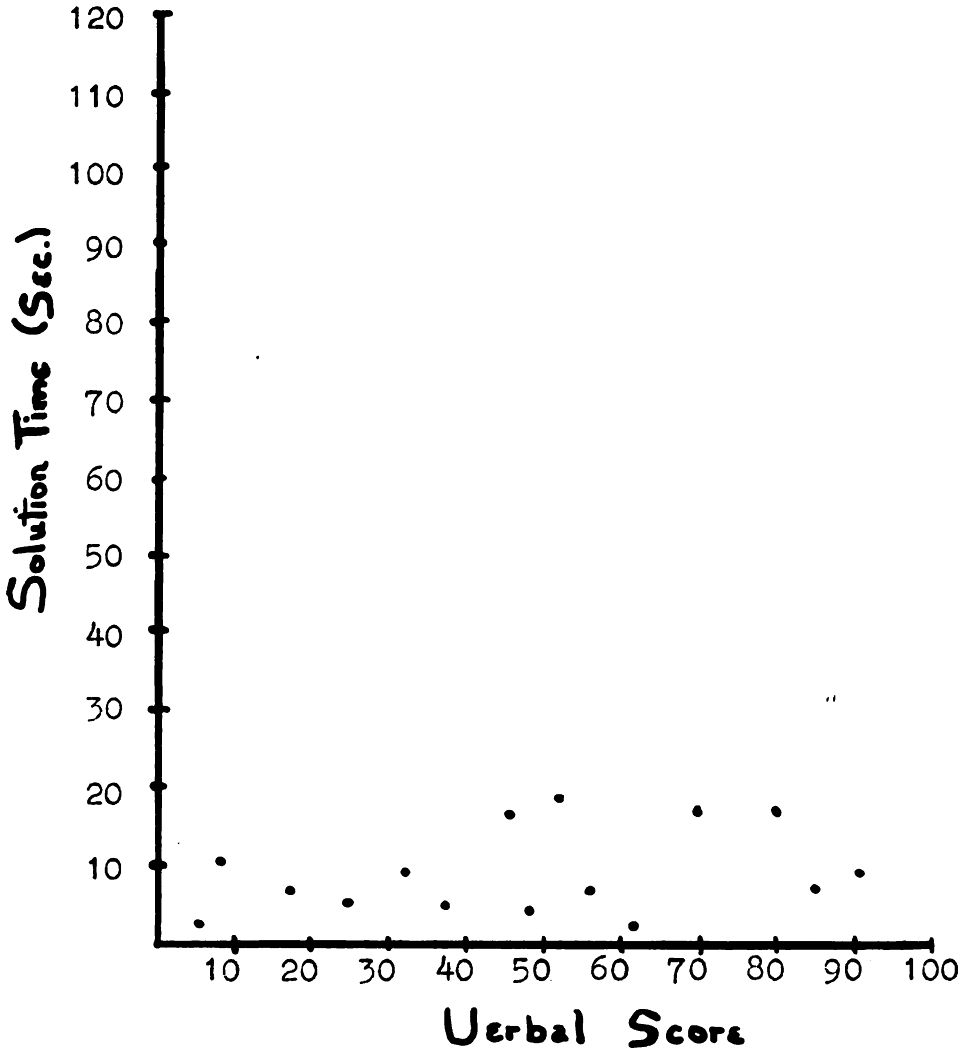

Fig. 1. The relationship between verbal score and solution time for the treatment condition N-O.

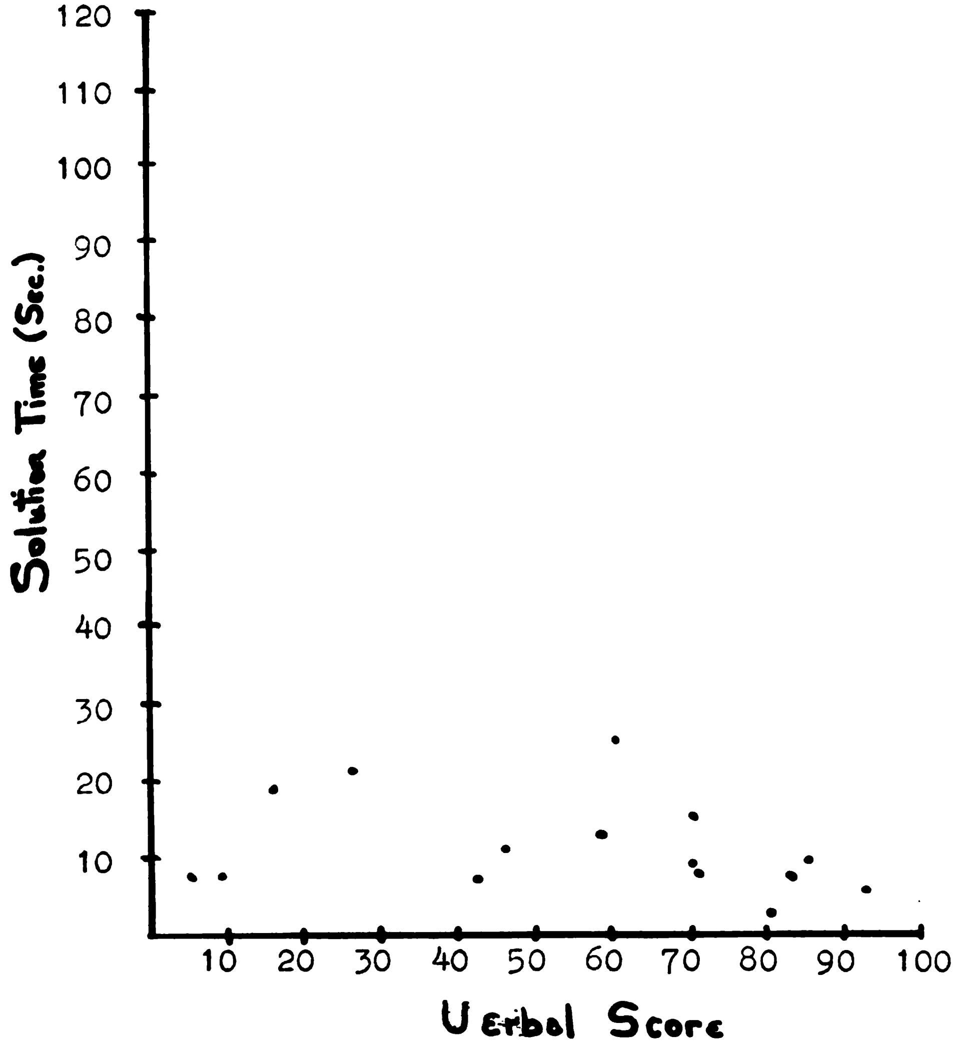

Fig. 2. The relationship between verbal score and solution time for the treatment condition N-P.

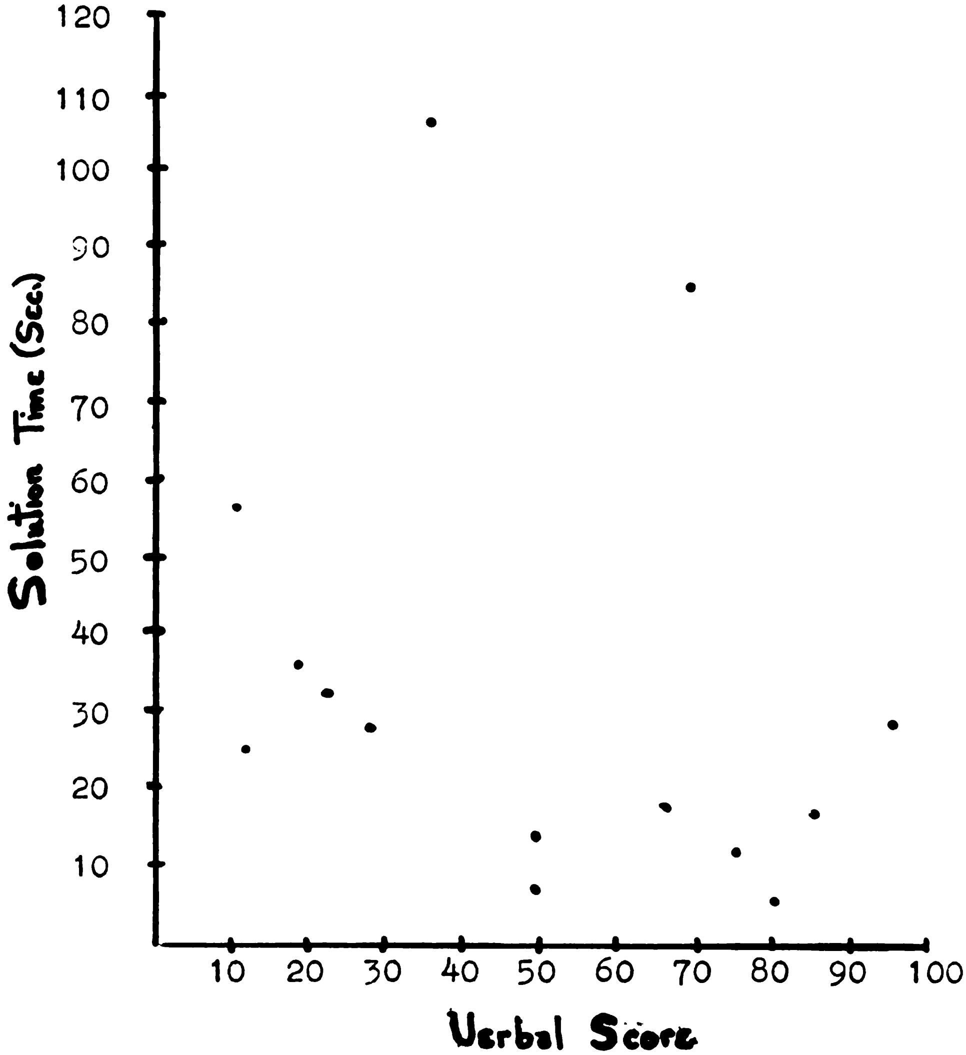

Fig. 3. The relationship between verbal score and solution time for the treatment condition W-0.

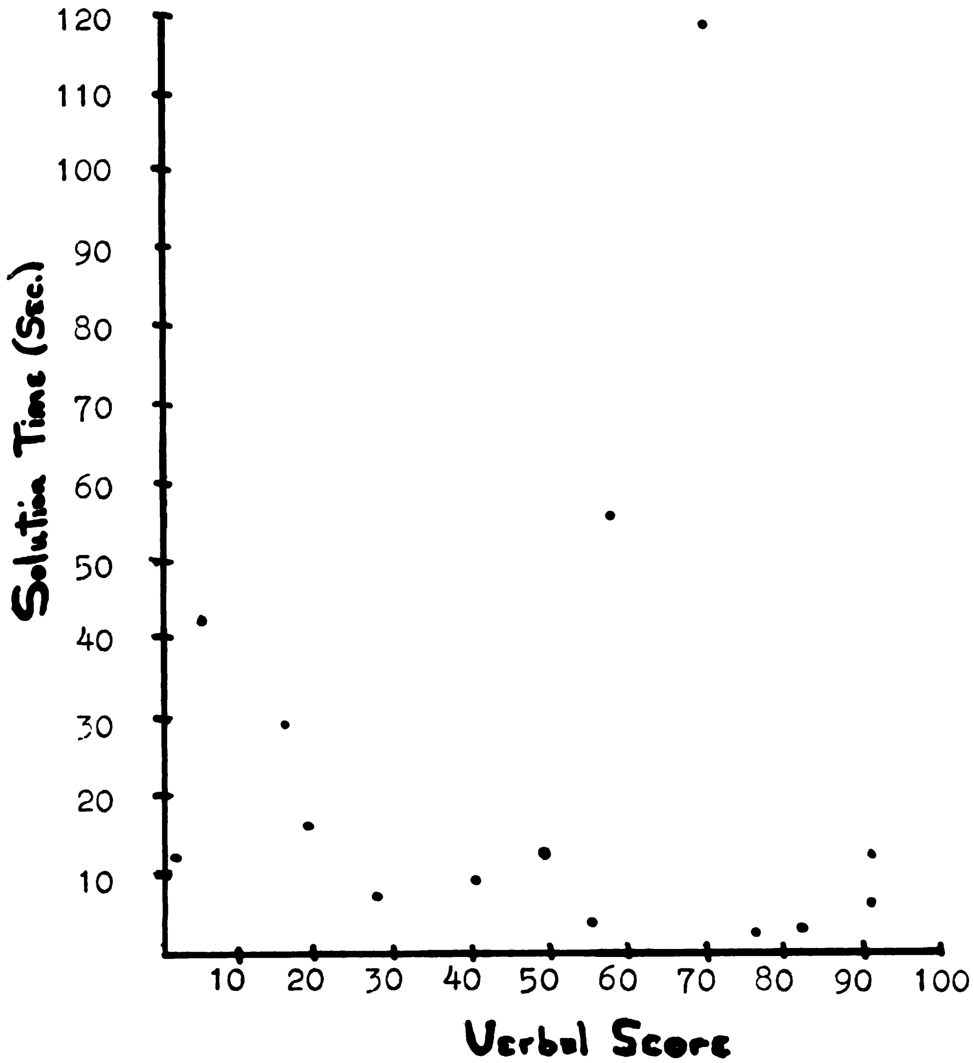

Fig. 4. The relationship between verbal score and solution time for the treatment condition W-P.

APPENDIX 3

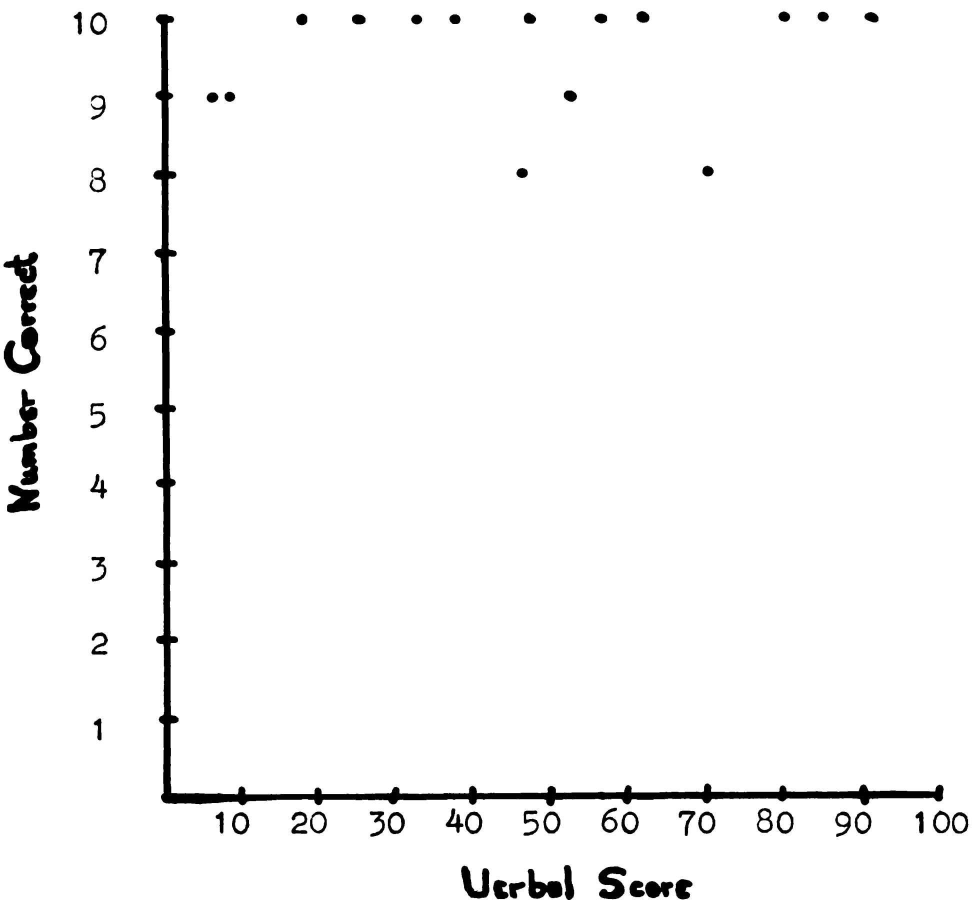

Fig. 1. The relationship between verbal score and number of anagrams solved correctly for the treatment condition N-O.

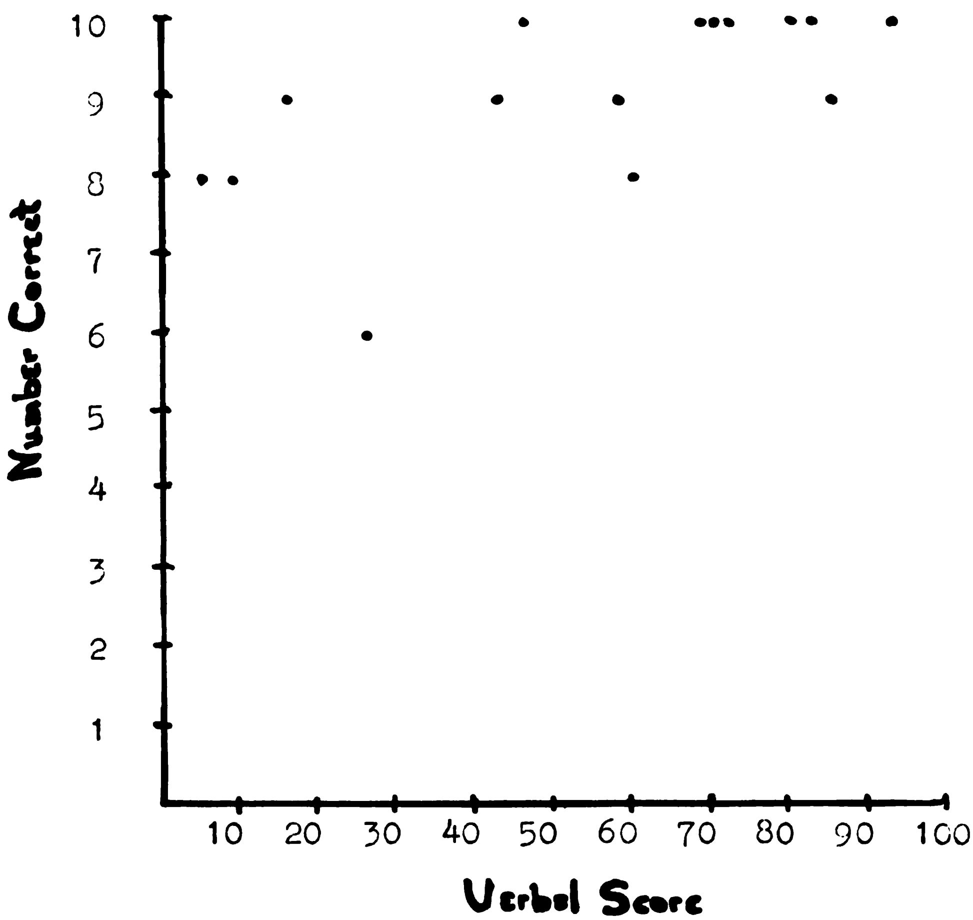

Fig. 2. The relationship between verbal score and number of anagrams solved correctly for the treatment condition N-P.

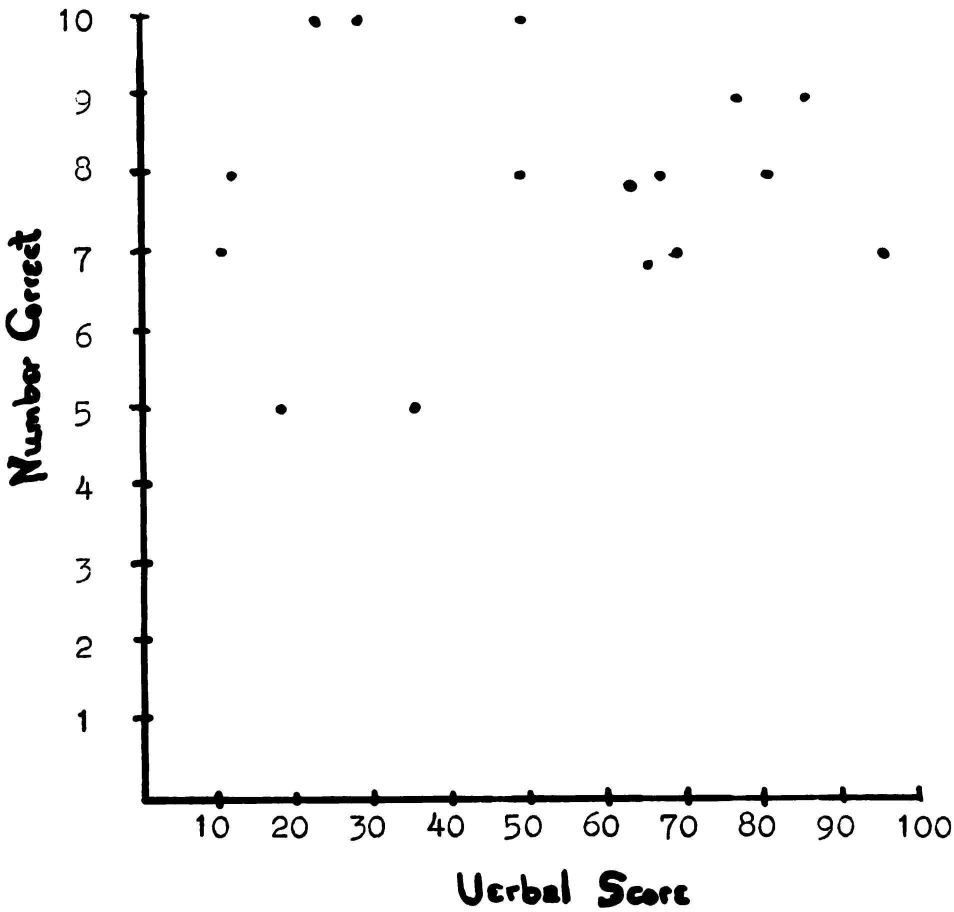

Fig. 3. The relationship between verbal score and number of anagrams solved correctly for the treatment condition W-0.

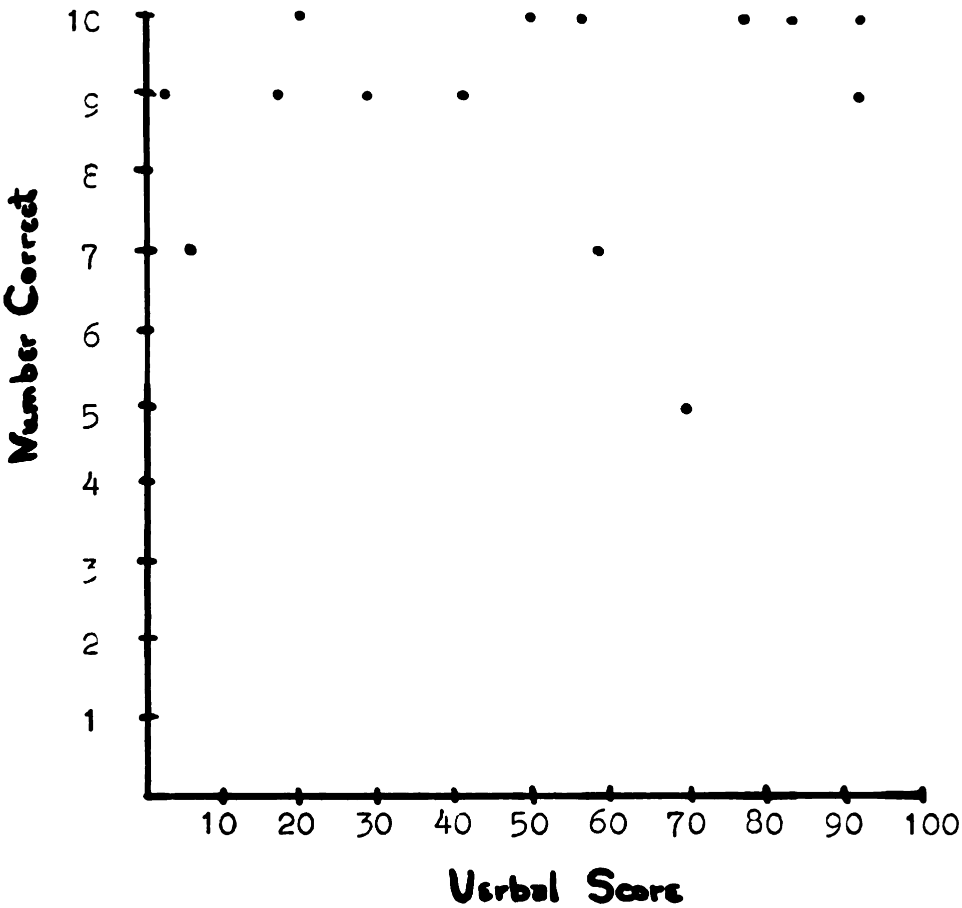

Fig. 4. The relationship between verbal score and number of anagrams solved correctly for the treatment condition W-P.