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INHIBITORY EFFECTS OF POSITIVE
TRANSFER IN PROBLEM SOLVING

Thesis for the Degree of M. A.
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Bradley August Bremer
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INHIBITORY EFFECTS ON POSITIVE
TRANSFER IN PROBLEM SOLVING

By

Bradley August Bremer

AN ABSTRACT OF A THESIS

Submitted to
Michigan State University
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Ronald M. Johnson

ABSTRACT

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By Bradley August Bremer

This study was designed to investigate the effects of prior exposure to anagram solution words on subsequent anagram solving performance. An increment in performance, due to positive transfer, was proposed. This increment, however, was hypothesized to be subject to two inhibitory factors. One of these factors was verbal embedding. This concept was generalized from the embedding of geometric figures. A word was considered to be embedded if responded to as a part of a meaningful whole, non-embedded if responded to in isolation. The second inhibitory factor proposed was an increase in the amount of material in which the solution appeared.

Two tasks were presented to five groups of college students. In the first task anagram solution words were presented to four of the five groups, with the presence of embedding and amount of material in different combinations. The first group received non-embedded words; in the second the words were embedded, while the amount of material remained constant; in the third the amount of material was increased without embedding the words; and the fourth received words embedded in an increased amount of material.

Bradley August Bremer

The fifth group, the control group, was not exposed to the solution words. Task II provided the independent variable. It consisted of fifty anagram problems. Performance on this task was hypothesized to vary with the variation of exposure in Task I.

Mean performance scores between similar groups with and without exposure to the solution words were significantly different, supporting the transfer hypothesis. The differences between all other groups were in the predicted direction, but were not statistically significant. The group which combined both inhibitory effects fell below the groups with only one. Both of these groups fell below the group with neither.

A second experiment was designed as a more direct test of embedding. It determined the ability to recognize words previously exposed under embedded and non-embedded conditions. It was hypothesized that fewer embedded words would be identified as having been seen in the prior exposure.

The results of the recognition test supported the hypothesis. Fewer words were recognized by the group exposed to the words under embedded conditions than non-embedded. The presence of the embedding effect was verified, but was not considered strong enough to influence the complex anagram solving task.

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INTRODUCTION

Duncan (4), in a review of the literature, attempts to classify all studies of problem solving on a methodological basis. He organizes most of the studies into three major classes which are defined in terms of the independent variables used to influence problem-solving performance. The independent variable may be introduced (a) prior to testing, (b) in the problem itself, and (c) in the characteristics of the subjects used.

The present study falls into the first of these three general classes. In Duncan's words, this is "essentially a training and transfer design" and methodologically the "independent variables were introduced prior to testing on the final task, which task was the same for, and presented under constant conditions to all subjects." A further possible breakdown, within this category, dichotomizes the relevant literature into a group of studies in which prior experience is detrimental to problem solving (negative transfer), and a second group in which prior experience aids problem solving (positive transfer).

The greater portion of the research on the positive effects of prior experience has been concerned with the transfer of problem-solving method or technique from one problem situation to another. In this type of study, the

previous experience usually consists of solving problems similar to the test problem or being given information on "how to solve problems."

Experiments designed to investigate the effects of prior exposure to the problem solution or solution-related materials are less common. Judson, Cofer, and Gelfand (8) show the value of previous exposure to solution-related cues. Their subjects learned five-word lists which included words relevant to solution of the problem, which was presented later. For example, the words rope, swing, and pendulum were learned before attempting the two-string problem; and prop, ceiling, and floor before the Maier hat rack problem. Although they found a general tendency for the group that learned all three key words to be better at solving the subsequent problem than other experimental and control groups, not all differences were statistically significant and their findings were limited to men. Koler (10) found some evidence that subliminal presentation of cues just before presentation of the problem aided solution.

Lorge and Solomon (12) investigated the relationship of prior exposure to the solution of the complex "Tartaglia transportation problem." The problem was shown to the subjects and they were asked a series of six questions about their previous experience with it. These questions included: Have you seen this problem before? Have you attempted to solve it before? Have you solved it before? They report

that "there does not appear to be a definite relation between prior exposure and successful solution," but add that "there may be a slight tendency that individuals with much prior exposure do somewhat better."

Using anagram problems Wiggins (19) produced more significant results. His subjects were given seven minutes to solve 100 anagrams. Included in the series were forty two-solution anagrams, each of which had one frequently given solution, and one infrequently given solution. Following this task, each of his two groups of subjects were given a list of twenty words composed of the infrequently given anagram solutions. Their instructions were as follows: "Here is a list of words which are solutions to the anagrams. Memorize them the best you can in the next three minutes. I want to see if they will help improve your score on the next trial on the anagram list." Following memorization of the infrequently given solutions all subjects were again given seven minutes to solve the same list of 100 anagrams. The results were summarized as follows: "The clues to the infrequent solution effectively increase the number of shifts from frequent to infrequent responses for both groups."

The present study is also designed to investigate the effects of exposure to correct responses or solution words on subsequent solving of anagram problems. An increment in the number of anagram solutions following experience with the correct response is proposed. This, then, is a study of positive transfer in problem solving.

If the transfer effect exists, a number of questions follow. What are the optimal conditions for such transfer? What variables facilitate transfer? What variables inhibit transfer? Such variables might be in the prior exposure of solution, in the presentation of the problem to be facilitated, or in the time, activity, etc. between prior exposure and problem. This suggests a large number of such factors. Only two will be investigated here. Both involve the prior exposure and are hypothesized to inhibit transfer.

The first such factor is verbal embedding. This concept is generalized from the embedding of geometric figures in larger figures, following the work of Gottschaldt (5). In this study Gottschaldt was trying to determine what factors influenced the perception of a smaller "A" figure in a larger "B" figure. He specified that "These forces are determined by the intrinsic properties of the stimulus object." Within the Gestalt framework, he explained that "A" figures were not seen in "B" figures because they "were psychologically not present in them at all." The "A" figure then, is changed or altered and is not the same when put in a certain "B" figure. Such "B" figures Gottschaldt described as having "figural cohesion" or "internal unity." He goes on to list factors contributing to this unity, such as changing boundary functions, surface characteristics, etc.

The proposed generalization involves words and meaningful sequences of words. A word is a verbal counterpart of an "A" figure and a sequence of words of a "B" figure. The

perception of a word should be altered by its relationship to a sequence of words, of which it is a part, if the generalization holds. The sequence gets its cohesion through its meaning and the word has its meaning only as it contributes to the sequence. The word is not the same out of sequence, just as Gottschaldt's "A" figure is not the same when taken out of the "B" figure. The reason Gottschaldt said the "A" figures were not seen was that they were not "psychologically" present in the "B" figures. In like manner when a sequence of words is responded to, a component word is not psychologically perceived as a word, as an isolated item, but only as a part of a whole. It is the whole that is responded to.

Verbal embeddedness, then, refers to a part-whole relationship. If the word we are concerned with is treated as a whole, i.e., is perceived as being a complete unit itself, the word is not embedded. If on the other hand, the word is treated as a mere part of a sequence of words, the word is embedded. We have then, proposed to define a word as being embedded if it is included in a meaningful sequence of words. If the generalization from geometric to verbal material holds, the whole will dominate the part and the individual word will not be as readily perceived when in a sequence.

An increase in the amount of material exposed is the second factor proposed to inhibit transfer. The material to be added is irrelevant to the problem solution. In this

way the amount of problem aiding information is held constant, while the total amount may vary. Similar increases have been demonstrated to increase the difficulty of a number of problem solving situations. For example, using information theory techniques, Archer, Bourne, and Brown (2) and Walker and Bourne (18) have shown that performance in concept identification was reduced by increasing the amount of irrelevant information in the stimulus situation. Johnson and Hall (7) varied the ratio of relevant to irrelevant material to be organized in the process of solving a problem and found "most of the variance was due to the proportion of irrelevant words to all words." As a final example, Shaw (16) varied the amount of irrelevant information in a small group as they tried to solve problems. Groups given irrelevant information took significantly longer to solve the problems than groups that were not. It is hypothesized that an increase of irrelevant information, and thereby total amount of material, in the prior exposure will have a like effect, in the present study. It will decrease the amount of transfer to the anagram problem. The three hypotheses to be tested are presented below:

HYPOTHESIS I: Previous exposure to solution words will increase the incidence of correct responses to anagram problems.

HYPOTHESIS II: The amount of increase will be reduced if the solution words are embedded, by including them in a

meaningful sequence of words, in the prior exposure.

HYPOTHESIS III: The amount of increase will be reduced, by an increase in the amount of material presented in the prior exposure.

EXPERIMENT I

Subjects:

Subjects for the study were members of five sections of the introductory psychology course at Michigan State University. The experiment was conducted during regular class periods. A total of 224 subjects took part in the experiment. They were divided into five groups. In order to have an equal number of subjects in each group, data from nine subjects were eliminated, by a random procedure, leaving five groups of forty-three subjects each.

Four of the five groups were distributed equally within four class sections. This was done by presenting the material for each group to every fourth person in each row. This procedure was used to randomize effects of previous classroom experience, etc. The remaining group was run later in another section, but was treated identically in all other respects. This group was added after the others had been run to strengthen the design of the experiment. Specifically, it provided a more direct test of Hypothesis III. This group has been designated as Group III. It was analyzed with the other four.

Design and Materials:

According to Schultz (17) transfer is defined operationally by Table 1.

Table 1.--Basic transfer design in problem solving.

	Task A	Task B
Experimental group	X	X
Control group		X

Within this basic operational paradigm of transfer, the second task, or Task B, always consists of the problem situation. "Transfer is said to have occurred when there is a reliable difference between the experimental and control group performance on Task B."

The design used in the present study was basically an expansion of the above paradigm. The expansion consisted of using five experimental groups, rather than one. For each group, the design involved the administration of two separate tasks to each subject. Essentially the purpose of the first task was to expose the subjects in the experimental groups to anagram solution words, and the purpose of the second task was to determine the effects of this exposure on the solving of anagrams.

Task I introduced the independent variable by varying the exposure to solution words for each of the five groups used. Each was given a different list of items which they were asked to evaluate affectively on a five point rating scale, ranging from very pleasant to very unpleasant. For Groups I, II, III, and IV, this list of items included the solution words. The amount of material and presence of embedding varied from group to group. The items given to

Group V did not include any of the solution words, and thereby provided a non-exposure or control group.

The list of items given Group I consisted of fifty single word items. Thirty of these fifty words were solution words to the anagram problems given in Task II. These same words also appeared in the list of items given to Groups II, III and IV and have been designated as "critical words." The other twenty words were not used again and have been referred to as "non-critical words." The critical words given in Group I were non-embedded, i.e., each critical word was responded to by itself, as a unit, and was not responded to as a part of a larger sequence of words.

Group II also received a task involving a total of fifty words, thirty critical and twenty non-critical. In this task, however, the words were embedded. The subjects were asked to evaluate ten phrases of five words each containing the critical words. Thus the total number of words remained the same as for Group I, while the number of responses made was reduced, as the response was made to the meaningful sequence of words rather than each word separately.

While the task of Group II represented embedding without an increase in amount of material, Group III received material in which there was no embedding, but an increase of material. The amount of material was three times as great as for Group I. There were 150 words, each responded to in isolation.

Group IV received material in which the critical words were embedded in ten 15-word sentences. This made a total of 150 words, thirty critical and 120 non-critical. This task combined the effects of embedding and increasing the amount of material.

The final group, Group V, served as a control group and was not exposed to the critical words. The task was similar to that given Group I with a list of fifty single-word items, each to be responded to separately. The only difference between the two was that the task given to Group I contains thirty critical words, while all fifty words given to Group IV were non-critical.

Task II consisted of fifty anagram problems. The purpose of this task was to determine what effect the previous exposure to anagram solution words had on the ability to solve anagrams. The same series of anagrams was presented to all subjects, in all groups. It thus provided a basis of comparison for the different types of exposure, i.e., the dependent variable.

All fifty anagrams used were selected as "one solution" anagrams from studies reported by other workers: Rees and Israel (14); Keehn (9); Mayzner and Tresselt (13); and Sargent (15).^{*} Thirty of these anagrams have as solutions words presented to Groups I, II, III, and IV in Task I.

^{*}Only one anagram used was found to have more than one solution. One subject produced "wheal" instead of "whale."

These thirty anagrams have been called "critical anagrams." The remaining twenty anagrams have been referred to as "non-critical" as they were unrelated to Task I. A complete list of all critical and non-critical anagrams used can be found in Table 2 on page 13. Appendix II consists of a complete set of printed materials for both tasks as used in the experiment.

Instructions and Procedure:

The subjects assembled for a regular class session and were unaware, in advance, that an experiment was to be conducted during the class period. The experiment was announced at the beginning of the hour and the subjects were asked to remove all books, etc. from their desks, retaining only pencils.

Instructions were given for both Task I and Task II before either task was presented. Instructions for Task I consisted of presenting a five-point rating scale to be applied to each item of that task. The scale called for a rating of +2 for items found very pleasant, +1 for pleasant, 0 for neutral, -1 unpleasant, and -2 very unpleasant. Five minutes were allowed for Task I.

Instructions for Task II briefly described an anagram problem, then gave an example and rules to follow in solving the anagrams. Twenty-five minutes were allowed for Task II. Complete instructions can be found in Appendix I.

Table 2.--Anagrams and solutions used in Task II.

Critical					
TIFUR - fruit	RACGI - cigar	CIBKR - brick			
EIVRR - river	GORMINN - morning	TOPLIE - polite			
DENRU - under	KURCT - truck	POCYNAM - company			
WEHTI - white	NORFIGE - foreign	LAEHW - whale			
CABEH - beach	WBORN - brown	TARPY - party			
DCHLI - child	SRGAS - grass	NUROD - round			
NEGRE - green	RASGU - sugar	SHUEO - house			
LUPCIB - public	MOSTR - storm	NATIG - giant			
WERAT - water	TEMYP - empty	NEESC - scene			
DACYN - candy	AAVGSE - savage	TNRSGO - strong			
Non-Critical					
NUHCL - lunch	OEWLT - towel	RAFSC - scarf			
YEMNO - money	TOCUR - court	RCMAE - cream			
PHSEE - sheep	LACTEMI - climate	IEAGM - image			
DEUGJ - judge	QLDIIU - liquid	WPAMS - swamp			
NELUC - uncle	MINLAA - animal	CCKOL - clock			
SEDRS - dress	OEZND - dozen	IETGWH - weight			
NIRAT - train		EATLHH - health			

Table 3.--Summary of experimental design for Experiment I.

Experimental Group	Task I	Task II
I	50 words--consisting of 50 single-word items; 30 critical and 20 non-critical.	Same for all five groups: 50 anagrams, of which 30 are critical (presented in Task I for Groups I, II, III, and IV) and 20 are non-critical (no previous experience for any group).
II	50 words--consisting of 10 five-word phrases; 30 critical and 20 non-critical words.	
III	150 words--consisting of 150 single-word items; 30 critical and 120 non-critical.	
IV	150 words--consisting of 10 fifteen-word sentences; 30 critical and 120 non-critical words.	
V	50 words--consisting of 50 single-word items; all 50 words are non-critical.	

The instructions were briefly reviewed and an opportunity for questions allowed. All questions were answered by repeating or paraphrasing the instructions. After questions were answered, Task I was distributed face down and turned over as a group. Five minutes were allowed for Groups I, II, IV and V. The larger number of responses to be made by Group III necessitated additional time. For this group ten minutes were given. All subjects in all groups completed Task I in the time allotted. After Task I was retrieved, Task II was distributed by the procedure used for Task I. After twenty-five minutes, Task II was collected and the group was dismissed.

Results:

Prior to statistical analysis, a performance score was determined for every subject used in the experiment. This score was produced in the following manner. For each subject, the number of non-critical anagrams solved correctly was subtracted from the number of correct critical anagram solutions. A constant of five was added to the resulting difference. The reason for these two steps follows.

The subtraction of the number of non-critical anagrams solved was an attempt to eliminate effects of individual differences in anagram solving ability, i.e., sampling error. If the number of critical anagrams solved was the

sole criterion of performance, an accidental incidence of either unusually poor or proficient anagram solvers in any particular group would have had an undesirable bias on the group. By using the number of non-critical anagrams solved as an indication of anagram solving ability, much of the difference in ability can be "subtracted out" of that criterion. The resulting score emphasizes the effects of prior exposure to the anagram solution words, which is the variable of interest. The same non-critical anagrams were given to all subjects, in all groups, thus providing an equal standard, or reference score, for all subjects.

The appropriateness of this standard, i.e., the number of non-critical solutions, as an indication of individual adeptness at solving anagrams in this experiment is supported by the data in Table 4.

Table 4.--Coefficients of correlation
between number of critical and non-
critical anagrams solved.

Group	
I	.64
II	.80
III	.86
IV	.83
V	.94
All Groups Combined	.76

In this table coefficients are recorded for correlations between number of critical and non-critical anagram solutions. Separate coefficients are given for subjects within each group. In addition, a correlation coefficient for all

subjects, disregarding groups, is recorded. Of special interest here is the correlation coefficient for Group V. This group, the control group, had no prior exposure to the solution words. The high correlation coefficient of .94 indicates that the number of non-critical anagrams solved is highly related to the number of critical solutions when there is no transfer involved. This relationship demonstrates the appropriateness of the number of non-critical solutions as an index of individual differences in anagram solving ability in this experiment. As shown by Table 4 above, the correlation between number of critical and non-critical solution words is lower for Group I than the other experimental groups, all of which are lower than the control group.

The second step in obtaining the performance score involved adding a constant of five to the difference obtained from the subtraction discussed above. The purpose of adding the constant was to eliminate negative numbers, and thus facilitate further calculation.

An analysis of variance was performed on the performance scores as an over-all test of differences between means of the groups. Table 5 summarizes this analysis of variance. An F-ratio of 5.55 was obtained, which is significant at the .01 level, with degrees of freedom of 4 and 210 for numerator and denominator respectively. The significant F-ratio indicates that the means for all groups were not

Table 5.--Analysis of variance of performance scores.

Source of Variance	d.f.	Sum of Squares	Mean Squares	F
Between groups	4	247.46	61.87	5.55 ($p < .01$)
Within groups	210	2340.75	11.15	
Total	214	2588.21		

equal. From this we can conclude that the various prior exposures to anagram solution words have resulted in different levels of anagram-solving performances.

In order to evaluate the data in respect to homogeneity of variance, variances were calculated for each group.

These are recorded in Table 6.

Table 6.--Means and variances of performance scores for each group.

Group	Mean	Variance
I	10.44	14.9
II	10.00	12.1
III	10.09	12.3
IV	8.51	8.7
V	7.65	7.8

Although there appear to be definite and systematic differences in variance between groups, an F-max. test for heterogeneity is not significant at the .01 level. Also, the analysis of variance is extremely insensitive to heterogeneity of variance when all N's are equal and large, as is the case in the present design (11). Thus the assumption of homogeneity of variance appears to be adequately met.

The significant F-ratio obtained from the analysis of variance indicates non-specific differences among means of the five groups. Of more interest in testing the hypotheses submitted are the individual comparisons possible between the groups. Table 6 lists the mean scores for each of the five groups. Table 7 consists of differences between mean scores for every possible comparison.

Table 7.--Individual comparisons of differences between means.

Group	I	II	III	IV	V
I		.44	.35	1.93	*2.79
II			.09	1.49	*2.35
III				1.58	*2.44
IV					.86
V					

*Significant at $p < .05$ by means of Q-test (1, 2).

Since all comparisons have meaning in this study, the multiple comparison Q test, using the "Studentized Range," as described by Dixon and Massey (1, 3) was employed. The least significant difference between means was calculated at the .05 level and all differences which exceed it have been marked with an asterisk in the table to indicate significance.

The order of mean scores is as would be predicted from the three hypotheses. Group I included all 30 critical words in Task I, none of which were embedded. As expected, this resulted in the greatest transfer to Task II and thus the highest mean score.

Mean performance scores for Groups II and III were both slightly lower than for Group I, indicating a possible reduction in amount of transfer. Group II represented an "embedding only" group, as the amount of material was held constant. This comparison with Group I is in agreement with Hypothesis II. Group III had an increase in material, but the critical words were not embedded. The lower mean performance score follows Hypothesis III.

Group IV fell below all other experimental groups in mean performance scores, but was higher than the control group. This group represented a combination of the two inhibitory factors, i.e., embedding and increase in amount of material. This combination retarded transfer more than either taken separately, but did not eliminate transfer completely.

Finally, Hypothesis I is supported as Group V, which included only non-critical words in Task I, fell below all other groups. The exclusion of critical words eliminated all transfer. In comparison all other groups contained the critical words, embedded or non-embedded, and with larger or smaller amounts of material. All these groups involved some transfer, which resulted in higher mean scores for all four groups.

Although the scores fell in the predicted order and direction, most of the differences between groups were not statistically significant. The smallest significant

difference between mean scores of the groups, as determined by the Q-test, is 1.96. As shown on Table 7 above, the difference between Groups I and II is not of this magnitude. Thus Hypothesis II which predicted inhibitory effects due to embedding is not supported by significant results. The difference was in the predicted direction, but too slight to meet the statistical standard.

Hypothesis III received the same degree of support as Hypothesis II. Although the direction was as predicted, the difference was too slight to reach statistical significance.

Group IV combined the inhibitory effects of embedding, as proposed in Hypothesis II, and increasing the amount of material as proposed in Hypothesis III. These combined effects produced a difference, in mean performance score, as compared to Group I, of 1.93. This is extremely close to the required 1.96 needed for statistical significance. It is interesting to note that a standard t-test for differences between two means would have produced significance, while the more conservative Q-test used does not.

The only hypothesis to receive strong support was Hypothesis I. The significant difference between Groups I and V is as would have been predicted. Differences between Group V and Groups II and III are also significant. The transfer from prior exposure to anagram solution words was effective, with or without the inhibitory effects of either

embedding or increasing the amount of material, taken separately.

EXPERIMENT II

In Experiment I, the critical words were considered embedded, by definition, if they were included in a meaningful sequence of words. The derivation of the definition consisted of a generalization from the embedding of geometric forms. The adequacy of this generalization may be questioned. The purpose of the following experiment was to provide a more direct test of embedding. This was done to illustrate the appropriateness of the generalization, and therefore the terminology and materials used.

A recognition test is presented here as a more direct test of embedding. That perception is personal and cannot be directly observed in another is unquestioned. It is necessary to ask the individual, or get him to indicate in some other way, what he has perceived. A recognition test simply asks the subject to indicate which words in a larger list of words he has perceived.

It is proposed that words presented in isolation will be more frequently recognized than words presented in a meaningful sequence of words.

Subjects;

A total of 59 subjects participated in the experiment. They were divided into two groups, one of 29 and one of 30. The subjects were members of two introductory psychology

classes at Michigan State University. The groups were evenly distributed in both class sections. Each group was composed of every other student according to the classroom seating arrangement.

Design and Materials:

The design involved the presentation of the same critical words used in the first task of Experiment I under embedded and non-embedded conditions. This was followed by a recognition test which provided an independent evaluation of the impact of that exposure.

One group, designated as Group VI, received the same material as Group I, in Experiment I, i.e., fifty single-word items, thirty of which were critical and twenty non-critical. These words were not considered to be embedded as each was responded to in isolation.

The same materials which had been presented to Group II in Experiment I were given to the other group, Group VII. This consisted of fifty words in the form of ten five-word phrases. Each phrase, not individual words, was responded to as a unit, so the words were considered to be embedded in the sequence of words, according to our definition. The fifty words contained the same thirty critical words, plus twenty non-critical.

In the second phase of the experiment, all subjects were given a list of one hundred words, in four typewritten columns, on a single sheet of paper. Thirty of these words

were the same critical words which had appeared on the previous material given to both Group VI and Group VII. These thirty words were randomly dispersed among seventy new words, to which the subjects had not been previously exposed. The form can be found in Appendix II.

The experiment was designed to determine if the difference in material, i.e., whether the words were embedded or non-embedded, influenced the ability of the subjects to recognize those words in the 100-word list.

Instructions and Procedure:

The groups were run during a regularly scheduled class period. The subjects were informed that they were participating in an experiment before any instructions were given.

Both groups received identical instructions. The same five-point rating scale that was used in Experiment I was presented, with instructions to apply it to each item. Five minutes were allowed for the task, after which the papers were collected.

All subjects were then given the list of 100 words. They were told that the list contained some of the same words that had appeared on the task which they had just completed, but were not told how many such words there were. The subjects were instructed to circle all those words which were common to both sets of material. No time limit was imposed, and all papers were collected when everyone had finished.

Results:

The mean number of words recognized by subjects in Group I, the single-word group, was 26.41. In Group II, which was given phrases in the first task, a mean number of 22.27 words was recognized by each subject. There was heterogeneity of variance between groups. The appropriate t-test for differences between means was significant at the .01 level. Information on the statistical analysis is given in Table 8.

Table 8.--Significance test for difference between means in recognition test.

Group	Variances	Means	t
VI	14.14	22.27	5.3
VII	3.96	26.41	(p < .01)

The mean number of errors made, i.e., words circled that did not actually appear on the first task, was 2.5 for Group I and 2.2 for Group II. This difference is not statistically significant.

DISCUSSION

The results indicate that previous experience with a problem solution facilitates problem solving. More specifically, when exposure to anagram solution words preceded anagram problems, performance was improved. Speaking in terms of the experiment, for the experimental groups, participation in Task I improved performance in Task II. We have referred to this as transfer from Task I to Task II. At what stage of the problem solving process does the facilitation take place, and what happens?

In an attempt to answer these questions, we will subject this study to the problem solving analysis of Johnson (6). His three-phase analysis of problem solving is comprised of preparation, production, and judgment processes. In the problem solving task of this experiment, preparation consisted of understanding the instructions when faced with the anagram problems. Judgment was relatively easy, as the subjects had only to identify, as a word, any produced arrangement of letters. It is the production process, i.e., the turning out of possible solutions, that is of most interest. It is proposed that the superior performance of the groups with previous exposure to the anagram solution words originates in this phase. Apparently the prior exposure to the critical words made those words more available for production. The subject, as he attempts to solve the anagram,

uses whatever cues are available and produces as many possible solutions as are suggested by the letters before him. The recent exposure to the solution word, in some way, increases the probability of producing that word.

This positive transfer, from the previous exposure to the solution words, to the problem-solving task supports the findings of Wiggins (19). One notable difference between his study and the present one should be considered, however. Wiggins' subjects were told that they were to be shown the solution words, and that they would be asked to solve anagrams later. In this study the subjects were not aware of the relationship of the words in the prior exposure to the anagram-solving task while being exposed to the solutions. The exposure to the solution of the problem transferred to the problem-solving task even though the subjects were not aware that the words seen in Task I were solutions to anagrams in Task II, when exposed to them.

In Experiment I embedding was hypothesized to inhibit transfer. The results indicate that this inhibitory effect was, at the most, very slight. Experiment II, however, indicates that significantly fewer words were recognized, as having been seen, when the words were embedded during the prior exposure. This supports the idea that putting the word in a meaningful sequence does limit the perception of the single word. When the whole phrase is responded to as a unit, the single word is lost in the meaning of the whole

phrase. The generalization from geometric forms apparently holds, and a word is not perceived as readily when it is a mere part of a dominant whole.

The recognition test was an attempt to provide a more direct test of the verbal embedding effects. There is a time span between the first exposure of the words, in the rating task, and the attempt at recognition. This brings in a question of the memory factor. However, the time span was relatively short, about ten or fifteen minutes. Also it seems unlikely that the words in the sequence were forgotten more quickly than those in isolation, assuming equal perception for both. The evidence seems to indicate that the words defined as embedded were not as readily perceived.

If the words were not as readily perceived, why didn't embedding inhibit transfer? A possible answer lies in the complexity and difficulty of the anagram task. Presumably a great number of factors influence anagram solution. It is quite possible that embedding would be but a minor factor contributing to performance. As such, it was not possible to show great differences between groups on a test of thirty answers. Perhaps embedding had a strong enough effect to influence the recognition test, but not strong enough to significantly change the more complex problem solving task.

At first glance the finding of the effects of verbal embedding, in the recognition test, seems to run contrary to the idea that meaningful material is easier to acquire.

This is a principle which has been frequently demonstrated. The difference in the present finding is that we are considering the part only. We have removed it from the meaningful whole, the whole in which the word had its meaning, as a contributor. We have not really asked the subject to recognize what he "picked up." He presumably perceived the meaning of the whole phrase. We asked him to recognize something else. This type of part-whole relationship should be studied further.

Increasing the amount of material in which the critical word was presented also produced a very small inhibitory effect. An explanation similar to that given for embedding seems feasible. That is, the complex anagram task involves so many factors that the effect was not strong enough to produce significant change. It is also possible that the increase of material simply was not great enough.

The argument that both inhibitory effects were present, but not strong enough to significantly influence the complex anagram task, gains strength from the near significance obtained when both factors were presented in the same task. The mean performance score for Group IV, representing the combined effects, is actually closer to that of the control group than it is to any of the other experimental groups. This indicates that the transfer effect was almost completely eliminated. The influence of each individual factor was slight. Together they had a considerable inhibitory effect on the ability to solve the anagram problem.

Two explanations of the combined effect are possible. One, the factors are simply additive. Two, there are interaction effects from the combination. The combined effect was more than twice as large as the summed effects of the factors taken separately. This provides a rough indication that they were not simply additive. However, there is insufficient evidence to provide conclusive support for either premise.

A possible limitation of the design centers around variation in total number of responses made. More specifically, Groups I and V made a total of fifty responses to the material in Task I, Group III made 150, while Groups II and IV made only 10. This difference in number of responses can be considered as an uncontrolled variable which might have influenced performance in Task II.

This variation, however, can also be viewed as intrinsic to the study of verbal embedding. Embedding as defined involves responding to the critical word as a part of a meaningful sequence. If we are to embed a word, we must use words in addition to the particular word being embedded. To keep the total number of responses constant for embedded and non-embedded words, new material must be added to the critical word. That this would increase inhibition is predicted by Hypothesis III. If we want to test the effects of embedding without added material, however, we are limited to those words used by the group exposed to non-embedded material. Under such conditions the total number of responses must be reduced if we are to embed any given word.

In either case, whether 10, 50, or 150 responses are made, each critical word is responded to once and only once. The critical question remains the same: Was the critical word embedded or not when it was responded to? We may add to total responding time by responding to 50 rather than 10 phrases, but each phrase would still only be responded to once. Thus each critical word is followed by the same response, i.e., that response which is given to a part of the whole sequence. So it is suggested that the response given to each critical word may remain the same regardless of the total number of responses made.

SUMMARY

This study was designed to investigate the effects of prior exposure to anagram solution words on subsequent anagram solving performance. An increment in performance due to positive transfer was proposed. This increment, however, was hypothesized to be subject to two inhibitory factors. One of these factors was verbal embedding. This concept was generalized from the embedding of geometric figures. A word was considered to be embedded if responded to as a part of a meaningful whole, non-embedded if responded to in isolation. The second inhibitory factor proposed was an increase in the amount of material in which the solution appeared.

Two tasks were presented to five groups of college students. In the first task anagram solution words were presented to four of the five groups, with the presence of embedding and amount of material in different combinations. The first group received non-embedded words; in the second the words were embedded, while the amount of material remained constant; in the third the amount of material was increased without embedding the words; and the fourth received words embedded in an increased amount of material. The fifth group, the control group, was not exposed to the solution words. Task II provided the independent variable. It consisted of fifty anagram problems. Performance on this task

was hypothesized to vary with the variation of exposure in Task I.

Mean performance scores between similar groups with and without exposure to the solution words were significantly different, supporting the transfer hypothesis. The differences between all other groups were in the predicted direction, but were not statistically significant. The group which combined both inhibitory effects fell below the groups with only one. Both of these groups fell below the group with neither.

A second experiment was designed as a more direct test of embedding. It determined the ability to recognize words previously exposed under embedded and non-embedded conditions. It was hypothesized that fewer embedded words would be identified as having been seen in the prior exposure.

The results of the recognition test supported the hypothesis. Fewer words were recognized by the group exposed to the words under embedded conditions than non-embedded. The presence of the embedding effect was verified, but was not considered strong enough to influence the complex anagram solving task.

APPENDIX I

INSTRUCTIONS

I have two separate tasks for you to do. The second will follow the first, with no instructions, or other interruptions in between, so you must understand both tasks before we begin.

Task I consists of a list of items which you are to evaluate. The basis for your evaluation will be entirely subjective. Judge each item, pleasant or unpleasant, according to the following scale; +2 very pleasant, +1 pleasant, 0 neutral, -1 unpleasant, and -2 very unpleasant. The type of items you receive will vary; some will be sentences, others words, phrases, etc. Whichever type you get, respond to it by the five point scale just given. You will have only five minutes to do this task, so time yourselves accordingly.

The second task is quite different; it consists of anagrams or mixed up letters, out of which you are to form a word. So if you are given the letters K E S D, you will unscramble them, or rearrange them to make the word "desk." You must use every letter given once, and only once. All words must be English words; you may not use words from another language. You will not need to use words with prefixes or suffixes or any proper nouns. The words may be any part of speech: verbs, nouns, adjectives, etc. Do

not spend too much time on any single item; if you cannot get one anagram, go on to the next. You will have twenty-five minutes for this task.

Just a quick review. First respond on the five point scale to the first list of items. You will have five minutes, and then hand them in and be given the mixed up words. Put your name on both tasks. Please do not look at your neighbor's paper. Are there any questions?

APPENDIX II

Experiment I - Group I
Experiment II - Group VI

_____ severe	_____ foreign	_____ extreme
_____ fruit	_____ cheer	_____ small
_____ candy	_____ brown	_____ party
_____ roof	_____ child	_____ small
_____ unusual	_____ round	_____ morning
_____ giant	_____ whole	_____ own
_____ cigar	_____ beautiful	_____ sugar
_____ strong	_____ empty	_____ early
_____ water	_____ white	_____ legend
_____ under	_____ long	_____ scene
_____ garbage	_____ house	_____ polite
_____ color	_____ public	_____ coat
_____ company	_____ grass	_____ cover
_____ beach	_____ gas	_____ tall
_____ green	_____ river	_____ flavor
_____ brick	_____ trunk	_____ killer
_____ bank	_____ storm	

Experiment I - Group II
Experiment II - Group VII

- _____ beautifully colored, under water scene
- _____ gay, cheerful, public beach party
- _____ long, strong smelling, brown cigar
- _____ unusually savage, early morning storm
- _____ small, extremely polite, foreign child
- _____ tall, round roofed, brick house
- _____ fruit flavored, sugar coated candy
- _____ green, grass covered, river bank
- _____ empty, company owned, garbage truck
- _____ legendary, giant, white, killer whale

Experiment I - Group III

___ flower	___ ground	___ hospital	___ telephone	___ village
___ foreign	___ under	___ range	___ record	___ group
___ wisdom	___ exhibit	___ cause	___ sport	___ recent
___ track	___ machine	___ repeat	___ film	___ simple
___ grant	___ point	___ rough	___ people	___ music
___ complex	___ text	___ family	___ conflict	___ taste
___ store	___ force	___ ticket	___ salad	___ fruit
___ plant	___ adult	___ morning	___ basic	___ dress
___ skill	___ month	___ number	___ special	___ bread
___ spirit	___ picture	___ cinema	___ chess	___ field
___ public	___ human	___ state	___ land	___ natural
___ modern	___ future	___ school	___ empty	___ green
___ craft	___ religion	___ brick	___ bridge	___ march
___ feast	___ plate	___ design	___ white	___ corner
___ whale	___ radio	___ program	___ shirt	___ line
___ powder	___ limit	___ party	___ store	___ winter
___ nature	___ brown	___ child	___ finish	___ voice
___ second	___ polite	___ table	___ sugar	___ value
___ agent	___ shoe	___ plane	___ doctor	___ grass
___ scene	___ round	___ happy	___ member	___ effort
___ welcome	___ candy	___ smooth	___ house	___ office
___ class	___ figure	___ middle	___ seven	___ lesson
___ other	___ problem	___ great	___ alone	___ crowd
___ knife	___ queen	___ berry	___ centre	___ cost
___ strict	___ light	___ youth	___ talent	___ face
___ earth	___ dance	___ honor	___ minor	___ fact
___ throat	___ tobacco	___ river	___ cigar	___ once
___ savage	___ splash	___ opera	___ chair	___ time
___ center	___ strong	___ lesson	___ enter	___ month

Experiment I - Group IV

- _____ Under water plant life and rock like coral formations formed a beautiful and colorful scene.
- _____ The public beach rang with gay cheerful sounds from happy throngs, attending the annual party.
- _____ The entire room filled with smoke, from the elderly gentlemen's long, brown cigar.
- _____ In the early morning, the storm struck with savage winds and literally tons of rain.
- _____ Although quiet, the small child, from the foreign land, was extremely polite and well mannered.
- _____ The tall house, built of glazed brick, featured a round roof and huge picture windows.
- _____ The candy was coated with glistening sugar and available in a variety of fruit flavors.
- _____ The banks of the slowly winding river were covered with grass and various green shrubs.
- _____ The truck, presently empty, but ordinarily filled with garbage was property of a local company.
- _____ The legendary whale was white in color, giant in size, and reputedly a wanton killer.

Experiment I - Group V

_____ ground	_____ noble	_____ foam
_____ electro	_____ march	_____ approve
_____ string	_____ punch	_____ active
_____ supply	_____ green	_____ craft
_____ night	_____ ship	_____ wave
_____ regal	_____ front	_____ ginger
_____ street	_____ punk	_____ mistake
_____ olive	_____ liquid	_____ home
_____ silver	_____ cotton	_____ diaper
_____ mystic	_____ preach	_____ import
_____ rich	_____ jacket	_____ finger
_____ young	_____ vault	_____ blank
_____ play	_____ parish	_____ crust
_____ powder	_____ power	_____ reward
_____ camp	_____ crack	_____ erupt
_____ height	_____ tribe	_____ dogma
_____ shiny	_____ tomato	

Experiment I - All groups - Anagrams

NUHCL	SRRAS
YEMSO	AAVGSE
TIFUR	RASGU
EIVRR	MOSTR
DENRU	TEMY?
WEHTE	CIBER
PHBEE	QLDIAU
KIRAT	MMILAA
DEUGJ	OEZHO
NELUC	RAFSC
SEDRS	TOPLRE
CABEH	POCHAM
DCHLI	LAEHW
MEGRE	TARBY
LUPCHB	ROMAE
OEWLT	IRAGM
TOGUR	WRAMS
WERAT	CCROL
DAGYN	TEEGWH
LACTEMI	KUROD
RACGE	SHUEO
GORMELN	KATIG
KURCT	REESC
MOFFIGE	EATLNN
WBORN	THRSEO

Experiment II - Both groups - Recognition task

open	olive	grass	sugar
stream	light	field	crumb
polite	bronze	house	short
father	thirst	month	force
wheel	stuffy	quart	lodge
place	cloud	apple	issue
acorn	flower	trick	voice
giant	sheet	number	round
letter	cotton	timid	point
candy	water	child	circle
empty	cigar	office	strong
music	carpet	brick	exact
river	fruit	march	thorn
whale	savage	range	vault
earth	chord	duty	legion
party	large	stone	green
infant	anchor	guilt	jungle
onion	sweet	instant	wealth
storm	motor	honest	scene
window	grass	morning	tongue
under	glass	happy	empty
gentle	company	truck	public
nervous	blood	frown	nurse
foreign	leather	brown	white
square	trout	grace	beach

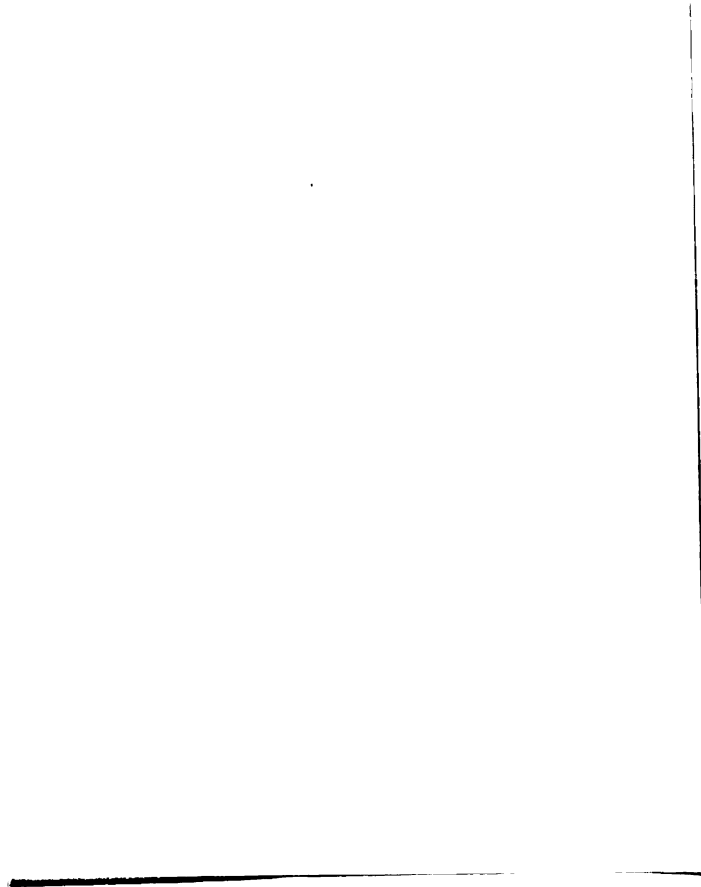
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