Increasing Resistance to the Negative Effects of Set

Paul B. Chance
Utah State University

INCREASING RESISTANCE TO THE NEGATIVE EFFECTS OF SET

by

Paul B. Chance

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ABSTRACT

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Paul B. Chance, Doctor of Philosophy

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Major Professor: Dr. David Stone
Department: Psychology

Two experimental studies were reported in which attempts were made to increase resistance to the negative effects of set. Set interference was measured by performance on 1) a task in which a set was experimentally induced, 2) a series of problems presumed to involve implicit sets, and 3) a test of creativity presumed to involve implicit sets.

The experimental treatments consisted of tasks which required set-breaking. An important aspect of this research was that no hints or instructions concerning sets were provided.

The findings offer modest support for the view that learning experiences can be designed which will increase resistance to interference from set. Suggestions for future research on this problem were discussed.

These experiments utilized a novel research design in which each group of subjects acted as both an experimental and a control group. Thus, each study was, in essence, two studies. The advantages and limitations of this design were discussed.

(78 pages)

INTRODUCTION

Considerable attention has been given to the role of sets in problem solving. It is well known that a set will facilitate problem solving so long as the set response is appropriate to the problem's solution. However, when the set draws attention to irrelevant aspects of the problem it will inhibit performance. Thus, the ability to avoid an inappropriate set, or to overcome one once it has been formed, may be an important variable in problem solving.

Maier (1933) suggested that "good reasoners ... jump from one direction to another" (p. 145). Later (Maier, 1945) he argued that changes in perceptions or memories (sets) are necessary to productive thinking. The relationship between the ability to change sets and creative problem solving is suggested by the research of Mendelsohn and Griswold, 1965, 1966). They found that the creative subject is more flexible in his perception and attack of a problem. And Loree (1965) found that successful problem solvers seemed able to change sets more readily than poor problem solvers.

The term Set Flexibility will be used here to refer to the ability to avoid or overcome interference from sets. If a set is viewed as a predisposition to respond in a particular way, then Set Flexibility is the ability to make alternate (non-set) responses.

A person with little Set Flexibility will persist in making the set response even when it is inappropriate; the person with greater Set Flexibility will switch from one response to another.[1] To the extent that this flexibility increases the number of different responses which will be tried, it should increase the probability of an appropriate response, and thereby improve problem solving.

Little attention has been directed at explaining the differences between individuals in Set Flexibility. Some research has suggested that this characteristic is inversly related to personality variables such as ethnocentrism (Rokeach, 1948) and rigidity (Schroder and Rotter, 1952). However, little is known about how Set Flexibility is acquired. It seems likely that whether or not an individual will adhere rigidly to a particular set will depend upon his learning history with respect to sets generally. If an individual has a history which favors adherence to sets, he may give up a set only after extensive evidence that the set response is inappropriate. That is, we may develop <u>sets about sets</u>; we may develop a predisposition to adhere to sets with considerable persistence, or we may develop a predisposition to change sets readily.

If Set Flexibility is a function of learning, it should be possible to design learning experiences which will increase it. Several

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[1] It should be emphasized that Set Flexibility is a tendency to make non-set responses. It does <u>not</u> refer to a "dynamic" or motivational factor within an individual.

researchers have suggested that this is an important goal. Luchins and Luchins (1959) have indicated that a person may master "a habit so well that it in turn masters him" (p. 1). They point out that:

> one of the objectives of modern education is so to educate the individual that, while he has a repertoire of certain habits, he does not become a mechanized robot, but instead is flexible enough in his behavior to meet the needs of a changing dynamic world. (p. 2)

In discussing scientific discovery, Henle (1962) stresses the importance of breaking away from "our system of assumptions and meanings and knowledge when it no longer does justice to the given material" (p. 37). Similarly, Roe, (1961) has stressed the need for scientists to have "an open attitude toward experience" which allows a "reordering of this accumulated experience" (p. 458). Schroder and Rotter (1952) describe rigidity as "a failure to learn something or the expectancy of a single correct solution" (p. 141). This sounds very much like a predisposition to respond in a particular way--i.e., a set. They suggest that we need to ask:

> What sequence of learning experiences would make for greater or lesser potentiality to try out alternative solutions in a problem situation rather than a repeated use of the same behavior?" (p. 141)

This is essentially the question dealt with in the research reported here. Is it possible to design learning experiences so that an individual will be less susceptible to interference from inappropriate sets? Can we learn to master our habits without letting our habits master us?

The studies reported here attempt to determine if Set Flexibility--the ability to resist interference from the negative effects of set--can be increased by selected learning experiences.

REVIEW OF THE LITERATURE

Research on sets and their effects on performance has been reviewed extensively by David (1966), Duncan (1959), Gibson (1941), Guetzkow (1951) and Johnson (1966). A few representative studies will be reviewed here to illustrate the positive and negative effects of set. Then the work relevant to increasing resistance to set interference will be reviewed.

Positive Effects of Set

A set facilitates problem solving so long as it is appropriate to the task. Among the earliest investigations of facilitative sets was that by Rees and Israel (1935). They gave subjects a series of anagrams to solve and induced sets by instructions or through training. They found that sets could be acquired for a certain letter order or for a particular subject area.

A study by Hunter (1956) also demonstrated that sets could be developed which enhanced anagram solution. In addition, he showed that the more specific set the subject is given, the easier the problem is to solve.

Harlow (1949) and Harlow and Warren (1952) investigated the formation and transfer of sets in discrimination learning. Their studies demonstrated that learning how to solve a particular problem improved performance on other similar problems.

Goodnow and Pettigrew (1956) trained subjects in a discrimination task, extinguished the discrimination responses, and then gave another series of discrimination trials. Performance on this final set of problems was better for trained subjects than for a control group. Thus, the set established in the first series produced positive transfer in the later series.

In a study by Judson, et. al. (1956) subjects learned series of words which were relevant or irrelevant to the solution of the two-string problem, the hat rack problem, and a verbal problem. Those who learned the relevant words did better than thos who had learned the irrelavent words.

Sets generally are helpful. As Harlow (1949) has pointed out, we would be handicapped if we did not acquire sets. He has even hinted that the chief value of education is in that it gives us a repertoire of sets. However, sets are only helpful in so far as they are appropriate to the solution. When they become inappropriate, they interfere with problem solving.

Negative Effects of Set

Luchins (1942, 1946) well known Water Jar Problems (WJP) represent one of the earliest measures of interferences from set.

Subjects are given a series of six measuring problems all of which can be solved with the same indirect formula. Then the subject is given two "critical" problems which can be solved in the set manner or by using a more eloquent "direct" formula. These problems are followed by an "extinction" problem which can be solved only by the non-set direct method. Two more "critical" problems complete the series.

Subjects characteristically solve the critical items in the set manner while subjects who have not received the training series nearly always use the direct formula. Similarly, trained subjects typically fail the extinction item while control subjects almost always solve it. Luchins argued that the experience with the indirect solution established a set which "mechanized" the problem solving process and precluded the use of the direct solution. Luchins called this phenomenon the Eistellung effect and showed that it occured in both sexes and at various educational and age levels.

Duncker (1945) introduced the concept of Functional Fixedness to describe a somewhat similar finding. His subjects used an object in its tranditional manner. They were then asked to solve the two-string problem which required that an object be used in an unconventional way. Subjects tended to use some object other than the one used earlier in a conventional way. This was so even though the object could easily have served the unconventional use. Duncker concluded that the earlier use of the object "fixed" its function and prevented the subject from using it in an unconventional way.*

Birch and Rabinowitz (1951) studied the effects of prior use of an object on problem solving. Like Duncker they found that ". . . different kinds of experience are differentially effective in influencing the content of problem solving behavior" (p. 124). Adamson (1952 replicated three of Duncker's experiments with similar results.

It is clear from this and other research that sets may interfere markedly with problem solving. This investigation is concerned with the possibility of acquiring resistance to such interference. Therefore, those studies which shed light on factors important in reducing the negative effects of set will now be considered.

Increasing Set Flexibility

A number of studies have identified factors which contribute to the strength of a particular set. For example, researchers have investigated the effects of massed versus distributive practice (see Chown, 1959) and reinforcement schedule (Adamson, 1959; Ray, 1965;

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*Anderson and Johnson (1966) have maintained that the Einstellung of Luchins and the Functional Fixedness of Duncker are different phenomena. They found different forgetting curves and differences in effect of distributive practice. However, a study by Adamson and Taylor (1954) indicates that set breaking on Luchins Water Jar Problems is related to Functional Fixedness. Also, in each case, a predisposition to respond in a particular way is apparent; therefore, both qualify as "sets" as defined earlier.

see also Chown, 1959) on strength of set. However, few studies have investigated factors which contribute to an individual's ability to avoid or overcome an inappropriate set.

Maier (1933) instructed his subjects to avoid a rut, to change their attack on the problem, etc. These subjects did better than a control group on the two-string problem, the hat ra ck problem and the candle problem. In a second experiment, he used different problems and again found that the instructions made a significant difference.

Maltzman, et. al., (1958) instructed their subjects to be "original" and this simple instruction improved scores on a test of originality.

In another experiment, Ray (1966) told one group of subjects that the average number of solutions to a problem was six. He told another group the average number of solutions was 15. As predicted, the group given the latter expectation gave more solutions to the problem.

Colgrove (1968) used the changing work procedure as a measure of creative problem solving. He told one group, as part of their instruction, that they were creative people who had a reputation for innovative solutions. These subjects gave more creative solutions than a control group.

These studies demonstrate the importance of the instructions and the structuring of the problem in determining how readily subjects will overcome sets. In essence, instructions may reduce interference from set by inducing an "innovative set" (Colgrove, 1968). That is, the effects of an interfering set may be weakened by inducing a facilitative set. Instructions provide a way of structuring a problem so as to minimize the negative effects of set or so as to maximize them.

A number of studies have shown that experiences prior to the problem situation can influence the degree of set interference.

Maltzman (1960) used a modified free association technique to increase the frequency of original (presumably non-set) responses. His procedure improved performance on a word association test and on a test of creativity.

Subjects were given single or multiple solution problems in a study by Ray (1966). Following this the subjects were asked to solve the cylinder in the can problem (a multiple solution problem). Subjects who had solved multiple solution problems gave more solutions than those who solved single solution problems.

Warren and Davis (1969) supplied subjects with checklists to induce ideas. These subjects gave more creative solutions than subjects without the checklists.

Schroder and Rotter (1952) used a card sorting task. Some subjects were rewarded for using different categories, some for using the same categories. As predicted, subjects who were reinforced for using different categories used more categories in an experimental trial.

The above studies suggest that set interference can be increased or decreased by a number of factors. However, none of these studies explicitly investigates sets about sets. Jacobus and Johnson (1964) hypothesized that subjects who were reinforced for conforming to a set response would be more likely to adopt a set in another situation. Experimental subjects were given a series of anagrams scrambled in a set order. Control subjects received the same words but scrambled in a random order. All subjects were then given Luchins WJP. Experimental subjects were more likely to use the set method and to fail the extinction problem than were controls. This study provides clear evidence of a set to adopt a set.

If it is possible to acquire a predisposition to adopt a set, it does not seem unreasonable to suppose that a predisposition may be acquired to avoid or overcome a set. Research in discrimination learning has shown that subjects can learn to abandon a set once it ceases to produce a reward (Bourne, 1965; Schusterman, 1962). This has been interpreted as a "win-stay, lose-shift" strategy. These studies have demonstrated an inclination to give up an inappropriate set, but they do not demonstrate a tendency for this Set Flexibility to transfer to other kinds of problem solving situations. Only one study was found which attempted to do this.

Gibbons (1965) gave a series of problems which presumably required that the subject overcome some implicit set. After working on these problems, subjects were told the correct solution and the assumptions (sets) which may have interfered with their performance. They were warned to look for and eliminate such assumptions. Subjects were then given a problem which presumably required them to overcome a set. Trained subjects clearly out-performed control subjects. The author concluded that the results demonstrated a "set-breaking set." Thus, the subjects apparently learned to avoid or overcome inappropriate sets.

One problem with the Gibbons study is that the training included both feedback concerning correct solutions and verbal instructions to "look for and eliminate" sets. Previous research, cited above, had already demonstrated that interference from set can be reduced by instructions. What is needed is research which investigates whether feedback (learning experience) alone can have this effect.

Another limitation of the Gibbons study is that it involved implicit sets only. No attempt was made to determine if training would reduce interference from an experimentally-induced set such as is found in the WJP.

The research reported here was conducted in an effort to extend the findings of Gibbons. Two studies were conducted in an effort to determine if learning experiences could be arranged such that subjects would learn to avoid or overcome the inhibitory effects of set. Such Set Flexibility was measured on a task in which a set was experimentally induced, on a series of problems presumed to involve implicit sets, and on a measure of creative problem solving.

STUDY I

Introduction

The purpose of this study was to determine whether the inhibitory effects of set could be reduced by training in set-breaking.

Methods

Subjects

The subjects were 32 volunteers from two introductory psychology classes at Utah State University. Fifteen subjects were male and 17 female. Al subjects received extra credit points for participation in the study.

Variables

Anagrams: Eighteen single solution anagrams (see Appendix A) were selected from those used by Hunter (1956). The anagrams were arranged in three groups of six problems. All but one anagram in each group of words dealt with one topic. In the first group, the first five words were all animals; the sixth word was "birch." In the second group of anagrams, the first five dealt with clothing; the sixth word was "piano." In the third group all but the fifth anagram were birds; the fifth word was "apple."

Thus each group of words was designed to produce a set for a particular class of solutions. This procedure has been found to be effective in producing sets (Rees and Israel, 1935; Hunter, 1956). The non-set word in each group was intended to give the subject experience in set-breaking. It was hoped that with each set-breaking word the subject would be less inhibited by the set. A set to expect a particular item to be non-set (the sixth word) might develop as a result of the first two groups. Thus, in the last group of words, the fifth problem was made the non-set item.

The anagrams were introduced by the following instructions, which the subject read from a card:

Anagrams

> An anagram is a word with its letters arranged in a scrambled order. Your task is to re-arrange the letters to form the word. (Be sure to use all the letters.)
>
> Write your answer on a separate sheet of paper, then turn to the next card. The correct answer will be on that card. After you have read the answer, go on to the next problem.
>
> There will be three sets of anagrams, six to a set. You will have two minutes for each problem.
>
> Any questions?
>
> Turn to the next card and begin.

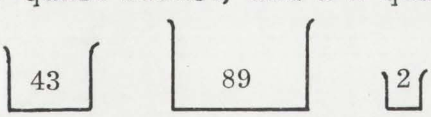
Each anagram was presented on a 4 x 6 card for two minutes. The subject wrote his response on a separate answer sheet. After answering the problem (or after the time limit had elapsed) the subject turned to the next card which provided the correct solution. He then went on to the next card, which revealed the next anagram. This procedure was followed until all 18 problems had been presented.

Water Jar Problems: The WJP are a series of eleven measuring problems designed to determine the influence of set on problem solving. The WJP were originally designed by Luchins (1942). However, a modified version of them was recommended by Bugelski and Huff (1962) and it was these problems that were used in this study (see Appendix B).

Each problem requires the subject to derive a formula for measuring out a given quantity of water. The first problem served as an example and was presented on a 4 x 6 card as follows:

Measuring

Suppose that you have an unlimited supply of water and three buckets. You have a 43-quart bucket, an 89-quart bucket, and a 2-quart bucket:



How would you measure out exactly 42 quarts of water? You have to measure the amount--no estimating--and you can use only these three buckets.

Write your answer on a separate sheet of paper and then turn to the next card.

On the next card the solution was explained to the subject as follows:

You fill the 89-quart bucket and from that you fill the 43-quart bucket once and the 2-quart bucket twice. There are now 42 quarts of water in the 89-quart bucket. The answer may be written:

$$89 - 43 - 2 - 2 = 42$$

Each of the remaining cards has a problem on it. As soon as you have solved a problem, write your answer down and turn to the next card. You will have one minute for each problem.

Any questions?

Now turn to the next card.

Any questions the subject had were answered at this time. No further help was given.

The example and the next five problems were solvable using the same B — A — 2C formula. Thus, a set for this solution may be acquired. Problems 7 and 8 are test problems. They may be solved in the set fashion or through a more eloquent, direct formula (A—C). Adherence to the set solution on problem 7 or 8 suggests inhibition from the previous use of the indirect formula. Thus, use of the direct solution to item 7 and/or 8 indicates a relative lack of interference from set (set avoidance).

Item 9 can be solved only with a non-set, direct formula. Thus failure to solve this problem provides additional evidence of inhibition from set. As subject who used the set solution to items 7 and 8 (and therefore clearly adopted the set) should have considerable difficulty with item 9. When such an subject correctly solves item 9, he may be said to have overcome the inhibiting set (set-breaking).

Following item 9, the subject was presented with a card which showed the correct solution to item 9. This feedback was thought to provide training in set-breaking which might later increase Set Flexibility. No instructions concerning sets or the applicability of this formula to other problems was given.

Problems 10 and 11 were test problems which, like items 7 and 8, could be solved in either the set or a more direct manner. The tendency to use the set solution provides a final measure of the strength of set. Use of a direct formula to these problems suggests Set Flexibility in that the subject is giving up the set solution for a new, more efficient one (set-changing).

The example and each of the problems were presented one at a time on 4 x 6 cards. The subject wrote his answers on a separate answer sheet. There was a maximum time limit of one minute for each problem after the example. If the subject had not solved the problem by the end of that time, he was instructed to go on to the next problem.

Bridge, Pennies and Square. Three problems were selected which intuitively appeared to derive their difficulty from the inhibitory effects of an implicit set. The problems selected were the Bridge, Pennies, and Square problems.

The Bridge problem (derived from Church, 1961, p. 109) consists of a three-dimentional model of a body of land surrounded by a moat, and two boards (see Figure 1 and Appendix C). The boards were just slightly shorter in length than the width of the moat.

The subject was presented with the model and the two boards, (Figure 1). Then the following instructions were read aloud to him:

Bridge Building

> This model represents a body of land surrounded by a moat.[1] The moat is infinitely deep. Your task is to build a usable bridge across the moat. The <u>only</u> materials available are the two boards, each slightly shorter than the width of the moat.
>
> Any questions?
>
> You will have five minutes.

It seems intuitively that the subject would have a set to build the bridge across the narrowest point of the moat. Observation of subjects attacking the problem provided support for this assumption: nearly every subject began by attempting to build the bridge at a narrow portion of the moat. Correct solution requires the subject to overcome this set and build the bridge at one of the corners (Figure 2).

No help was given the subject beyond the instructions above, except that if an incorrect solution was offered (such as resting the bridge on the "water") the inadequacy of the solution was stated and the subject allowed to continue working. Feedback of this sort was

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[1] Experimenter indicates moat

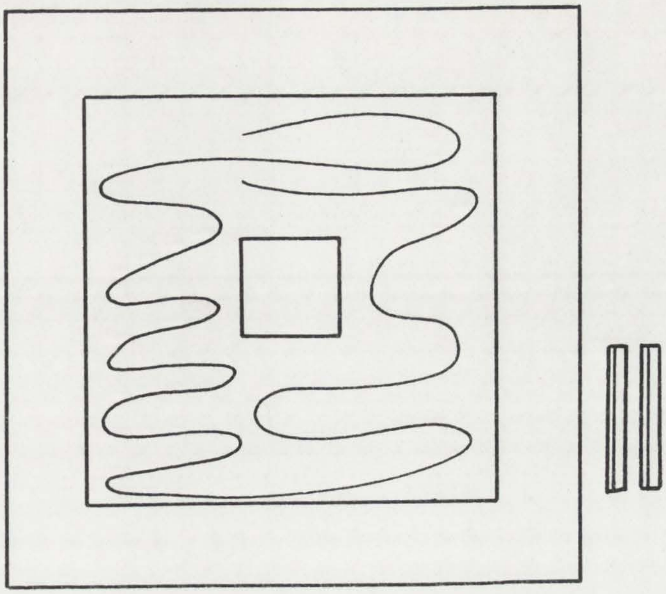

Figure 1. Bridge problem

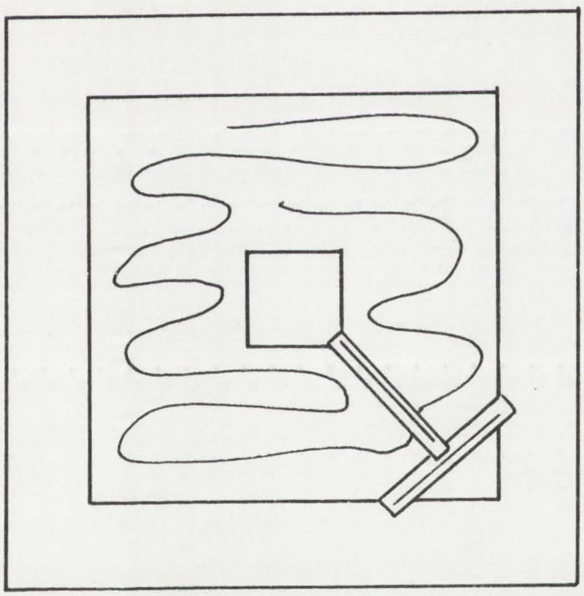

Figure 2. Solution to bridge problem

given because preliminary testing suggested that such inadequate solutions would be offered frequently. (This was, in fact, the case.)

The Pennies problem consisted of giving the subject seven pennies while the experimenter read the following instructions:

> Arrange these pennies in two lines so that there are four pennies in each line.
>
> Any questions?
>
> You will have five minutes.

It seemed intuitively that a set would exist for arranging the pennies in two separate lines, whereas the correct solution requires the use of two intersecting lines as shown, for example, in Figure 3. This set seemed, in fact, to exist: many subjects arranged the pennies in two separate lines and then joined them.

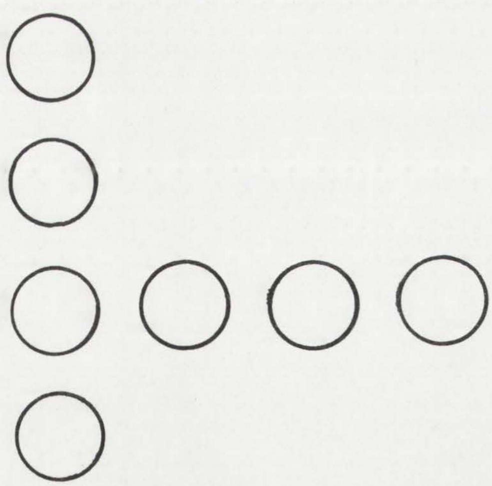

Figure 3. One solution to pennies problem.

In the Square problem (Krech and Crutchfield, 1961, p. 382) the subject was presented a 4 x 6 card as shown in Figure 4. At the same time he was told, "Find the area of the square."

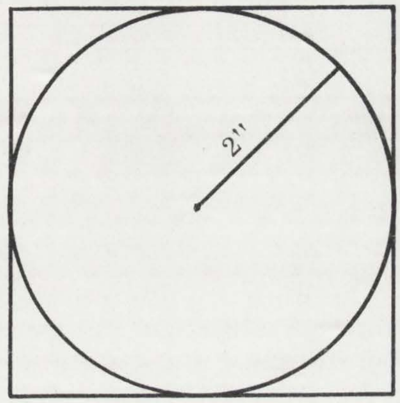

Figure 4. Square problem.

Krech and Crutchfield (1961) have suggested that this problem will be more difficult when the line from the center of the circle to its perimeter is aimed at one of the corners of the square than when it is aimed at one to the sides. Presumably this inhibits the subject from seeing the relationship between the radius of the circle and the width of the square.

A maximum time limit of five minutes was allowed for each of the three problems. No feedback was given (except as noted for Bridge) until all three problems had been administered. Then the subject was shown the correct solution to any of the problems he had not solved correctly. No other instructions about sets or problem solving were given.

Procedure

Subjects were randomly assigned to one of two groups. Each group acted as both an experimental and a control group. Group A received the Bridge, Pennies and Square problems (BPS), Anagrams, and WJP, in that order. Group B received the WJP, Anagrams, and BPS, in that order:

A	B
BPS	WJP
ANAG	ANAG
WJP	BPS

The variables were administered to one subject at a time in a single session which lasted an average of about 45 minutes.

The first half of Study I was concerned with the effects of training on Set Flexibility as measured by the WJP. For this part of the study Group A acted as the experimental group and Group B acted as the control group. Training consisted of thw BPS problems and the Anagrams, administered as described above. Following training, experimental subjects were given the WJP. Group B subjects were given WJP in the same manner as Group A subjects, but since these subjects received the WJP first, they acted as a control group for this part of the study.

If training decreased inhibition from set, experimental subjects should show greater Set Flexibility on the WJP: that is, they should be more likely to use a Direct, non-set formula. The hypotheses to be tested in this part of the study were as follows:

Ho_1 There is no difference between treatment groups in the frequency of non-set solutions to items 7 and/or 8 (Set Avoidance).

Ha_1 The frequency of non-set solutions to items 7 and/or 8 will be greater for trained than for untrained subjects.

Ho_2 There is no difference between treatment groups in the frequency of solution to item 9 following set solution on items 7 and 8 (Set Breaking).

Ha_2 The frequency of solution to item 9 following set solution on items 7 and 8 will be greater for trained than for untrained subjects.

Ho_3 There is no difference between treatment groups in the frequency of non-set solutions to items 10 and/or 11 (Set Changing).

Ha_3 The frequency of non-set solutions to items 10 and/or 11 will be greater for trained than for untrained subjects.

The second half of Study I was concerned with the effect of training on Set Flexibility as measured by performance on the BPS problems. Overcoming set is presumed to be an important variable in solving problems of this type (Gibbons, 1965; Guetzkow, 1951). Therefore, it was reasoned that if Set Flexibility were increased, performance on the problems would be improved. For this part of the study Group B acted as the experimental group and Group A as the control group. Training consisted of the WJP and Anagrams, administered as described above.

Following training, experimental subjects were given the BPS problems. Group A subjects were given the problems in the same way as were Group B subjects. However, since Group A subjects received the problems first, these subjects acted as a control group for this part of the study.

If training increased Set Flexibility, experimental subjects should show superior performance on the three problems. The hypotheses to be tested for this part of the study were as follows:

Ho_4 There is no difference between treatment groups in frequency of solution to the Bridge problem.

> Ha_4 The frequency of solution to the Bridge problem will be greater for trained than for untrained subjects.

Ho_5 There is no difference between treatment groups in frequency of solution to the Pennies problem.

> Ha_5 The frequency of solution to the Pennies problem will be greater for trained than for untrained subjects.

Ho_6 There is no difference between treatment groups in frequency of solution to the Square problem.

Ha_6 The frequency of solution to the Square problem will be greater for trained than for untrained subjects.

Ho_7 There is no difference between treatment groups in solution time to the Bridge problem.

Ha_7 The solution time for the Bridge problem will be shorter for trained than for untrained subjects.

Ho_8 There is no difference between treatment groups in solution time to the Pennies problem.

Ha_8 The solution time to the Pennies problem will be shorter for trained than for untrained subjects.

Ho_9 There is no difference between treatment groups in solution time to the Square problem.

Ha_9 The solution time to the Square problem will be shorter for trained than for untrained subjects.

Results

It has been established (Gardner and Runquist, 1958; Mayzner, 1955; Ray, 1965; Smith, 1966; van de Geer, 1957; see also Chown, 1959) that strength of set is a function of the number of reinforced set responses. To determine whether training increased resistance to interference from set, it was necessary to insure that the subjects had approximately the same opportunity for interference. Therefore, in the first half of Study I, only those subjects who gave at least four correct set solutions to items 2 through 6 of the WJP were included in the analysis. There were two subjects who failed to meet this criterion, one in Group A and one in Group B. Of the experimental (Group A) subjects, 7 were males and 9 were females. Of the control (Group B) subjects, 7 were males and 7 were females. The hypotheses were tested on the data from these 30 subjects.

Set avoidance

The tendency to avoid the inhibitory effects of set is one indication of Set Flexibility. Such "Set Avoidance" is indicated in this study by the tendency to give a direct solution to items 7 and 8 of the WJP, since these problems could be solved in either the set or direct fashion. The proportion of subjects in each group giving a direct solution to items 7 and/or 8 was computed and subjected to chi square analysis.[1]

Chi square tests were run to determine if there were any differences between males and females in either treatment group. For Group A, the experimental group, a X^2 of .084 was found ($p > .70$, 2 tail test). For the control group the X^2 obtained was 0.000. Obviously no sex differences were suggested. Accordingly, male and female subjects were combined for testing the hypotheses concerning Set Avoidance.

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[1] All chi square analyses in this study are corrected for continuity using Yates' formula.

Table 1. Chi square analysis of frequency of direct solutions to items 7 and/or 8 (Set Avoidance).

Treatment	f Direct solution	f Set solution	X^2 df = 1	p^{**}
Trained (A)	4	12	.670	< .25
Untrained (B)	1	13		

** 1 tail test

As can be seen from Table 1, 25% of the experimental subjects gave direct solutions to items 7 and/or 8 compared to only 7.1% of control subjects. This is over three times as many as controls. However, this difference yields a X^2 value of only .670 which falls far short of statistical significance.

The null hypothesis of no difference between treatment groups in Set Avoidance can not be rejected.

Set breaking

The ability to overcome a set, once formed, is an important aspect of Set Flexibility and may well be an important step in problem solving (Guetzkow, 1951). Subjects who had given the set solution to items 7 and 8 were judged to have firmly developed a set. Eleven of the 16 experimental subjects met this criterion (6 males and 5 females), as did 13 of the 14 control subjects (6 males and 7 females). Of these 24 subjects, those who subsequently solved item 9, which could only be solved using a direct formula, were overcoming or breaking a set, and were therefore more flexible than subjects who failed item 9.

Again there were no differences between males and females in either treatment group ($X^2 = .095$, $p > .70$ in Group A[1]; $X^2 = .048$, $p > .80$ in Group B*). Male and female subjects were therefore combined for the analysis.

The data were analyzed by the chi square test, the results of which are presented in Table 2. Nearly 73% of the experimental subjects solved item 9, whereas about 62% of control subjects did so. However, this difference does not reach statistical significance.

Table 2. Chi square analysis of frequency of solution to item 9 (Set Breaking).

Treatment	f Solution	f non-solution	X^2 df=1	p^*
Trained (A)	8	3	.021	> .40
Untrained (B)	8	5		

* 1 tail test

The null hypothesis of no difference between treatment groups in Set Breaking can not be rejected.

[1] 2 tail test

Set changing

The term Set Changing is used here to refer to the tendency to give up a successful solution for a new, more efficient one. Following problem 9, which required a direct (A — C) formula, subjects were shown the correct solution.

Items 10 and 11, like 7 and 8, could be solved in the set manner or in a more direct way. Number 10 could be solved using the A — C formula applicable to item 9; number 11 could be solved using an A + C formula. Thus, the tendency to use a direct solution on item 10 or 11 reflects a willingness to give up a successful but cumbersome solution, and to adopt a new, more efficient one.

Chi square analyses were made to determine if there were any differences between male and female subjects. A X^2 of .016 ($p = .90$, 2 tail test) was found in the experimental group; the control group produced a X^2 of 0. Since there were clearly no differences between male and females, the data were combined for the purpose of testing the hypothesis.

Table 3. Chi square analysis of frequency of direct solution to items 10 and/or 11 (Set Changing).

Treatment	f Direct solution	f Set solution	X^2 df=1	p*
Trained (A)	15	1	5.24	< .02
Untrained (B)	7	7		

* 1 tail test.

The proportion of subjects giving direct solutions to items 10 and/or 11 was computed and submitted to chi square analysis (Table 3). The results indicate a significant difference in favor of the trained subjects ($X^2 = 5.24$, $p < .02$, 1 tail test). Thus, trained subjects were significantly less inhibited by the set on these items.

The null hypothesis of no difference between treatment groups was rejected. The alternative hypothesis that trained subjects were more inclined to adopt a new solution was accepted.

To test the hypotheses of the second half of Study I, Group B (experimental)subjects compared with Group A (control) subjects on the BPS problems. Training consisted of the WJP followed by Anagrams. These exercises were intended to produce increased Set Flexibility. Set Flexibility, it was hypothesized, would be useful in solving problems which appear to derive their difficulty from an inhibiting set. Group A received the problems without prior training and thus acted as control subjects for testing the hypotheses.

All 32[1] subjects were included in the analysis: 15 experimental subjects (7 males and 8 females) and 17 control subjects (8 males and 9 females).

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[1] The analysis of the Bridge problem was based on 31 subjects; one experimental subject was excluded because of familiarity with the Bridge problem.

Solution frequency

It was predicted that training would increase the probability of solution to the three problems. Analyses were made to determine if there were any differences between male and female subjects. No such differences were found. The proportion of correct solutions were almost identical for the sexes on the Bridge problem and were the same on the Pennies problem. On the Square problem, males did slightly better than females in both experiments and control groups, but neither of these differences reached significance ($X^2 = .614$, $p > .30$ and $.435$, $p > .50$, respectively, 2 tail test).

Chi square analyses were made on the combined solution frequency of male and female subjects to determine if training improved the probability of solution for any of the three problems. These results are presented in Table 4. None of the differences reaches significance, and the control group actually did better than the trained group in the Bridge problem. The Pennies problem was passed by all subjects in both conditions.

The greatest difference between treatment groups was on the Square problem. In the experimental group, about 87% of the subjects solved the problem correctly as compared to about 59% of control subjects. This difference approaches significance with a X^2 of 1.83 ($p < .10$, 1 tail test).

Table 4. Chi square analysis of frequency of solution to Bridge, Pennies, and Square problems.

	Trained (B)	Untrained (A)	X^2 df=1	p*
Bridge	14.3%	29.4%	.326	< .35**
Pennies	100.0%	100.0%	0	--
Square	86.7%	58.8%	1.83	< .10

* 1 tail test

** Difference not in predicted direction

There is little support from these data that training increased Set Flexibility as measured by frequency of solution. The null hypotheses of no differences between treatment groups in solution frequency could not be rejected.

Solution time

Another measure of improvement in problem solving is a reduction in time to solution. It was expected therefore that solution times for the Bridge, Pennies, and Square problems would be lower for trained subjects than for untrained subjects. The frequency of solution to the Bridge problem was so low (14.2% and 29.4% for the experimental and control groups, respectively) that any analysis of solution times would be meaningless.

Thus, the null hypothesis of no difference between treatment groups in solution time to Bridge could not be rejected.

Table 5. Mean solution times: Pennies problem

	Trained (B)	Untrained (A)
Males	16.3	23.8
Females	15.0	30.8

All subjects solved the Pennies problem. The solution times for correct solution to this task were submitted to examination by Analysis of Variance.* The means for each group are presented in Table 5, and the results of the AOV are presented in Table 6. There were no significant differences between treatment groups or between sexes. The interaction was also non-significant.

Table 6. Analysis of variance for mean solution times: Pennies problem.*

Source	SS	df	MS	F	P
Treatment	135.72	1	135.72	2.10	NS
Sex	8.12	1	8.12	.13	NS
TXS	17.23	1	17.23	.27	NS
Error	513.88	28	(Adjusted) 64.64		

$F_{.05}(1,28) = 4.20$

* AOV for unequal n's using method of unweighted means (Winer, 1971).

The null hypothesis of no difference between treatment groups in solution time to the Pennies problem could not be rejected.

Of the experimental group, 13.3% failed the Square problem as did 41.1% of the control group. With failure rates this high, using mean solution times based on correct solutions only would bias the results in favor of the control group. To attribute the maximum time limit of 300 seconds to subjects with incorrect solutions and then run an AOV (a procedure followed by Gibbons, 1965) would bias the results in favor of the experimental group, since subjects who gave incorrect solutions might have given correct solutions had they actually taken the full time limit. To reduce these biases, errors were attributed the maximum time of 300 seconds and the Mann-Whitney U test of ranks was run.

Within the control group, males were found to be significantly superior to females ($U = 13$, $p < .05$, 2 tail test). No sex difference was found in the experimental group ($U = 20.5$, $p < .43$, 2 tail test).

U values were computed to compare treatment groups. The data were analyzed separately for males and females because of the sex differences noted above. U values are presented in Table 7. The training had the effect of reducing solution time for females ($U = 17$, $p < .05$, 1 tail test). The difference between treatment groups did not reach significance for males.

Table 7. Mann-Whitney U values for solution times: Square problem

	U	p*
Males	21	< .23
Females	17	< .05

*1 tail test

The null hypothesis of no difference between treatment groups in solution time to the Square problem could be rejected for females, but not for males. For female subjects the alternate hypothesis that trained subjects had shorter solution times was accepted.

STUDY II

Introduction

The purpose of this study, as with Study I, was to determine if experience in set-breaking would reduce the inhibitory effects of set. Set inhibition was measured by performance on a task in which a set was experimentally induced (Water Jar Problems) and on a task involving implicit sets (Unusual Uses Test).

Methods

Subjects

The subjects were 30 volunteers from two introductory psychology classes at Utah State University. Twelve subjects were male and eighteen were female. All subjects received extra credit points for participation in the study.

Variables

Anagrams: These were the same 18 problems described in Study I and listed in Appendix A.

Water Jar Problems: The WJP were the same as those described in Study I and listed in Appendix B.

Unusual Uses Test: This test is part of a battery of tests which make up the Torrance Tests of Creative Thinking, Form B. The Unusual Uses Test (UUT) is intended to measure the subjects ability to produce novel uses for familiar objects. The test consisted of two sheets of paper with spaces numbered 1 to 45. The following standard instructions appeared at the top of the first page:

> Most people throw their tin cans away, but they have thousands of interesting and unusual uses. In the spaces below and on the next page, list as many of these interesting and unusual uses as you can think of. Do not limit yourself to any one size of can. You may use as many cans as you like. Do not limit yourself to the uses you have seen or heard about; think about as many as possible new uses as you can. (Torrance, 1966a, p. 10)

Any questions the subject had were answered at this point. He was then told that he would have 10 minutes and was asked to begin. If a subject used all of the spaces provided he was given additional paper. (This actually happened only a few times).

The UUT was developed as a measure of creative ability. However, tests of creativity may be viewed as problem solving tasks which differ from other problem solving tasks only in that the solutions tend to be novel (Newell, et. al., 1962; Eisenstadt, 1966). In this case, correct solutions are those which call for using a tin can in an unusual (novel) way. Subjects may be expected to be inclined to give usual uses for tin cans. This inclination may be viewed as a set which may interfere with the production of other, more novel responses.

The UUT yields scores for Fluency, Flexibility, and Originality.

Each of these scores is thought to be a factor in creativity (Torrance, 1966b). To the extent that set-breaking is required for creative production, increased Set Flexibility should result in increased scores on Fluency, Flexibility, and Originality.

Procedure

Subjects were randomly assigned to one of two groups. Each group acted as both an experimental and a control group. Group A received the UUT, Anagrams, and WJP in that order. Group B received the WJP, Anagrams, and the UUT in that order:

A	B
UUT	WJP
ANAG	ANAG
WJP	UUT

The variables were administered to one subject at a time in a single session which lasted an average of about 45 minutes.

The first half of Study II was concerned with the effects of training on Set Flexibility as measured by the WJP. For this part of the study Group A acted as the experimental group. Training consisted of the UUT and the Anagrams, administered as described earlier. Following training, experimental subjects were given the WJP. Group B subjects were given the WJP without prior training and therefore acted as controls.

If the UUT and Anagrams increased Set Flexibility, trained subjects should show a greater tendency to use direct, non-set solutions on WJP. The hypotheses to be tested in this part of the study are identical to those of the first half of Study I, but will be repeated here for convenience:

Ho_1 There is no difference between treatment groups in the frequency of non-set solutions to items 7 and/or 8 (Set Avoidance).

Ha_1 The frequency of non-set solutions to items 7 and/or 8 will be greater for trained than for untrained subjects.

Ho_2 There is no difference between treatment groups in the frequency of solution to item 9 following set solution on items 7 and 8 (Set Breaking)

Ha_2 The frequency of solution to item 9 following set solution on items 7 and 8 will be greater for trained than for untrained subjects.

Ho_3 There is no difference between treatment groups in the frequency of non-set solutions to items 10 and/or 11 (Set Changing).

Ha_3 The frequency of non-set solutions to items 10 and/or 11 will be greater for trained than for untrained subjects.

The second half of Study II was concerned with the effects of training on Set Flexibility as measured by performance on the UUT. For this part of the study Group B was the experimental group. Training consisted of the WJP and Anagrams administered as described in Study I. Following training, experimental subjects were given the UUT. Group A were given the UUT first and therefore acted as a control group for this part of the study.

Changing sets is presumed to be an important variable in creative problem solving (Guilford, 1967a, b). If training increased Set Flexibility and if Set Flexibility is important in creative production, experimental subjects should obtain higher scores on the UUT. The hypotheses to be tested were as follows:

Ho_4 There is no difference in treatment groups in the mean Fluency scores on the UUT.

Ha_4 The mean Fluency score on the UUT will be higher for trained than for untrained subjects.

Ho_5 There is no difference in treatment groups in the mean Flexibility scores on the UUT.

Ha_5 The mean Flexibility scores on the UUT will be higher for trained than for untrained subjects.

Ho_6 There is no difference in treatment groups in the mean Originality scores on the UUT.

Ha_6 The mean Originality scores on the UUT will be higher for trained than for untrained subjects.

Results

As in Study I, only those subjects who solved at least four of WJP 2 through 6 were included in the analysis. There were two subjects who failed to meet this criterion, one in Group A and on in Group B. In addition, three subjects were excluded from analysis because of errors in testing or because of familiarity with the WJP. Thus, the present analysis is based on the data from 25 subjects, 13 experimental (Group A) subjects and 12 control (Group B) subjects. Of the Group A subjects, 6 were male and 7 sere female. Of the Group B subjects, 5 were male and 7 were female.

Set avoidance

As in Study I, Set Avoidance was defined as the tendency to give a direct solution to items 7 and/or 8 of the WJP. The number of subjects in each group giving direct solutions to items 7 and/or 8 was computed and subjected to chi square analysis.[1]

Chi square tests were run to determine if there were any differences between males and females in either treatment group. In Group A, the experimental group, a X^2 of .791 was found ($p > .30$, 2 tailtest). The control group yielded a X^2 of .274 ($p > .50$, 2 tailtest). Since these chi squares fall far short of significance, male and female subjects were combined for testing the hypotheses concerning Set Avoidance. The results of this analysis are presented in Table 8.

It is clear that there are no differences between treatment groups in Set Avoidance. Two of 13 trained subjects (15%) and 2 of 12 control subjects (17%) gave direct solutions to problems 7 and/or 8. These figures are as close to equal as could be produced with unequal n's.

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[1] All chi square analysis in this study were corrected for continuity using Yates' formula.

Table 8. Chi square analysis of frequency of direct solutions to items 7 and/or 8 (Set Avoidance).

Treatment	f direct solution	f set solution	X^2 df=1	p**
Trained (A)	2	11	.210	< .35
Untrained (B)	2	10		

** 1 tail test

The null hypothesis of no difference between treatment groups in Set Avoidance can not be rejected.

Set breaking

As in Study I, subjects who gave the indirect solution to items 7 and 8 were judged to have firmly developed a set. Eleven of the experimental subjects (4 males and 7 females) and 8 of the control subjects (4 males and 4 females) met this criterion. Subjects who gave set solutions to items 7 and 8 and then solved item 9 were judged to have broken or overcome a set.

Chi square analyses revealed no significant difference between male and female subjects in either group ($X^2 \leq .003$, $p > .95$, 2 tail test). Thus, male and female subjects were combined for the analysis, the results of which are shown in Table 9. Thirty-six percent of the experimental subjects solved item 9 compared to 25% of the control subjects, but this difference falls far short of statistical significance.

The null hypothesis of no difference between treatment groups in Set Breaking can not be rejected.

Table 9. Chi square analysis of frequency of solution to item 9 (Set Breaking).

Treatment	f solution	f non-solution	X^2 df=1	p*
Trained (A)	4	7	.001	> .48
Untrained (B)	2	6		

* 1 tail test

Set changing

As in Study I, subjects were shown the correct (direct) solution to item 9 after completion of that item. Subjects who then gave a direct solution to items 10 and/or 11 were more flexible than those who continued to use the set formula.

Once again there were no differences between males and females in either treatment group ($X^2 \leq .425$, $p > .50$, 2 tail test). Thus, the data for males and females were combined.

Eighty-five percent of trained subjects gave direct solutions to items 10 and/or 11 compared to 58% of the subjects in the control group (Table 10). This yields a X^2 of 1.03 ($p < .20$). Since this difference does not reach statistical significance, the null hypothesis of no difference between treatment groups in the tendency to change sets can not be rejected.

Table 10 Chi square analysis of frequency of direct solution to items 10 and/or 11 (Set Changing).

Treatment	f direct solution	f set solution	X^2 df=1	p*
Trained (A)	11	2	1.03	< .20
Untrained (B)	7	5		

* 1 tail test

For the second half of Study II, Group B was the experimental group and Group A was the control group. Training consisted of the WJP and Anagrams. If the training increased Set Flexibility, these subjects should obtain higher scores than control subjects on a measure of creative problem solving.

Of the 30 original subjects, one from Group B was excluded from analysis because of an error in the administration of Anagrams. Thus, usable data were obtained from 29 subjects, 14 in Group B (6 males and 9 females).

Table 11. Mean creativity scores on Unusual Uses Test

		Fluency	Flexibility	Originality
Male	Trained (B)	21.8	12.3	11.5
	Untrained (A)	21.0	11.8	12.2
Females	Trained (B)	21.5	12.5	13.5
	Untrained (A)	23.2	12.8	15.3

Fluency, flexibility, originality

Mean scores for Fluency, Flexibility and Originality are presented in Table 11. The data were analyzed by way of a 2x2 Analysis of Variance for each of the three scores. The results of these analyses are presented in Tables 12, 13 and 14. The mean scores are so similar that statistical analysis is hardly necessary. None of the F values reaches significance.

The Null hypotheses of no difference between trained and untrained subjects in Fluency, Flexibility, and Originality can not be rejected.

Table 12. Analysis of variance for mean scores on Fluency.

Source	SS	df	MS	F	p
Treatment	4.18	1	4.18	.78	NS
Sex	3.48	1	3.48	.65	NS
TXS	5.93	1	5.93	1.11	NS
Error	938.39	25	5.35 (Adjusted)		

Table 13. Analysis of variance for mean scores on Flexibility

Source	SS	df	MS	F	p
Treatment	.01	1	.01	.01	NS
Sex	2.78	1	2.78	1.57	NS
TXS	−2.26	1	−2.26	−1.28	NS
Error	309.72	25	1.77 (Adjusted)		

Table 14. Analysis of variance for mean scores on Originality.

Source	SS	df	MS	F	p
Treatment	1.56	1	1.56	.43	NS
Sex	6.50	1	6.50	1.81	NS
TXS	.29	1	.29	.08	NS
Error	632.33	25	3.60 (Adjusted)		

DISCUSSION

Set Flexibility and Induced Set

The WJP provide a measure of the degree of inhibition from an experimentally-induced set. One purpose of this research was to determine if resistance to such interference could be increased by training in set breaking.

There was no evidence in either study that training increased the likelihood of avoiding a set solution when a less cumbersome one was possible. There also was no improvement in the tendency to overcome a set, once formed. However, increased Set Flexibility on the WJP was demonstrated at a statistically significant level ($p < .02$) in the tendency to give up a set solution when a more effecient one was presented.

These results do not offer dramatic support for the view that Set Flexibility may be readily increased by training in set-breaking. However, the performance of subjects over all five test problems is more encouraging. Figure 5 shows the mean percent of direct solutions to problems 7 through 11. The proportion of direct solutions was calculated separately for males and for females. These were then averaged in order to allow equal weight to male and female subjects.

Figure 5 shows that trained subjects in both studies show an increasing tendency to use the non-set solution more frequently than control subjects.

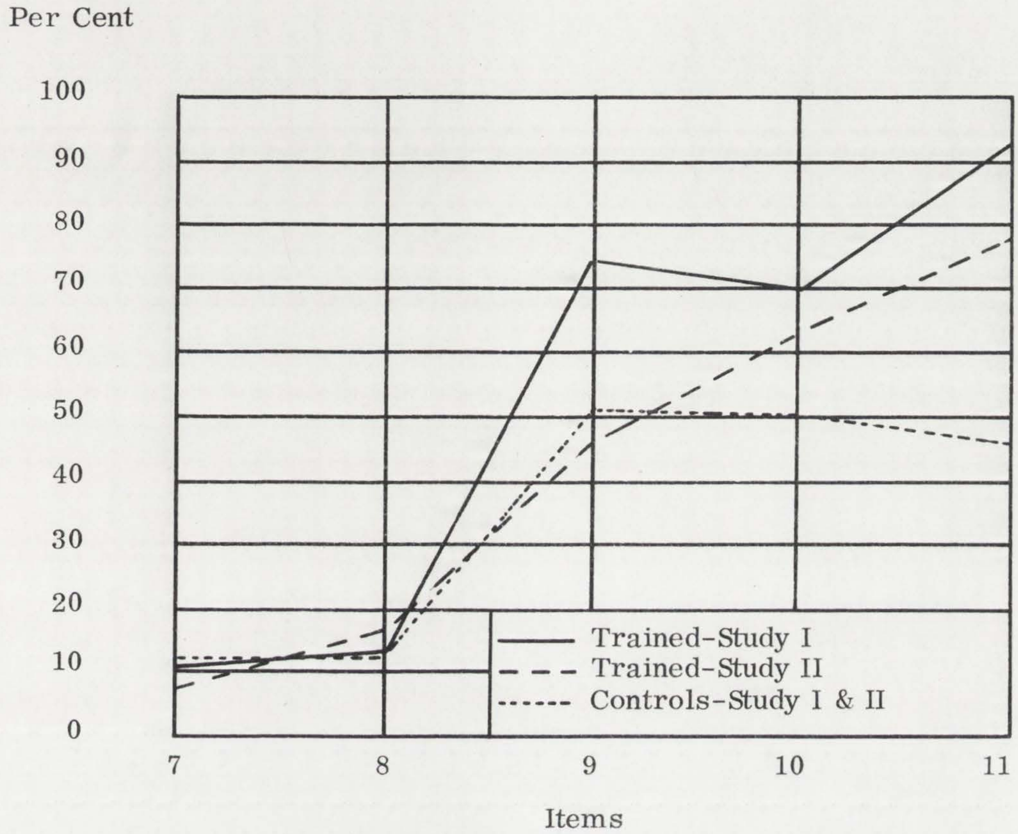

Figure 5. Percent of direct solutions to Water Jar Problems.

Figures above were obtained by computing male and female percents separately and then averaging them so as to give equal weight to each sex.

It will be noted that while control subjects showed a slight decline from item 10 to item 11, both trained groups showed an increase. This is important since all the problems require the subject to subtract except items 9 and 11 (See Appendix B). Thus, in addition to the set to use the indirect solution, subjects may have developed a set for subtracting. This is especially likely since even three of the five direct solutions require subtraction. The decline in performance of control subjects suggests inhibition from this set to subtract. Trained subjects show no evidence of this interference. This provides additional evidence of increased Set Flexibility on the part of trained subjects.

It was mentioned earlier that Jacobus and Johnson, (1964) demonstrated that subjects could acquire a set to adopt a set. The present research suggests it is possible to develop a set to give up an induced set when it becomes inappropriate.

Set Flexibility and Implicit Set

Performance on the Bridge, Pennies and Square problems was assumed to provide a measure of interference from implicit sets. It was hoped that Set Flexibility training would reduce such interference.

On the Bridge problem control subjects actually did better than trained subjects although this difference did not reach significance.

There were no differences between treatment groups on frequency of solution to the Pennies problem. Differences in mean solution times were also non-significant. However, both male and female trained subjects had lower solution times than control subjects. In fact, the mean for trained female subjects was less than half that of control females. While these differences are not statistically significant, they are consistantly in the predicted direction.

The frequency of solution to the Square problem was higher among trained subjects than among controls. This difference yielded a near-significant X^2 ($p < .10$). The solution times were also superior for trained subjects although this difference reached significance only in females.

There was so evidence that rraining was more effective for females than for males. On the Pennies problem control males had somewhat lower solution times than control females (23.8 and 30.8, respectively), but trained males and females had practically identical mean solution times (16.3 and 15.0, respectively). In addition, the improvement in Square solution times for females was statistically significant while that for males was not.

The research by Gibbons (1965) cited earlier was similar to the work reported here. However, in addition to providing training problems, Gibbons also instructed his subjects to "look for and eliminate" the interfering "assumptions" or sets. Earlier research (see, for example Maier, 1933) had already demonstrated that instructions to "avoid ruts," etc. would facilitate problem solving. What had not been demonstrated was that learning experiences in set breaking could facilitate problem solving. Since the present research did not use hints or instructions, the improvements in problem solving obtained may be attributed to the differential learning experiences of the subjects.

Set Flexibility and Creative Problem Solving

Newell, et. al. (1962) have suggested that creativity is "a special class of problem solving activity characterized by novelty, unconventionality, persistence and difficulty in problem formulation" (p. 66). Their description sounds like that of problems involving powerful interfering sets. Presumably, considerable flexibility would be required to solve such problems and other researchers have emphasized the importance of this factor (Guilford, 1967a, b). Thus, it seems reasonable to expect that an increase in Set Flexibility would facilitate creative production on the Usual Uses Test. However, there was no evidence that training in Set Flexibility improved creativity.

Trained and control groups had practically identical scores on Fluency, Flexibility, and Originality. Differences between males and females were also negligible. The Unusual Uses Test was presumed to require the subject to overcome sets concerning the normal uses of an object. Previous research in Functional Fixedness (Adamson, 1952; Duncker, 1945) has shown that such sets may be quite strong. Thus, it may be that the UUT involves long-established sets too powerful to be overcome by a short training procedure such as was used here.

The Importance and Limitations of Set Flexibility

Several authors have noted an inverse relationship between problem solving and creativity on the one hand, and rigidity, dogmatism, and authoritarianism, on the other (Eisenman, and Cherry 1970; Helson and Crutchfield 1970; Rokeach, 1948; Uhes and Shaver, 1970; Weissman, 1970). The importance of "flexibility" in problem solving and discovery have been stressed. Authors have identified the ability to see new relationships as characteristic traits of scientists (Barber, 1961; Roe, 1961) and of creative individuals (Guilford, 1950, 1967a,b; Stratton, 1970). Yet little has been done to determine what kind of learning history is most likely to produce such a tendency. It is suggested that Set Flexibility, and ability to change sets, is an important aspect of problem solving and creative production. The study of individuals who are creative or good problem solvers is limited since it has little potential for telling us how they became that way. It is suggested that research attention should be directed at experimentally producing learning histories which increase Set Flexibility.

The ability to avoid or overcome inappropriate sets is an important aspect of problem solving including creative problem solving. However, as Guetzkow (1951) has suggested, overcoming an inhibitory set does not guarantee problem solution. Rejecting an inappropriate set allows the subject to make other more appropriate responses, but it does not give him those appropriate responses. The training used here was directed at producing a set for trying alternative responses, but it did not attempt to increase the subjects repertoire of alternatie responses. Research efforts should be directed at increasing Set Flexibility and improving the response repertoire of individuals over a prolonged period of time. The possibility that such training will substantially improve an individual's performance is worth investigation.

Limitations of the Study

The research reported here would have been strengthened had the training procedure been altered slightly. For those subjects who received the WJP first, these problems formed part of their training in Set Flexibility. However, no feedback was given following completion of these problems. Before proceeding to the Anagrams, the experimenter could have shown subject the direct solution to any of problems 7 through 11 to which subject had given the set solution. Instead, feedback was provided only after item 9. Providing more complete feedback at the end of the series of problems might have made the training procedure more effective.

The Unusual Uses Test was used as part of the training procedure for one group. However, no feedback was given to subjects. Thus, while the UUT may have provided practice in set-breaking, it was probably not effective in increasing Set Flexibility.

Suggestions for Further Research

Set Flexibility would seem to merit further attention. The present research suggests that people can acquire a willingness to give up a set that interferes with performance. However, research is needed to identify what kinds of learning experiences will be most effective in increasing Set Flexibility.

Studies which use a longer training period would almost certainly provide helpful information.

Finally, studies which compare the effects of a given training procedure on various dependent variables could provide a gradient of transfer for Set Flexibility. Programmed materials, used as independent and dependent variables, might be particularly useful.

A Note about the Research Design

So far as the writer knows, the experiments reported here are the first to have groups which act as both experimental and control groups simultaneously. This means that what would ordinarily be one study becomes, in essence, two parallel studies.

Of course, this design does not lend itself to a wide variety of research problems. This is because a *dependent* variable must also be appropriate as an *independent* variable. While this requirement severely limits the applicability of the design, there are a number of variables used in problem solving research which can easily act as both independent and dependent variables.

This design provides greater efficiency in that two studies are conducted with only slightly more work than one ordinary study. In addition, fewer subjects are needed since each subject is "used" twice. Finally, the problem of experimenter bias (Rosenthal, 1966) may be reduced. It is more difficult for the experimenter to "favor" an experimental group if each group is an experimental group.

This design would appear to be an attractive alternative to the traditional two group design. While it may be most appropriate for research in problem solving, it is hoped that researchers in other areas will also find it useful.

SUMMARY AND CONCLUSIONS

Two experimental studies were reported in which attempts were made to increase resistance to the negative effects of set: that is, to increase Set Flexibility.

Study I

Subjects were assigned to one of two groups. Each group acted as both an experimental and a control group. Group A received the Bridge, Pennies, and Square problems (BPS), Anagrams, and Water Jar Problems, in that order. Group B received WJP, Anagrams, and BPS in that order:

A	B
BPS	WJP
ANAG.	ANAG.
WJP	BPS

In the first half of this study training consisted of the BPS problems and Anagrams. The dependent variable was the frequency of non-set solutions to the WJP. The purpose of this part of the study was to determine if training in set-breaking would increase Set Flexibility as measured by the WJP. The results indicated that training did not help subjects avoid an inappropriate set nor to overcome a set once it was formed. However, trained subjects were more likely to give up the set response for a more appropriate solution on the last two items ($p < .02$).

In the second half of this study training consisted of the WJP and Anagrams. The dependent variables were the frequency of solution and solution times to the BPS problems. The purpose of this part of the study was to determine if training in set-breaking would increase Set Flexibility as measured by solution frequency and solution times on the BPS problems.

The results revealed no significant difference between trained and control subjects on frequency of solution. However, the difference between trained and control subjects on the Square problem approached significance ($p < .10$). The difference in solution time to the Square problem was found to be significant ($p < .05$) for females, but not for males. Solution times were lower for trained subjects on the Pennies problem, but this difference did not reach statistical significance.

<u>Study II</u>

Subjects were assigned to one of two groups. As in Study I, each group acted as both an experimental and control group. Group A received the Unusual Uses Test (UUT), Anagrams, and WJP, in that order. Group B received the WJP, Anagrams, and the UUT in that order.

A	B
UUT	WJP
ANAG	ANAG
WJP	UUT

The first half of Study II was concerned with the effects of training of Set Flexibility as measured by the frequency of non-set solutions on the WJP. There were no significant differences in frequency of non-set solutions, although frequency of non-set solutions to the last two problems approached significance ($p < .20$).

The second half of this study was concerned with the effects of training on Set Flexibility as measured by the UUT. Scores for Fluency, Flexibility, and Originality revealed no difference between trained and control subjects.

Conclusions

It is concluded that Set Flexibility training increased the tendency to give up an experimentally-induced set when a more efficient response was made available. There was no indication that training increased the ability to avoid interference from an induced set, or to overcome a set once formed.

There is some evidence that Set Flexibility training increased the tendency to overcome an implicit problem solving set. This tendency reached a statistically significant level only on solution time to the Square problem and only among females.

It is concluded that Set Flexibility training had no effect on the tendency to overcome implicit sets on a measure of creativity.

The research reported here supports the conclusion that interference from sets (implicit or experimentally-induced) is a function of the individual's learning history with regard to sets generally. Experiences which require set-breaking appear to reduce interference from sets. Investigations which attempt to clarify the relationship between learning history and resistance to set interference should be productive.

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APPENDIXES

APPENDIX A

Anagrams

Set I

1. EPHES	SHEEP
2. LECMA	CAMEL
3. RETIG	TIGER
4. NKSUK	SKUNK
5. ABZER	ZEBRA
6. IBHCR	BIRCH

Set II

1. RTIKS	SKIRT
2. OAPNR	APRON
3. CSFRA	SCARF
4. SDESR	DRESS
5. IHRST	SHIRT
6. AINOP	PIANO

Set III

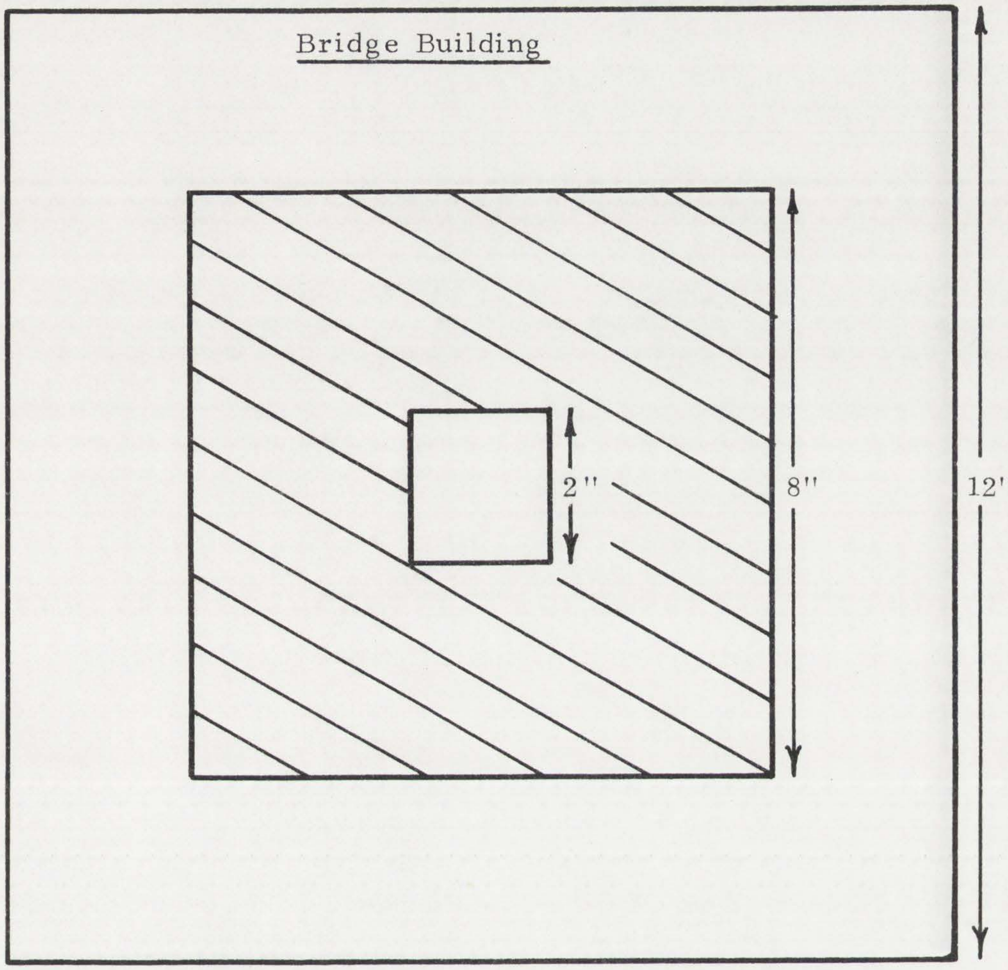
1. KOTRS	STORK
2. AELGE	EAGLE
3. SEGOO	GOOSE
4. BRNIO	ROBIN
5. PLEPA	APPLE
6. EVANR	RAVEN

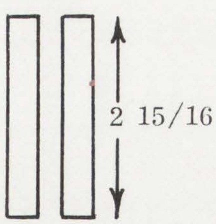
APPENDIX B

Measuring

	Given these buckets:			Get this amount:
1.	43	89	2	42
2.	25	59	2	30
3.	32	69	3	31
4.	52	78	3	20
5.	43	93	4	42
6.	31	61	4	22
7.	17	37	3	14
8.	41	86	4	37
9.	47	68	4	51
10.	27	59	5	22
11.	13	35	3	16

APPENDIX C





VITA

Paul B. Chance

Candidate for the Degree of

Dr. of Philosophy

Dissertation: Increasing Resistance to the Negative Effects of Set

Major Field: Psychology

Biographical Information:

Personal Data: Born in Glen Burnie, Maryland, September 15, 1941, son of Edward G. and Dorothy E. Chance; married Diane E. Pfeiffer November 7, 1960; no children.

Education: Attended public schools in Glen Burnie, Maryland; received Bachelor of Science degree from Towson State College (Maryland) with a major in English, 1963; received Master of Arts degree in psychology from University of Northern Colorado, 1966.

Professional Experience: 1963 to 1965, public school teacher; 1967 to 1970, psychologist, U. S. Navy; 1972 to present, Manuscripts Editor, Psychology Today magazine, Del Mar, California.