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**Learning-Performance Distinction in the Water Jar Test**

**by**

**Carol Rothman Karzen**

**A Thesis Submitted to the Faculty of the Graduate School  
of Loyola University in Partial Fulfillment of  
the Requirements for the Degree of  
Master of Arts**

**November**

**1965**

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## Chapter 1

### Introduction of Test and Problem

Failure on the part of experimenters working on the Water Jar Einstellung Test (WJT) to consider whether stress conditions influence learning or performance has stimulated this study. "Learning always must remain an inference from performance and only confusion results if performance and learning are identified." (Hilgard, 1956) In spite of this warning, review of literature on the WJT indicates an arbitrary useage of these terms, with no attempt having been made to determine whether performance independent of learning has taken place, or, if learning does take place, whether it has been accurately gauged through its symptoms in performance.

For example, Silvers (1953) finds that stress produces the same kind of impairment on "performance" as an abstracting test in both flexible and rigid Ss. He concludes that the WJT is a simple "learning" paradigm not related to the measurement of rigidity. Luchins (1956) also refers to the WJT as a learning paradigm and compares it to other tasks used in learning experiments. It is characterized by the fact that one of two competing responses is made dominant. Levitt, on the other hand, in reviewing five studies on stress labels this section "performance on the WJT under stress".

The version of the water-jar test used in this study is of the

type designed by Luchins. The S is required to manipulate the contents of three water jars of known quantity in order to obtain a specified amount of liquid. For example, the S is told that he has a 21 quart jar, a 127 quart jar, and a three quart jar. He must get 100 quarts of water using only the maximum capacities of the jars for measures. Solutions for the Einstellung problems require the use of a complex  $B - A - 2C$  formula. Following administration of the Einstellung problems are the critical problems which may be solved either by the Einstellung formula or a relatively simple method such as  $A - B$  or  $A + B$ . Solution of a critical problem by the complex formula rather than by the simpler method is taken as an indication that a mental set has been strengthened. This phenomenon of fixated responses or mental sets might be explained by a number of "learning" theories.

Krechevsky breaks the learning process into two distinct stages. According to his theory a "pre-solution period" exists in which incorrect hypothesis are tried and rejected until the correct one is discovered. In the solution period the correct response (in this case the  $B - A - 2C$  formula for the Einstellung problems) is adopted and strengthened. This corresponds to the hypothesis behavior of Tolman and Krech in which a "provisional try" is either confirmed if successful or denied if unsuccessful. If confirmed it becomes a model to be followed in similar circumstances. Thorndike's "law of multiple response" refers to the tendency of the individual to

vary his response until the correct one is found. The "law of effect" then states that as a result of reinforced practice there is a great probability that this response will occur earlier in the response hierarchy in similar situations.

The general hypothesis underlying this study is that mental sets develop to a greater degree when "learning" takes place in stressful rather than non-stressful situations. In attempting to evaluate this statement we must make the all important distinction between learning and performance and also establish just what is meant by stress.

Learning may be thought of as a "relatively permanent" change in response potential brought about by reinforced practice. Performance is the translation of this response potential into behavior and is often thought to be affected by short term factors such as motivation and amount of practice. Even this distinction is somewhat ambiguous since it has not been proven that motivation has no effect upon learning. Hull discusses these concepts in his 1943 continuity theory of learning. He considers learning a gradual process in which habit strength varies in direct proportion to number of reinforced trials. "Before habit reveals itself in performance however, it is transformed into 'reaction potential' through its interaction with such variables as generalization and motivation."

The problem of differentiating the influence of motivational factors such as stress upon these two variables is extremely difficult.



It is necessary to consider the concept of stress in two ways. Situational stress refers to those reactions which most people exhibit in specific situations designated as stressful. Individual stress reactions on the other hand refers to the unique reaction of an individual in any situation in which the reaction is attributed to a general personality characteristic of the individual rather than to the threatful nature of the situation. Different people react differently in stress situations and individual stress reactions may be a function of many unrelated variables such as motivation or change in approach or orientation to the task. Luchins, in his approach, has emphasized situational factors as main determinants of increased use of Einstellung solutions, while such experimenters as Rokeach have emphasized individual stress reactions in the establishment of strong mental sets.

Since it is difficult to consider stress as a concept relating exclusively to stimulus or response, we may consider it a secondary concept inter-related with the concept of motivation and the situation itself. We may think of a situation as stressful when it threatens self-esteem or the attainment of a goal. In administering varying degrees of stress to individuals in a group setting it is assumed that the individual stress reactions will be equally divided among the groups so that situational stress becomes the contributing factor to group differences.

One of the most difficult methodological problems confronting

a psychologist dealing with the laws of learning is that the only data available to him are the performance data from which he must assess the value of the learning involved. This can be accomplished through the use of a factorially designed experiment which is the standard method of separating learning and performance effects.

## Chapter 2

### Review of Related Literature

In 1927, Karl Duncker and Karl Zener of the University of Berlin first utilized the Water Jar Einstellung Test (WJT) in habituating Ss to solve certain types of problems in a given way. Little work was done in this line until the introduction of the WJT into American psychology by Abraham Luchins in 1942.

Luchins' comprehensive monograph (1942) asks whether the individual taking the WJT is indeed "blinded" to the possibility of a simpler solution after having worked problems in the more complex Einstellung manner. Luchins defines Einstellung as "the set which immediately predisposes an organism to one type of motor or conscious act." (Warren, 1934) If a blinding process does occur, is it affected by age, educational levels, or IQ of the Ss? Further, is it influenced by variations in the test such as number of Einstellung problems, or separation of E tasks from test tasks by time intervals or comments to the Ss? Luchins administered the WJT and numerous variations to different groups of Ss and, in general, found that the degree to which the Ss were "blinded" to the possibility of a more simple and direct solution to the test problems was indeed affected by variation of test and Ss.

Since Luchins' monograph, a vast amount of research and con-

troversty has surrounded the WJT. Experimental research has been attempted which correlates the test with: political attitude scales (Brown, 1953; Jackson, Messick, and Solley, 1957); anxiety scales (Ainsworth, 1958); perceptual-motor tasks (Schale, 1955; Forster, Vinacke, and Digman, 1955); diagnostic tests (Applezweig, 1954); intelligence tests (Luchins, 1951); etc.

In 1956, Levitt reviewed 31 studies in which the WJT had been used to measure personality or problem solving rigidity. Of these 31 studies Levitt classified five as having positive results, 10 as ambiguous, and 16 as negative. A study is classified as positive, according to Levitt, if more than 75% of the reported correlations were significant at the .05 Level or beyond. It is classified as negative if less than 25% were significant. All the remaining studies are considered ambiguous. In 1959, Levitt replicated his 1956 review of the WJT without limiting the WJT to measures of rigidity. Using the same criterion as in his previous study, Levitt determined that of the 26 studies reviewed that three studies have positive results, 11 have ambiguous results, and 12 have negative results.

In Levitt's 1956 review, those investigations which are especially pertinent to this study concern "performance on the WJT under stress". Pally (1955) randomly assigned 80 college students to four experimental conditions. Groups A and B experienced failure prior to administration of the WJT, Group C experienced success, while Group D was a comparison group. Pally found that "rigidity", defined as

"the inability to utilize a more simple direct method as against a complicated one in the solution of a prearranged set of numerical problems", was exhibited more frequently by Ss working under threatening rather than non-threatening conditions. Levitt regarded Pally's study as ambiguous due to faulty experimental design. Pally used 10 critical equations followed by an extinction equation. Levitt felt that Pally's four criterion measures: 1) time required to solve the first critical equation by the short solution, 2) number of Ss solving the extinction problem, 3) mean number of critical problems solved, and 4) mean time for extinction solution, were not independent measures since the Ss stopped working after correctly solving a criterion problem.

Levitt felt of the five studies he reviewed on performance under stress that only those of Cowen were positive. Cowen (1952) hypothesized that "increasingly stressful psychological atmospheres will tend to elicit rigid problem-solving behaviors". Having three groups of 25 college juniors each, Cowen administered mild stress (MS) to one group, severe stress (SS) to another, while a third group served as a control. The MS group was given a non-soluble puzzle prior to the critical problems. This was to induce mild stress through lack of closure. The SS group was told that they were the standardizing group for a new projective device and then they were given the Levy Movement Cards. The Ss were then recalled and told that the presence of maladaptive features had been found and that

further testing was needed to verify this diagnosis. They were then given the WJT. Cowen found the SS group greater than the MS group, and the MS group greater than the C group, in the non-solution of extinction problems and in slower reacting time.

Maher (1957) stressed his Ss with "achievement anxiety". He implied that the WJT was an intelligence test needed to help in assigning class grades. There was a significant increase of WJT rigidity in the experimental group over the control group.

Ainsworth (1958) hypothesized that "problem-solving rigidity is attributable to insecurity experienced in the problem-solving situation". He divided 120 university students into four groups on the basis of insecurity and defensiveness in their general life adjustment as measured by four tests of security-insecurity constructed by Ainsworth and Ainsworth. Ainsworth felt that the more insecure individual would be subject to a greater degree of stress than the secure individual under the same circumstances. Of the four groups, group A was tested under relaxed conditions with no time limit and groups B, C, and D received increasing increments of stress. Significant support was found for Ainsworth's hypothesis that rigidity is related to situational stress as well as insecurity in general life adjustment.

In each of the studies previously discussed, with the exception of Cowen's, varying degrees of stress were induced prior to administration of the Einstellung or learning equations. In

Cowen's study, on the other hand, the only difference between the control group and the mild stress group was administration of a stress inducing puzzle prior to the critical or performance equations. Conditions under which learning took place was identical for these two groups. That Cowen found a significant difference between the control and the mild stress groups suggests that performance on the WJT is affected by stress regardless of degree of stress on the learning equations.

## Chapter 3

### Experimental Design and Procedure

The purpose of this study was to determine the effect of situational stress upon learning, as differentiated from performance, on the Water Jar Einstellung Test (WJT). This was attempted by using a factorially designed experiment to separate learning effects from performance effects. This experimental design calls for separation of two or more groups of Ss to be trained under different conditions known to affect levels of performance. These groups are then subdivided, one group continuing under the original condition, the other switching to an alternative condition. The Ss' behavior in the second phase of the experiment is then analyzed. If there is a residual effect of previous training after the training condition has been altered, then it is assumed a learning variable was present.

#### Subjects

The subjects used in this study were 79 high school sophomores comprising four "average" math classes--classes in this school being divided into "below average", "average", and "above average" on the basis of Otis scores, scores on the ITED, and reading scores on the SCAT. Since students were placed in classes merely on the basis of time available for the class it was assumed that no difference existed among the groups and therefore they would not differ significantly in



any variable which might affect the measured response. Each class was tested under one of the four experimental conditions. Twenty Ss had been eliminated after the testing since their responses to the critical equations had been incomplete, incorrect, or had been worked in a manner which utilized neither of the acceptable methods of solution.

### Procedure

All the Ss were given the test forms and a sample problem was worked on the board (see appendix). The instruction preceding the Einstellung equations on the test forms was read to the Ss.

Group I (N = 23) and Group II (N = 20) received the following NON-STRESS instructions:

Your task is to figure out on paper how to obtain a required volume of water -- given certain empty jars for measures. No other measure except the maximum capacities of the jars can be used.

Work each problem in order and do not go back.

Group III (N = 19) and Group IV (N = 17) received the following STRESS instructions:

Your task is to figure out on paper how to obtain a required volume of water -- given certain empty jars for measures. No other measure except the maximum capacities of the jars can be used. Work each problem in order and do not go back.

It is important to WORK AS RAPIDLY AS POSSIBLE AS there is a time limit of ten minutes.  
DO YOUR BEST! The results of this test have been found to be related to academic success.

Upon completion of the Einstellung equations the Ss broke the staple seal on the bottom of page one and went on to the critical problems on the next page. Groups I and III received no additional instructions between the Einstellung and the critical problems. Group II received the following STRESS instructions before the critical equations.

It is now important to WORK AS RAPIDLY AS POSSIBLE  
as there is a time limit on this section.  
DO YOUR BEST! The results of this test have been  
found to be related to academic success.  
RAISE YOUR HAND WHEN YOU ARE FINISHED.

Group IV received instructions prior to the critical equations which were designed to nullify the STRESS instructions previously given.

This page WILL NOT be graded by your instructor.  
TAKE YOUR TIME. The time limit does not apply here.

In general then, each test is divided into two sections: 1) nine Einstellung or learning equations, and 2) six critical or performance equations. Groups I and II learn under NO-STRESS conditions. While Group I performs under this condition also, Group II performs after STRESS instructions have been administered. Groups III and IV learn under the STRESS condition. This stress is continued through performance for Group III but void before performance for Group IV. See Table 1.

Table 1

Method of Dividing Ss into Groups

Equations	Groups			
	I	II	III	IV
	NON-STRESS Instructions		STRESS Instructions	
Einstellung Equations	learning	learning	learning	learning
	Break	STRESS	Break	VOID-STRESS
Critical Equations	perform.	perform.	perform.	perform.

## Chapter 4

### Results

The factorial design of this experiment permits analysis of results to determine whether situational stress on the WJT is a learning variable or a performance variable. Scores represented in Table 2 indicate the number of Ss in each experimental condition who utilized either the Einstellung (B - A - 2C) formula for solution of the critical problems, or a simpler (A - B, or A + B) method of solution. The assumption is that stress increases the Ss' use of the previously learned formula.

Table 2

Number of Subjects Utilizing the  
Einstellung or Simpler Method of  
Solution for the Critical Equations  
(Excluding 20 Unqualified Subjects)

Method of Solution	Groups			
	I	II	III	IV
Simple Method	8	4	1	2
Einstel- lung Formula	15	16	18	17

The significance of difference between the experimental groups in their method of solution of the critical problems is presented in Table 3.

Table 3

Significance of Difference  
Among Experimental Conditions  
(N = 79)

Group Comparisons	$\chi^2$
All Groups	6.693
I & LI vs III & IV	4.88*
I & IV vs II & III	1.39
I vs II	.54
I vs III	3.86*
III vs IV	0

\* Significant at .05 Level

In the factorially designed experiment, if there is no change in behavior after the change in conditions then a learning rather than a performance variable is assumed to be present. Groups I and II both learned under NON-STRESS instructions. The administration of stress prior to performance in Group II did not produce a significant difference between the two groups. In the same way, while Group III and Group IV both learned under STRESS conditions, voiding this stress before performance in Group IV did not produce a significant difference between the two groups in their utilization of simpler solutions for the criterion questions. The two groups (Groups I and II) that learned under NON-STRESS instructions are significantly different from the two groups (III and IV) that learned under STRESS instructions. But the two groups that performed under NON-STRESS instructions (Groups I and IV) do not differ significantly from Groups II and III that performed under STRESS instructions.

## Chapter 5

### Discussion and Conclusion

Results presented in Table 1 and Table 2 show a significant difference between the two groups (Groups I and II) that learned under NON-STRESS conditions, and the two groups (Groups III and IV) that learned under STRESS conditions. Table 2 also shows a significant difference between Group I, the group that learned and performed under NON-STRESS instructions, and Group III, the group that learned and performed under STRESS instructions. These results suggest that situational stress is a learning variable which influences the degree to which a mental set is established on the WJT.

On the other hand, no significant differences were found between the groups in which a change was made in conditions after the learning had already taken place. Group I did not differ significantly from Group II even though Group I performed under the original NON-STRESS instructions while Group II performed under STRESS instructions. Nor was there a significant difference between Group III and Group IV even though the attempt was made to void stress prior to performance by Group IV. No indication of a significant difference was found between Groups I and IV (the groups which performed under stress) and Groups II and III (the groups which performed under NON-STRESS instructions).

these results suggest that situational stress on the WJT is not a performance variable.

There are several possible interpretations for the findings reported in this study. Perhaps situational stress on the WJT is indeed a learning rather than a performance variable as results of this study would indicate. This would be consistent with findings reported by such experimenters as Pally (1955), Cowen (1952), Maher (1957), and Ainsworth (1958); and would seem to verify the claim of Luchins and others that the WJT is indeed a simple learning paradigm in which a "relatively permanent" change in the Ss' response hierarchy has been brought about by reinforced practice. The reward in this case would be the immediate reduction of tension as the solutions to the Bin-stellung equations are rapidly found. The greater the initial tension the greater is this reward potential.

The interpretation that situational stress is not a performance variable is contrary though, to the results found by Cowen (1952). In his study a significant difference was evidenced between two groups differing only in that stress was induced prior to performance by one group but not the other. Cowen introduced stress in the form of a non-soluble puzzle administered prior to the critical equations. It is possible that situational stress is indeed a performance variable as evidenced by Cowen's study, and that in the present study the lack of significant difference evidenced between groups separated after learning had taken place reflects an inadequate attempt at producing



different degrees of group stress. This seems unlikely in explaining the lack of significance between Groups I and II since the same stress instructions when introduced to Group III prior to the Einstellung equations produced a significant difference from Group I. It is possible however, that the lack of difference evidenced between Groups III and IV reflect an inadequate attempt to void the stress condition under which learning had taken place for Group IV.

On the basis of evidence presented in this study, it might be suggested that situational stress on the WJT is a learning rather than a performance variable, and that this situational stress will affect the degree to which mental sets are exhibited in responses to the WJT. As previously mentioned, of 57 studies reviewed by Levitt in 1956 and 1959, eight were classified by Levitt as having positive results, 21 as having ambiguous results, and 28 as having negative results. It should be noted that Levitt would probably classify the results of this study as ambiguous since more than 25 per cent but less than 75 per cent of the reported correlations are significant at the .05 level or beyond. Thus, this study falls within a large body of contradictory and ambiguous evidence accumulated on the WJT since its introduction in 1942. It is suggested that further research be attempted on the WJT utilizing the factorially designed experiment in an attempt to clarify those factors contributing to mental sets.

## Chapter 6

### Summary

The general hypothesis of this study is that situational stress affects learning, as distinguished from performance, on the Water Jar Einstellung Test (WJT). The concepts of learning, performance, and situational stress have been considered in evaluating this hypothesis, as well as the factorial method for separating learning variables from performance variables. In the factorially designed experiment two groups of 36 are trained under different conditions and then the groups are subdivided. One group continues under the original condition, the other group is switched to an alternative condition.

Seventy nine high school sophomores comprising four average math classes were tested under the following conditions. Group I learned and performed under NON-STRESS conditions. Group II learned under NON-STRESS conditions but performed under STRESS conditions. Group III learned and performed under STRESS conditions. Group IV learned under STRESS conditions but performed under NON-STRESS conditions. A time stress was utilized in establishing the stress conditions.

No significant difference was found between the groups in which a change in conditions had been made after the learning or Einstellung equations had been completed. There was a difference evidenced though, between the groups that learned under NON-STRESS conditions and those

that learned under STRESS conditions. Results of this study suggest that situational stress administered prior to learning the Einstellung equations increases the degree to which mental sets are exhibited. Situational stress administered after the Einstellung equations but prior to performance on the critical equations did not affect the degree to which mental sets develop. Several possible interpretations for these results were suggested.

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## **APPENDIX**

GENERAL INSTRUCTIONS TO SS GIVEN ORALLY PRIOR  
TO DISTRIBUTION OF MIMEOGRAPHED TEST FORMS

"I am now distributing mimeographed sheets of paper on which there are a series of numbers.

(The test forms are handed out and the instructions on the front page are read aloud.)

"Let us work a sample problem. (on board)

A.  $\boxed{29}$   $\boxed{3}$  get 20

"Using the maximum capacity of the jar we fill the 29 quart jar once and from it fill the 3 quart jar 3 times. Your equation should look like this.

$29 - 3 - 3 - 3 = 20$  (on board)

"Now let us work problem 1.

$\boxed{21}$   $\boxed{127}$   $\boxed{3}$  get 100 (on board)

"Try this.

(When SS are finished.)

"Your work should look like this:

$127 - 21 - 3 - 3 - 3 = 100$  (on board)

"One fills the 127 quart jar once and from it fills the 21 quart jar once and the 3 quart jar twice. Any questions?"



I /

Your task is to figure out on paper how to obtain a required volume of water -- given certain empty jars for measures. No other measure except the maximum capacities of the jars can be used.

Work each problem in order and do not go back.

1. [21] [127] [3] get 100

2. [13] [83] [28] get 14

3. [8] [61] [6] get 41

4. [24] [52] [3] get 22

5. [19] [42] [3] get 17

6. [31] [61] [12] get 6

7. [29] [72] [4] get 35

8. [36] [86] [20] get 10

9. [6] [21] [4] get 7

10.     $\boxed{24}$      $\boxed{72}$      $\boxed{8}$     get 32

11.     $\boxed{15}$      $\boxed{39}$      $\boxed{3}$     get 18

12.     $\boxed{14}$      $\boxed{36}$      $\boxed{8}$     get 6

13.     $\boxed{28}$      $\boxed{65}$      $\boxed{9}$     get 19

14.     $\boxed{18}$      $\boxed{48}$      $\boxed{4}$     get 22

15.     $\boxed{28}$      $\boxed{59}$      $\boxed{3}$     get 25

### APPROVAL SHEET

The thesis submitted by Carol Rothman Karzen has been read and approved by three members of the Department of Psychology.

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

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

April 1, 1966  
Date

Frank J. Koblitz  
Signature of Adviser