DIFFERENTIAL EFFECTS OF DISTRACTION ON THINKING

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

Philip K. Jensen

1954

This is to certify that the

thesis entitled

DIFFERENTIAL EFFECTS
OF
DISTRACTION ON THINKING

presented by

Philip K. Jensen

has been accepted towards fulfillment
of the requirements for

M.A. degree in Psychology

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Date December 2, 1954

DIFFERENTIAL EFFECTS OF DISTRACTION ON THINKING

By

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A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

MASTER OF ARTS

Department of Psychology

Year 1954

Approved _____

ACKNOWLEDGMENT

The author wishes to express his thanks to Dr. Donald M. Johnson, without whose constant interest and helpfulness this study could not have been brought to completion, and to whom these results are herewith dedicated.

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INTRODUCTION

"Since the time of the classical experiments of the Würzburg school virtually all investigators have recognized, implicitly if not explicitly, that a major feature of thinking processes is their directed character." (4) "It has never been clear however, whether the thinking process was directed by another process or whether the thinking process was itself simply characterized by directedness. Writers who accept the latter alternative in theory are usually forced back upon the former alternative when they do an experiment." (5)

While the problem of set is as old as the field of experimental psychology little work has been done upon it. Mowrer (8) points out that practically all of the information we have on this area is the result of the work of the early introspectionist studies. These studies indicated that set may be the key to understanding problem solving and creative thinking. The looseness and confusion of the terminology in this area is demonstrated by Gibson's (5) list of current variants: mental set, motor set, neural set, voluntary set, unconscious set, postural set, organic set, preparatory set, task set, situation set, goal-set, temporary set, permanent set, set to react, set to perceive, expectation, hypothesis, anticipation, foresight, intention, attitude, directing tendency, determining tendency, tension, vector, need, attention, perseveration, preoccupation.

The original set concept of Einstellung was developed by Marbe,

Ach, and Watt. (5) In the beginning this concept was well defined and limited; later its meaning changed and it became a muscular concept having no central basis in the nervous system. It was in effect the simple readiness of the musculature to respond. Complications developed in such studies as those of Mowrer, Rayman, and Bliss (9) which demonstrated that a difference in expectation causes a difference in reaction time even when the muscular assignment is the same. Rees and Israel (10) established two different types of set in their subjects depending upon the method of solution of anagrams. One solution was based on letter position, the other, on word types such as food. Sells (11) with Woodworth demonstrated what they term an "Atmosphere effect" in which syllogisms are solved in terms of sounding like the premises rather than on logical validity. While many recent experiments have concerned the presence or type of set little research has been devoted to its dynamics or nature.

The early studies on set by the introspectionists began to conflict with the Wundtian view of the reaction and problem processes. Instead of finding the mental activity during the reaction time, these studies suggested that most of the conscious mental work was done in the preparatory period. Exner, (3) the coiner of the term "reaction time," said, "While one is awaiting the stimulus with tense attention one feels an indescribable something going on in his sensorium, which prepares for the quickest possible reaction . . . . If the sensorium is in this state, the reaction is involuntary, i.e., no new will impulse is needed after the entrance of the stimulus in order that the reaction shall follow." This opinion was substantiated by Wundt's

assistant Cattell. (15) Ach, (1) in 1905, agreed that the foreperiod between the ready signal and the stimulus contained everything of reportable significance, while the remaining periods contained little or nothing.

Perhaps the classical study of this type is that of Watt, (13) especially since it deals with this problem in the case of problem solving rather than simple reaction time. Watt used words presented visually as stimuli, and alternated between six tasks. These were: to name a supraordinate concept; to name a subordinate concept; to name a coordinate concept; to name a part of the given whole; to name a whole including the part; to name another part of the same whole. Watt first assigned the task, then presented the word stimuli by means of a card changer. He recorded the reaction times by means of a voice key and chronoscope and after each response had the subject introspect on his own performance. He divided the time of the reaction into three parts. The foreperiod, which lasted from the task assignment until the stimulus presentation, was followed in order by the main period, stimulus to response, and finally the afterperiod, of indefinite length following the response. Watt reports that the foreperiod was occupied in this manner.

> "O made the task clear to himself in a verbal, visual, or kinesthetic form. He defined the relation, or found an example, or got a diagram or gesture symbolizing the relation. He also made appropriate muscular adjustment....and muscular tension. When the stimulus word arrived, the reaction followed sometimes automatically, sometimes after an interval of waiting or searching, sometimes after false reactions had been suggested and rejected. Only in the last case did the definite consciousness of the task emerge again during the main period; usually it was confined to the foreperiod."

With a repetition of the task conscious awareness faded out altogether. Watt listed three factors which determined the response in this situation: 1) stimulus word, 2) its associations, 3) the task set. He concluded that the set made any purely associative explanation of the thought processes impossible.

May (6) repeated this study in a more varied manner. He varied the length of the foreperiod, he let the subject choose his own foreperiod, and, finally, he assigned the task in different ways. May found that, as familiarity with the situation increased, the subject, in both his introspective reports and in his reaction times and choice of shorter foreperiods, showed less mental operations before the response.

Several non-introspectionist studies have been run on the optimal foreperiod in a simple reaction time situation. Woodrow, (14) using auditory stimuli on three subjects, determined the optimal length of the foreperiod as two to four seconds. This was roughly in accord with the later study of Telford (12) which suggested one to two seconds as the most favorable foreperiod. Woodrow further found that varying the foreperiod slowed down the responses greatly. He then extended the length of the foreperiod to better than twenty seconds. The curves of reaction times for any given foreperiod tended to level off at around twenty seconds.

Woodworth (15) has suggested three possible curves of readiness in a long foreperiod. One would be when readiness is immediate then deteriorates with time; the second, when readiness reaches a peak at the expected time of the stimulus; the third, a slow increase and

decrease with no peak potential. This last view has been partly substantiated by Mowrer (8).

At present then we find ourselves with a definite body of experiments indicating the importance of set or the presence of differing types of set. Aside from the studies on optimal foreperiod, however, there has been very little objective work done on the dynamics of this phenomenon. The introspectionist studies mentioned above suggest strongly that the reaction period is of secondary importance in either simple reaction time or in problem solving behavior. If this is true then a distraction introduced during the period of set formation should have more effect than the same distraction introduced during the reaction period. The following experiment will attempt to give objective verification of this viewpoint.

EXPERIMENT

Hypotheses

General--Distraction during set formation will cause greater changes in response than distraction during solution in a problem situation.

Specific-- 1) Ringing a bell during the set period of visually presented problems will increase the frequency of errors more than ringing the same bell during the response period, or control period.

2) Ringing a bell during the set period of visually presented problems will increase the length of time till response more than ringing the same bell during the response period, or control period.

Definitions--Set Period- the time from presentation of the first card until presentation of the card which completes the task assignment in this experiment.

Response Period - the time from presentation of the card which completes the task assignment until the response in this experiment.

Set Condition - The bell is rung during the set period.

Response Condition - The bell is rung during the response period.

Control Condition - The bell is not rung during either set or response periods.

Design

The problem confronting the experimenter in this case was to structure the experimental situation so that the period of set formation could be distinguished from the response period. This was accomplished by developing questions each of which was divisible into two parts. The first part was to establish the method of solution while the second part consisted of a key word without which the problem was incomplete. An example of this type of question would be: Card 1 — What is the second letter in _____?, Card 2 — Chair. The answer being H. These questions were presented in an electrically timed and controlled exposure apparatus so that they could be presented under set, response, or control conditions.

In order to control for individual differences it was decided to present equivalent material under all three conditions to each subject. This was accomplished by means of a preliminary study in which thirty questions were tested for difficulty level and stability of response time, then the fifteen most stable were divided into three matched blocks, A, B, and C. These three blocks of questions were rotated through the three conditions so that each subject had each group under a different condition. The first subject had the blocks and conditions matched like this: A-Set, B-Response, and C-Control. The second subject: A-Response, B-Control, and C-Set. The third subject: A-Control, B-Set, and C-Response. Thus for every three subjects a complete replication of the conditions occurred,

with each block of questions asked under each condition once. The impossibility of exhausting all possible order effects in the fifteen questions necessitated the use of a random sequence of presentation which tended to eliminate practice effects and sequence effects of the three conditions. This sequence of presentation of the questions was determined by a chance drawing from a receptacle containing the numbers one to fifteen. Since the condition depended upon the number of the question and the block of the question, the different conditions were randomized for order of presentation in the same draw. The questions were made as different as possible to necessitate a change of set regardless of order of acquaintance.

The experiment was run in two sections, the first thirty subjects were scored on correct or incorrect responses but not on time of incorrect responses. This permitted an analysis of error data but not of time scores. The second thirty subjects were scored on time and correctness of response for all items. This permitted an examination of the time data in terms of medians.

The only procedural difference between the two groups was in the composition of the blocks of problems A, B, and C, which, on the basis of the additional data derived from the first half of the experiment, were again equated to eliminate a difference of seven percent error frequency which had become apparent in the first division into blocks.

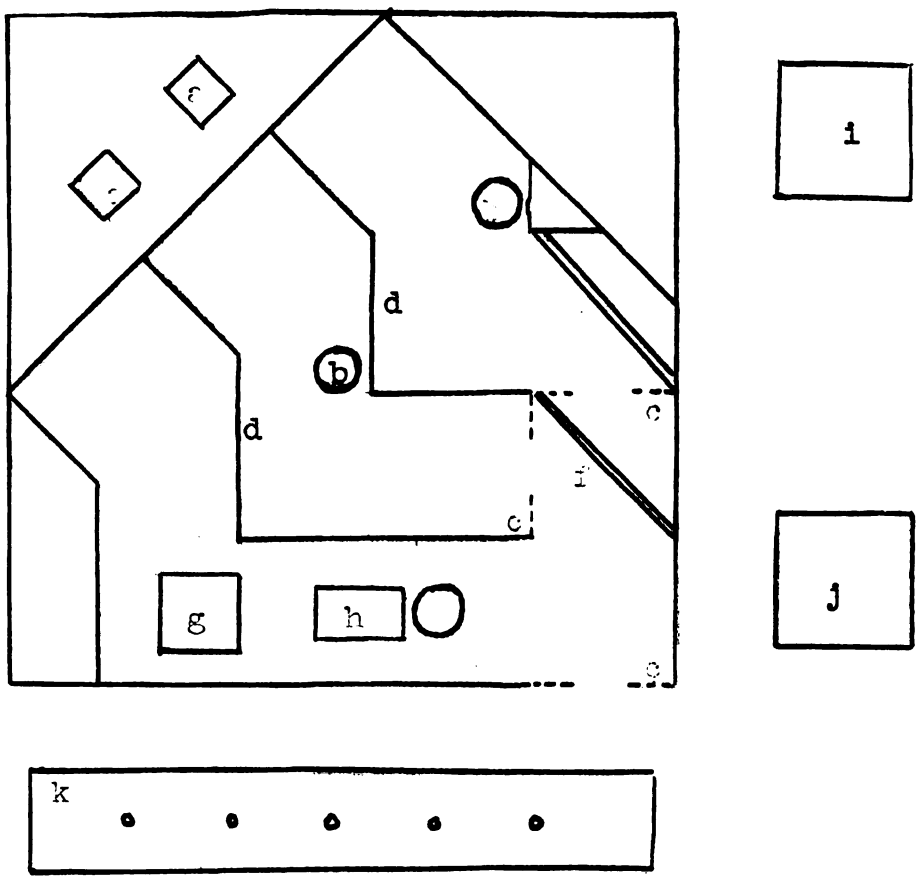
Apparatus

In this experiment the stimuli were presented by means of an electrically operated exposure apparatus. (See Figure 1) While two of the presentation alleys were used to permit the succesive exposure of two cards to the subject, the third was blocked off and a doorbell and transformer installed in it. The wiring circuits were arranged (See Figure 2) so that upon pressing the starter one light would come on and remain for five seconds, after which it would be turned off and a second light in the other alley would turn on. This second light would remain on until the subject pushed one of the five response keys or until the experimenter turned it off. The doorbell was wired in such a way that it could be presented simultaneously with either light or not at all. The timing unit was installed on the same circuit as the second light so that it measured the period from the switching on of the second light until the circuit was broken by the subject's use of the response keys.

The cards on which the questions were presented were of thin white cardborad, unlined, eight inches by four inches. The questions were typed on the cards in capitals with double spacing between the letters. Since a single mirror was used to present the card to the subject, the writing had to be done in mirror image. This was accomplished by use of carbons. One of the major difficulties of the experiment was this mirror image. The printing which resulted from the carbon was not clear at the presentation distance of about three feet and tended

FIGURE 1

Apparatus



a. Relays
b. Lights
c. Screens
d. Presentation positions
e. Mirror
f. Half silvered mirror
g. Transformer
h. Doorbell
i. Interval current timer
j. Clock
k. Keyboard

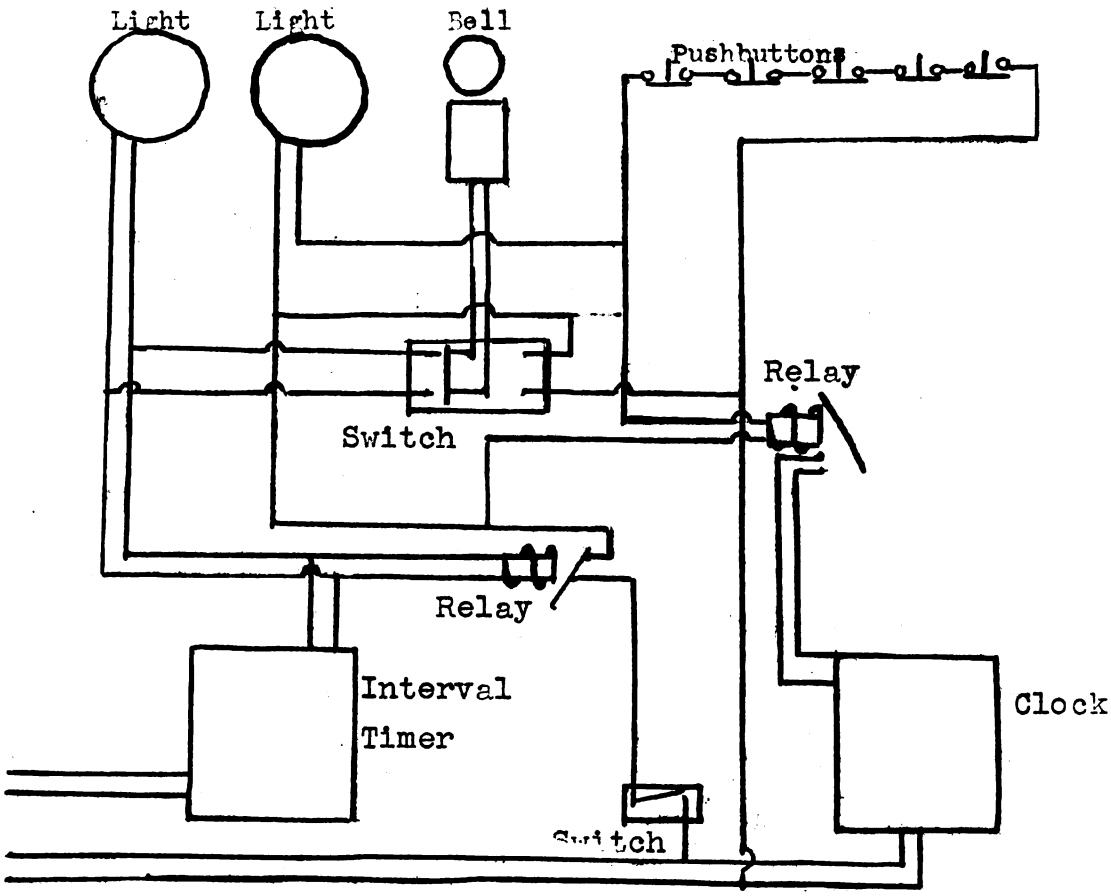
to blur further with usage. It is suggested that in any further work a double reflection be used to eliminate this difficulty.

Subjects

The subjects were selected from elementary psychology students. They ranged in age from seventeen to thirty-two, both male and female. All were volunteers. Testing periods ran from eight in the morning to five at night. The subjects for the first half of the study, run during the summer, averaged three years older than those used in the second half of the experiment. Age was not a major factor in determining performance in errors or time.

FIGURE 2

Wiring Diagram



Procedure

First the subject was shown the interior of the exposure apparatus and instructed in this manner:

This is a mirror tachistoscope. When I push this button a light comes on, after exactly five seconds it turns off and another light comes on. (Demonstration) You may turn this light off by pushing one of these response keys. You notice also that I have a bell in here that I can ring at my discretion. (Close box)

The subject was seated in front of the opening of the apparatus and instruction continued:

By means of those lights I am going to show you two cards. On these cards will be written a question which you can answer by pushing one of these keys. You will notice the keyboard is labeled one, two, three, four, five, a, b, c, d, and e. All of the questions I am going to show you will have one of these ten answers. Your job will be to push the key that corresponds to the correct answer. When you push the key please hold it down for half a second till I can break this switch. If you don't the light will come back on. (Demonstration) On the first card I show you will be all of the question except one word. On the second card will be the missing word. You put the missing word in the blank on the first card and then answer the question. For instance the first card might say "What number is three plus blank?" and the second might say "one"; well, three plus one is four so you push key four. Any questions?

The subject was then given three trial pairs to familiarize

himself with the procedure. The subject is asked if he has any further questions. If so, they are answered, giving no information about the nature of the experiment, if not, then the final instructions are given:

You will be marked on both speed and accuracy in your responses, do not sacrifice either for the other. From the time the second card comes on you will have twenty seconds to respond, if you don't we will start the next question.

The subject is then presented with the fifteen questions in the correct order and under the determined conditions, and is informed of both errors and correct responses. This entire procedure requires between fifteen and twenty minutes for each subject.

RESULTS

The results fall naturally into two areas, one for each of the dependent variables, errors and time. Let us first consider the time differences between the conditions; then secondly look at the variation of the freezes, which are defined as those cases in which no response is made during the twenty second period allowed. Finally the error frequencies may be considered.

In the time scores it was found to be impossible to work with normal distribution statistics for two reasons; first, the highly skewed nature of the distributions, and secondly, the existence of six percent of the total responses as freezes which have no actual length. The time data were therefore analyzed by means of medians and chi square.

The median response time for the response condition trials was 3.38 seconds; for the set condition trials the median was 3.77 seconds; and for the control condition trials the median was 4.05 seconds. A test of the number in each condition over and under the total median yielded a chi square of 2.78 for a two-by-three table, which is significant at the 25% level. For a two-by-two table, in which response condition trials were compared with the other two groups of trials combined, a chi square of 2.41 was obtained which is significant at the 15% level of confidence.

It is interesting to note that the percentage of freezes varied in the three conditions to a significant degree. The proportions of

TABLE 1

ANALYSIS OF ERROR DATA

	Set-Control	Set-Response	Response-Control
Differences by Proportion	.103	.060	.043
t-test without correction for Correlation	2.861	1.622	1.143
Level of Significance	0.3%	6%	13%
t-test corrected for Correlation	3.133	1.796	1.284
Level of Significance corrected	0.1%	5%	11%

TABLE 2

ORIGINAL DATA BY CONDITIONS

	Set Condition	Response Condition	Control
Proportion of Errors	.323	.263	.220
Median Time	3.77	3.38	4.05
Proportion of Freezes	.080	.027	.067

freezes in each condition were: Set, .080; Control, .067; and Response, .0267. The difference between the Set and Response conditions is significant at the five percent level.

The analysis on the basis of percentage of errors may be based on the entire sixty cases and nine hundred responses. A breakdown of error frequencies depending on condition of presentation between the first and second halves shows the stability of the tested factors. The error scores by frequencies for the Control condition trials in the first and second halves of the experiment were respectively 31 and 35, for Response they were 37 and 42, and for Set condition they were 45 and 52. There is a small increase of four percent in total errors in the second half of the experiment, which lacks significance.

The total figures for each condition in proportions are: Control, .220; Response, .263; and Set, .323. When tested by the standard error of a difference between means, the difference between the Set and Control condition scores is found to be significant at the .3% level, while the difference between the Set and Response condition scores is significant at the six percent level. The final difference, that of the Control from the Response condition errors is significant at only the 13% level.

By computing instead the difference between the groups individually for each subject and hence the actual sigma of the difference, thus eliminating the correlation factor, the figures may be raised slightly. The levels of significance now become 0.1% for the Set-Control conditions, five percent for the Set-Response conditions, and finally 11% for the Response-Control conditions.

DISCUSSION

It is the experimenter's belief that the results of this study while not conclusive may be considered as definite support of the general hypothesis. The first results to be considered will be the error data, followed by the freeze data, and finally the time results. In conclusion a possible framework for considering the results will be presented.

In the error data, the crucial test of the first specific hypothesis lies in the Set-Response condition difference. This was significant at the five percent level, which, when taking into consideration the masking factors in this study such as the poor visibility of the stimuli, appears highly significant. The other two differences are as expected. The Set-Control and Response-Control differences tend to establish that ringing a bell at any point or time in problem solution will tend to interfere with the accuracy of response as any layman would doubtless predict.

The variation in freezes between the combined Set and Control groups and the Response group is also reasonably open to explanation. Since the pair of conditions are alike in presenting no opportunity to turn off the bell, while the Response condition does provide this possibility; the difference may be considered as caused by a normal dislike for having a bell ringing in one's ear and the subsequent guess to turn it off as opposed to freezing.

The time data, while they lack the high statistical significance of the error scores, may be considered as indicative. The medians show an interesting inversion from expectations in the location of the Control condition median. (R-3.4, S-3.8, C-4.1) It was expected that lack of distraction would permit the fastest solution time in this group. While the first hypothesis stands as supported by the error data, it becomes obvious that the apparent satisfaction of the second hypothesis is due to a misstatement of the situation. While the hypothesis states that the Set condition will cause higher scores than the Response condition, it should read, on the basis of the Control condition, that the Response condition will produce lower scores than the Set condition. The hypothesis as stated implies an increase from Control condition to both Set and Response conditions which does not occur.

It now becomes obvious that we have a difference in order between the error data and the time data. The errors increase from Control to Response to Set, while the time increase runs from Response to Set to Control. If we set up a small framework of three propositions an explanation of the difference emerges. These statements are:

1) Set formation is the major portion of problem solving.
   a) Response, once set has been formed, is largely mechanical and unalterable.

2) Increase in tension, above a minimum, causes rigidity of behavior.
   a) Once a complete set has been formed an increase in tension will not change the response.

3) Increase in tension tends to cause the organism to react.
   a) The higher the tension, the faster the organism tends to react.

Morgan (7) and Davis (2) have demonstrated that noise, either during a task or at rest, causes a state of tension in the individual, whether this tension is purely physical or has a mental component has not been established, but the latter appears probable. The bell in this experiment may be safely assumed to produce a state of tension in the subjects.

Let us now consider the results in the light of these suggestions. First, the third proposition simply enough accounts for the scarcity of freezes under Response condition, the presence of the bell producing a high tendency to action. The order of the times also falls into place. The Response condition causes the highest tension state via the present bell and therefore the fastest responses. In the Set condition the bell is just past and its effect is therefore partially dissipated but still present. This produces a speed of response between that of the Response condition with the bell present and that of the Control condition with its lack of bell-produced tension. The error scores remain for explanation. Under the Set condition, the tension is introduced during the attempted change of set and thus causes through rigidity a poor set formation and hence a high proportion of errors. The increment in the Response condition errors over those of the Control condition are accounted for by a flaw in the division of the set and response periods. Actually a part of set formation, albeit a small one, is carried into the response period with the presentation of the final material necessary for the solution. This could account for a large part of the Control-Response difference.

While this study must be considered as exploratory in its area we still find strong support for the first hypothesis. The second hypothesis is apparently misstated and therefore incorrect.

SUMMARY AND CONCLUSIONS

An experiment was run on elementary psychology students using an exposure apparatus and bell in which questions were presented. The questions were divided into an orientation section and a cue section from which combined an answer could be located on a multiple response keyboard. The questions were presented under three conditions, bell in set period, bell in response period, and no bell as a control. The sequence and conditions of presentation of the fifteen questions were randomly varied. Each subject was given equivalent questions under each condition. Response differences were analyzed in terms of errors and time of response.

The error data indicate strongly that the Set condition causes the most errors, followed by the Response and lastly the Control conditions.

The time data indicate that the Response condition causes the most rapid responses followed by the Set condition, and finally the Control period.

The percentage of no response answers proved significantly less in the Response condition than in the Set period.

These results tend to prove the accuracy of the first hypothesis and the misstatement of the second. Significance levels varied between the one and twenty-five percent levels.

The results suggest a framework of three propositions:

1) Set formation is the major portion of problem solving.

2) Increase in tension above a minimum causes rigidity of behavior.

3) Increase in tension tends to produce response in the organism.

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APPENDIX

Questions Used

What letter falls three letters before _____ in the alphabet?
Card two: G
Answer: D

What letter occurs most often in the group _____?
Card two: FBAAFAAF
Answer: A

How many sides are always found in a _____? Card two: Square
Answer: 4

What number is one fourth of _____: plus five?
Card two: 0
Answer: 5

What is the fourth number before seven in the group _____?
Card two: 32156789
Answer: 2

What compass reading is one hundred and eighty degrees from _____?
Card two: W
Answer: E

If an inch is one, and a foot is two, what is a _____?
Card two: Rod
Answer: 4

What number turned on its side looks like the letter _____?
Card two: m
Answer: 3

With what letter does the opposite of _____ end?
Card two: Black
Answer: E

What letter falls before _____ in the alphabet?
Card two: C
Answer: B

What number is missing from the group _____?
Card two: 658245791
Answer: 3

What is the second digit of the number in a _____?
Card two: Dozen
Answer: 2

What number said aloud sounds like the word _____?
Card two: Sun
Answer: One

What letter follows M in the name of the last _____?
Card two: President
Answer: A

If D minus C equals A: what is _____ minus B?
Card two: E
Answer: C

Form on Presentation Card

W I T H W H A T L E T T E R
D O E S T H E O P P O S I T E
O F _____ E N D ?