FACTORS CONDITIONING EFFICIENCY IN A MOTOR SKILL

by

Rex Livingstone Hoke, A.B., A.M.

A Dissertation Presented to the Graduate Faculty of the College of Education of the University of Cincinnati in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in Education

University of Cincinnati

1 9 2 9

ACKNOWLEDGMENT

I am indebted to Dr. Gordon Hendrickson, Dean L. A. Pechstein, and Dr. James Vaughn for their numerous suggestions and criticisms. I am also indebted to the persons who acted as subjects in the experiments.

R. L. H.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Chapter I

THE PROBLEM AND ITS SETTING

A. Introduction

When a golfer swings at a ball with his driver, when a carpenter drives a nail, or when a typist moves his fingers swiftly over a keyboard, exceedingly refined muscular adjustments are necessary to make the movements successful. An important difference between the skilled and the unskilled individual is that the former makes the movements with little attention to their details. For the unskilled, the act is performed in parts, each separate movement being consciously attended to. In the early stages of acquiring skill, the separate parts are more or less disconnected, but they become coordinated and unified into a complete process as learning proceeds.

Doubtless many influences modify progress in the early stages of such learning. Some of these influences may be the words of an instructor, while

others may be inherent in the problem to be learned. If one were to discover the factors that tend to accelerate and retard the acquisition of skill, he might set up guiding principles for use in teaching skill subjects.

Certain possible factors may be suggested. The teacher may set up a situation in which errors by the learner automatically result in some form of punishment. The learner may be instructed to direct his attention along various lines; e.g., to the process, to the objective result, to the idea of success, or to some irrelevant matter. He may be kept fully aware of the progress being made. The time interval between his attempts to perform the required act may be regulated. Although this list is very incomplete, it suggests certain factors that may be used to modify efficiency in a motor activity.

B. Previous Investigations

Previous investigators in this general field have usually limited themselves to the study of one or two factors. Examples of the more significant work may be

found in reports by Rexroad [1], Johanson [2], Hoge and Stocking [3], Arps [4], Judd [5], Langfeld [6], and Vaughn [7]. Their studies may be briefly reviewed.

1. Effect of Punishment on Continuous Multiple Choice Reaction

Rexroad studied the effect of punishment on continuous multiple choice reaction in an experiment in which he used a machine having five keys. Five colors, a color corresponding to each key, rotated in the machine, one at a time, as the appropriate key was pressed. If the correct key was pressed, the color passed out of sight in the machine. If an incorrect key was pressed, the subject was punished

1. Rexroad, C., "Administering Electric Shock for Inaccuracy in Continuous Multiple Choice Reaction." Journal of Experimental Psychology, IX (1926), pp. 1-25
2. Johanson, E., "Influence of Incentive and Punishment upon Reaction Time." Archives of Psychology, no.54 (1923), p.53.
3. Hoge, N. and Stocking, Ruth J., "A Note on the Relative Value of Punishment and Reward as Motives." Journal of Animal Behavior, II (1912), p.43.
4. Arps, G.F., "Work with Knowledge versus Work without Knowledge of Result." Psychological Review Monograph, XXVIII (1920), no.125, p.41.
5. Judd, C.H., "Practice without Knowledge of Result." Psychological Review Monograph Supplement, VII (1905), pp. 185-198.
6. Langfeld, H.S., "Voluntary Movement under Positive and Negative Instruction." Psychological Review, XX, no. 6 (1913), p.459.
7. Vaughn, James. "Positive versus Negative Instruction". New York: National Bureau of Casualty and Surety Underwriters, 1928.

with an electric shock, and the color remained before the subject until the correct key was pressed.

Rexroad summarized the experiment thus:

a. Punishment has three effects, disruptive, incentive, and instructive.

b. The instructive effect is in inverse proportion to the previous comprehension of the task, and consequently is not present after a certain amount of practice.

c. The incentive effect shows itself in the rapid adoption of a scheme or plan for learning any code and in greater care to avoid errors throughout the experiment.

d. The disruptive effect is in inverse proportion to the thoroughness with which the habit is established, and consequently will offset the incentive effect during the learning of a code, but will be offset by the incentive effect after the code is learned.

2. Effect of Punishment and Knowledge of Result on Reaction Time

Johanson was able to decrease the reaction time of individuals by the use of punishment and knowledge of result. Unless the finger was withdrawn from a

telegraph key in the required length of time, an electric shock was administered. In this way the reaction time was made less than under ordinary circumstances. Similarly, by use of the telegraph key, but without punishment, Johanson decreased the reaction time by telling the subject how much time he had taken on the preceding trial to withdraw his finger from the key. He explains the fact that the subjects reacted more quickly when punished and when told how much time it had taken in the preceding trial by saying that the subjects, during the experiment, gave keener attention to the task than under ordinary circumstances.

3. Effect of Food and Punishment on Training the White Rat to Run a Maze

Hoge and Stocking used food and punishment as incentives in training the white rat to traverse a given path through a maze. The incentives were used separately and together. Punishment was administered when the rat attempted to enter the wrong path by means of electrifying the floor of the entrance. Food was given only when the correct path was traversed.

Punishment alone was found to be more effective than food alone, but both together were still more effective.

4. Effect of Knowledge of Result on Achievement in Lifting Weights with the Ergograph

Arps collected data for studying the effects of knowledge of result by having subjects do work with the ergograph. The work consisted in lifting weights with the free finger by means of a system of ropes and pulleys. "The hand and arm of the observers (subjects)", says Arps, "were strapped in the ergograph in the usual manner so as to secure maximum freedom of the middle finger of the right hand and to exclude, so far as possible, all irrelevant movements contributory to the efficiency of this finger." The speed of lifting was fixed by a metronome beating sixty strokes to the minute. The work in each period continued to exhaustion, or until the subject was no longer able to lift the load for two successive attempts.

Arps concludes that, in lifting weights with the ergograph, the amount and rate of work done with knowledge of result exceeded that done without knowledge of result. He raised the question as to whether increased attention is a result of desired pleasurable effort or a cause of such effort.

5. Effect of Practice Without Knowledge of Result on Learning to Locate the Projection of a Line Behind a Screen

The conclusions of Arps are similar to those of Judd. In a study of practice without knowledge of result, Judd had subjects practice locating the projection of a pencil mark behind a screen. When a given line appeared the subject was required to place a pencil on the opposite, or unseen, side of the screen, in what he regarded as the exact continuation of the line. The data furnish substantial evidence of the superiority of practice with knowledge of result.

6. Effect of Positive and Negative Instruction on Moving a Stylus Along a Narrow Groove

Langfeld studied the effects of positive and negative instruction by having each of five subjects move a stylus along a narrow groove in a tracing board. One instruction directed that the stylus be moved down the middle of the groove; the other was similar, but with the additional instruction to direct attention toward keeping the pencil from touching the sides of the groove. Langfeld found little difference

between the records made under the two instructions. He believes, however, that negative instruction decreases the steadiness of voluntary movement.

7. Effects of Various Forms of Positive and Negative Instruction on Certain Forms of Motor Behavior

Vaughn may be said to have opened up the field of investigation of the relation of different patterns of response to different types of instruction. His experiments were for the purpose of "discovering, under rigidly controlled laboratory conditions, how far the behavior of various persons is affected by types of instruction which are more or less closely related to those which are given in the family and in the school to prevent children from getting into danger."

The first five of these experiments were arranged for the purpose of comparing the effects of threat and punishment on the time required to stop the horizontal movement of the arm. Electric shock was used for punishment. Adults and children were used as subjects.

The movement consisted in moving a metal slide along a horizontal bar. The subject began the movement at the appearance of a green light and attempted to stop at the appearance of a red light. A record of the

"stopping time", or time required to stop the movement after the appearance of the red light was made with electromagnetic markers on a kymograph.

Five forms of threat and punishment instruction were given and the records compared with the record for simple positive instruction. The instructions were: (1) The subjects might be injured if they failed to stop the movement in less than one-fourth of a second after a red light appeared. No shock was given. (2) They were told they would be badly hurt in case they took more than one second to stop. No shock was given. (3) They were shown how they could receive an electric shock if the movement was not stopped in less than one-fourth of a second. No shock was given. (4) They were given a severe electric shock each time they failed to stop the movement in less than one-fourth of a second. (5) They were instructed that they would be given a severe electric shock in case they repeatedly failed to stop in less than one-fourth of a second. Punishment was administered periodically.

The purpose of the sixth experiment was to compare the effects of positive and negative instruction. The subjects moved a stylus through a narrow groove. Positive instruction directed attention to the middle

of the groove, and negative instruction directed the subjects to avoid the sides of the groove.

The seventh and final experiment compared the effects of positive and negative instruction by use of two mazes. The floors of the blind alleys were rough, and the floors of the correct paths were smooth. The instructions used in running these mazes were: (1) Instruction of the nature of the task with directions to run the maze; (2) Instruction to follow the smooth paths; (3) Directions to avoid rough paths; and (4) instruction to run the maze after the relation of roughness and smoothness to success and failure had been mentioned.

In comparing the effects of simple positive instruction and the five punishment and three instructions, Vaughn states that "the least effective type of instruction was that in which the subjects were told in positive terms what behavior was expected of them. Second in the series was the simple negative instruction not to do something which was given in verbal form. This is the form of instruction which is commonly known as the 'don't' instruction. Third in the series was the form of instruction in which an indefinite threat

was offered. The experiments show that when the subjects did not recognize clearly the possibility of actual punishment, they did not control their behavior in any marked degree as the result of the threat. Fourth in the series was the form of instruction which in some cases was very effective, namely, a threat supported by an explicit description or demonstration of the way in which punishment could follow a failure to heed the threat. Fifth, and final in effectiveness, was the series of punishments actually administered. These were in turn shown to be increasingly effective when administered with increasing certainty."

Vaughn makes the following general conclusions:

a. "Verbal instructions unsupported by other forms of stimulation are relatively ineffective, expecially with children.

b. "The effects of warnings and threats are transient, especially with children.

c. "Demonstrations of the manner in which injury may take place have more effect on behavior than mere positive or negative directions.

d. "Actual experience of the ill effects of wrong reactions is most effective.

e. "Drastic threats or punishment may occasionally inhibit desired behavior."

8. Evaluation

All the studies that have been made, excepting the one by Vaughn, compared the effects of one or two factors on efficiency. For example, Rexroad studied only the effect of punishment upon accuracy in pressing the keys of his machine; Arps studied work with knowledge of result versus work without knowledge of result in lifting weights with the ergograph; and Johanson compared punishment and knowledge of result as to their effects on reaction time. While Vaughn compared several varieties of instruction, he did so by using three or four forms of behavior. He did not use all of his instructions with the same subjects, or in such a manner that they could be directly compared.

C. The Problem

The problem of this investigation, stated in general terms, was to discover the effects of bringing certain modifying factors to bear on performance of a simple sensori-motor act. Such a discovery, aside from being of purely psychological interest, should aid

in the development of efficient methods of acquiring a motor skill. Five types of conditioning factors were studied by the method of the controlled laboratory experiment, namely, punishment for varying degrees of inaccuracy, giving knowledge of exact result achieved, direction of attention in various ways, modification of the interval between trials, and simple instruction to perform the act.

Answers were sought to the following detailed questions:

1. Is anything to be gained by the use of instructions involving punishment, direction of attention in specified ways, and knowledge of exact results, in contrast to simple instruction to perform the act? What are the relative effects of the instructions used?

2. What is the relative effect of punishment for failure to perform the act successfully? Is it more advantageous to punish only when gross errors are made, or to punish for each error large or small? Is it more economical to use some incentive other than punishment?

3. What is the effect of keeping the individual fully aware of the degree of success attained?

4. What is the role of attention in the efficient performance of a task requiring accuracy? Where should attention be directed? Is it more desirable to direct attention to the process, to the objective result of the act, to the task itself, away from the task, or to the idea of success?

5. What is the relationship to accuracy of the interval between attempts at the act?

6. With what degree of uniformity do individuals react to the various instructions? On what instruction is there greatest variability among individuals? On what instruction least?

None of the previous investigators made direct comparisons between the effects of punishment for various degrees of error, direction of attention in various ways, knowledge of detailed results, and varying intervals between trials. The present study attempts to compare these factors by the use of a technique that makes them comparable. All instructions are given to all subjects, and the effects of instructions are compared for a single form of behavior.

D. The Skill Investigated

Accuracy in tossing balls at a target was selected as the skill to be studied. The following considerations entered into this choice:

1. The chosen skill should lend itself to various methods of attack. For example, punishment and knowledge of exact results were to be studied, and such modifying factors could be introduced in connection with the practice of this skill.

2. The skill should be one in which efficiency can be measured.

3. The skill should arouse interest and effort on the part of the subjects practicing it.

4. The skill should lend itself to laboratory treatment, yet provide a real learning situation.

5. The skill should be of such a nature that conclusions could be given fairly wide application.

6. The particular form of behavior studied should involve many of the learner's neural and muscular processes and not merely a specialized segment of them. Studies of reaction time do not adequately meet this requirement. In tossing balls at a target the behavior involves practically all the muscles of

the body, as well as the mental processes of cognition, emotion, volition, and the like.

The special technique by which the ball tossing skill was investigated as a means of attacking our problem will next be reported.

Chapter II

EXPERIMENTAL TECHNIQUE

A. Apparatus

1. Introduction

To permit carrying out such an investigation as proposed, it was necessary to devise special apparatus which would comply with certain conditions. The apparatus should permit control of such factors as record of results, time interval between trials, freedom from distraction, and punishment for errors, and should provide a uniform task for the subjects.

The apparatus prepared consisted of a target, twelve steel balls, three mounted lamps, an induction coil, a metronome, a single stroke electric bell, three dry cell batteries, a supply of ordinary bell wire, and a supply of city current (110 volts, A.C.). These will now be described in detail.

2. The Target

The target was placed at a distance of eighteen

feet from the pitcher's box, and a chalk mark on the floor served to indicate the point from which the balls were tossed.

The target is represented in Figure 1. The disc is made of linden boards, one inch in thickness. The front of the disc is covered with galvanized iron, which is held in place by screws. The three concentric zones are separated at every point by one-eighth inch. The galvanized iron is an electric conductor and the wood to which it is attached serves to insulate the zones.

The opening in the center of the target - bull's eye - is five inches in diameter. The widths of the three zones from the center outward are five, five, and ten inches respectively. When a ball strikes the center it passes through and out at the back of the target, returning down a chute to the thrower. The balls are automatically returned. The apparatus for returning the balls, not shown in Figure 1, is a long, wide width of fly screening, formed into a chute and elevated at the end adjacent to the target.

There are five areas in which the ball may strike. In this report these areas are designated zones. Zone

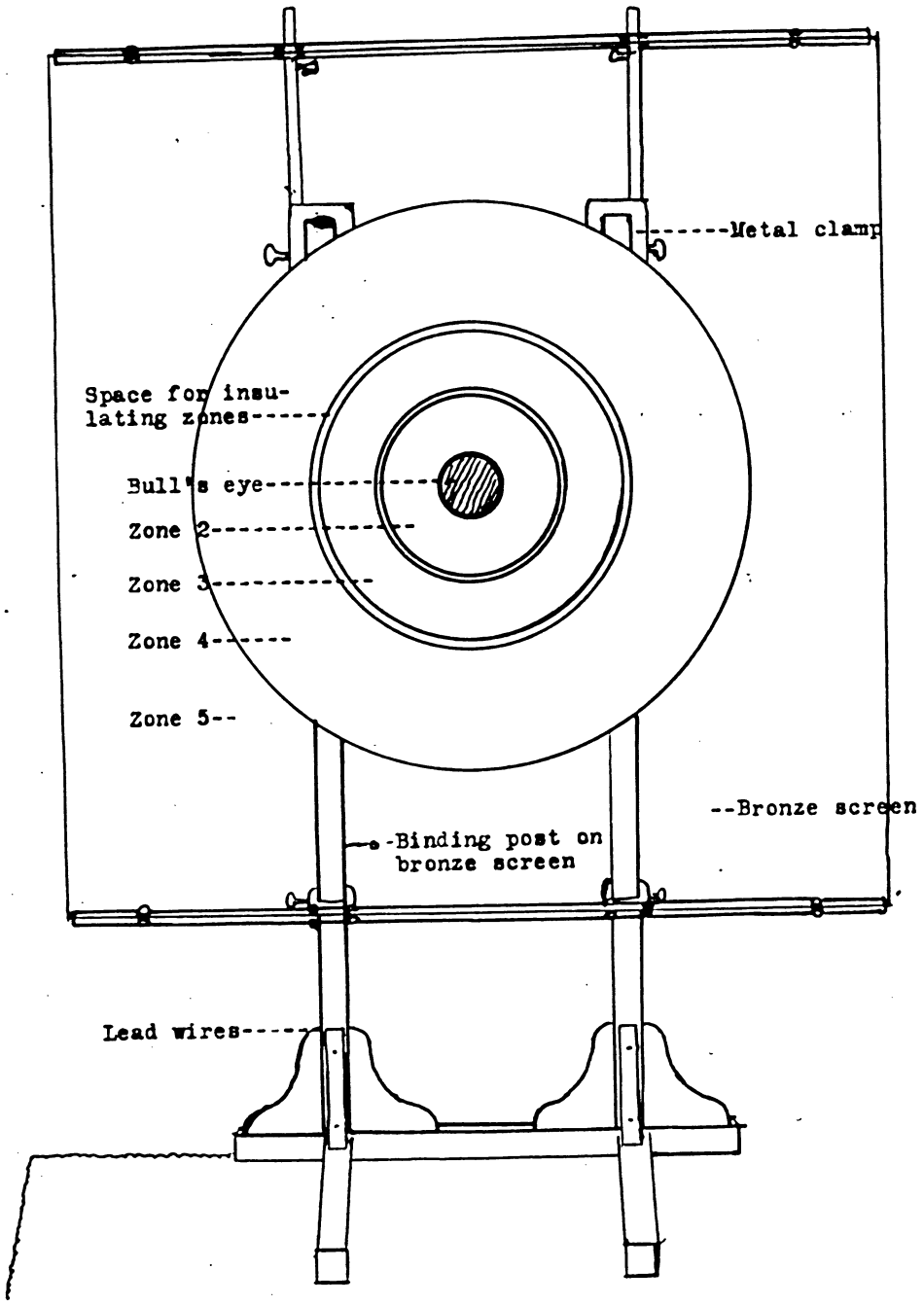


Figure 1.--The Target

one is the bull's eye; zones two, three, and four are the three zones from the bull's eye outward; zone five is the area outside the outer zone, or the area struck when the ball missed the target.

Vertical and horizontal lines, not shown in Figure 1, were ruled on the face of the target. These corresponded accurately in position with lines on the record sheets, as shown in Figure 5, page 38. These lines did not obscure the zone limits, but aided the experimenter in recording hits exactly.

The square bronze screen, shown in front of the disc of the target, is held in a vertical position by a number of coil springs. The screen is about four inches from the face of the target at every point, and a hole directly in front of the opening in the disc permits the ball to pass through the bull's eye. The target may be clearly seen through the screen (a more closely woven screen might have obscured the target).

3. Signal Lamps

The purpose of the three lamps, represented in Figure 2, was to signal the zone struck by the ball. When zone one was hit, no light flashed; when zone two

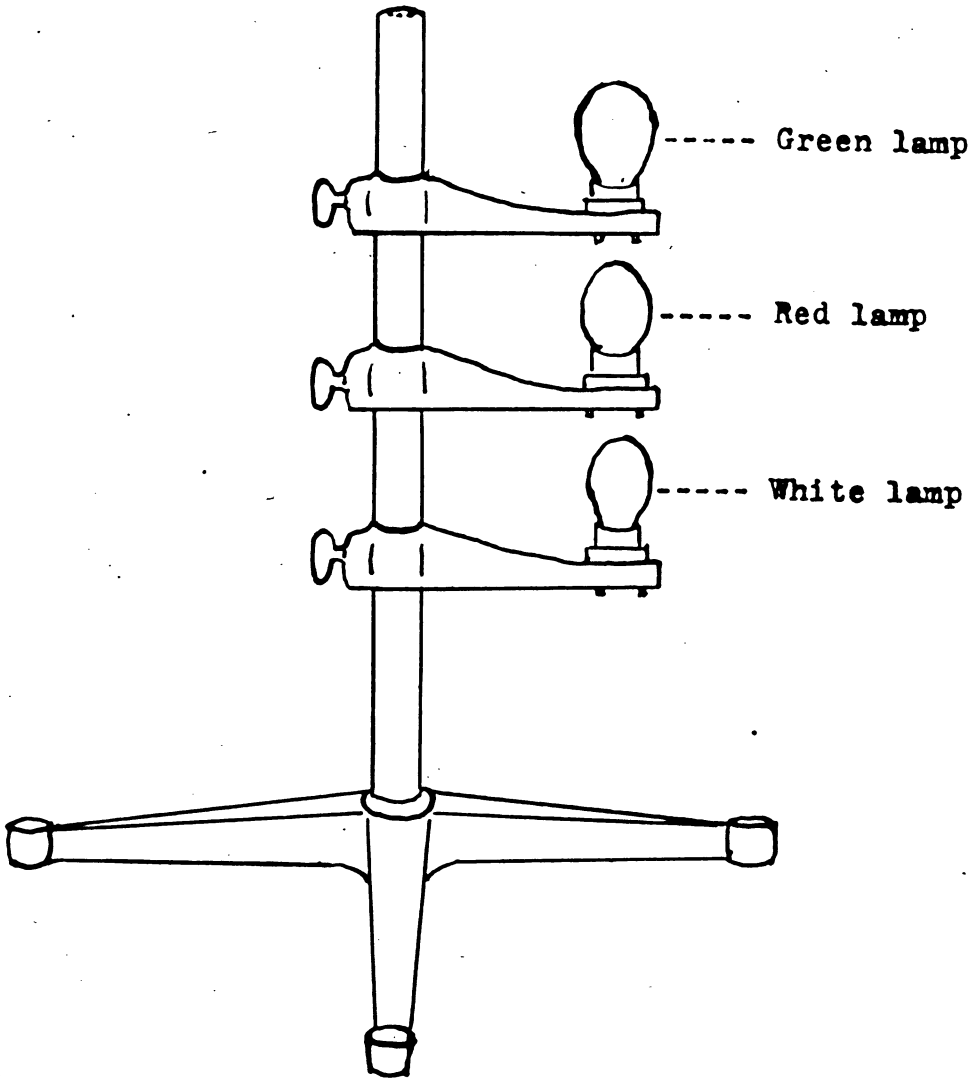


Figure 2.--The Three Lamps Used to Signal the Zone Struck

was hit, the green light flashed, when zone three was hit, the red light flashed; when zone four was hit, the white light flashed. No light flashed for zone five. Direct observation determined whether zone one or five was hit. If two lamps flashed, as happened when the ball struck in the margin of two zones, the zone that appeared to be struck was counted.

The lamps were arranged vertically - one above the other - and were placed on the experimenter's desk, which was placed to the rear of the pitcher's box so as to distract the subject as little as possible.

4. Opening and Closing the Circuit

The signals that indicated where the ball hit and the electric shock that punished for inaccurate hits were operated by the impact of the ball against the target. The bronze screen and the metal face of the target acted as a switch which closed each time the ball hit the target (see wiring diagram, Figure 3). After a contact, the screen returned to the original position, leaving the circuit open. The flow of current in the circuit was thus momentary, and the zone struck was indicated by a flash of one

of the lights.

5. The Punishment Circuit

The momentary pulsation of current resulting from the impact of the ball was also used to produce the electric shock used for punishment. The circuit was arranged so that an electric shock could be automatically administered the instant a subject hit outside a prescribed zone. The wiring diagram, Figure 3, shows how the wires were connected for the punishment circuit, and the relation this circuit bears to the signalling circuit.

For administering the punishment two ellipse shaped pieces of sheet copper were fastened to the subject's hand with rubber bands. One piece was placed in the palm of the hand, the other directly opposite on the back of the hand. A glove was used to cover the hand so that the balls could be conveniently held. These copper strips were connected by flexible covered wire to an inductorium (Figure 4), which was activated by the pulsations of current resulting from the impact of the ball.

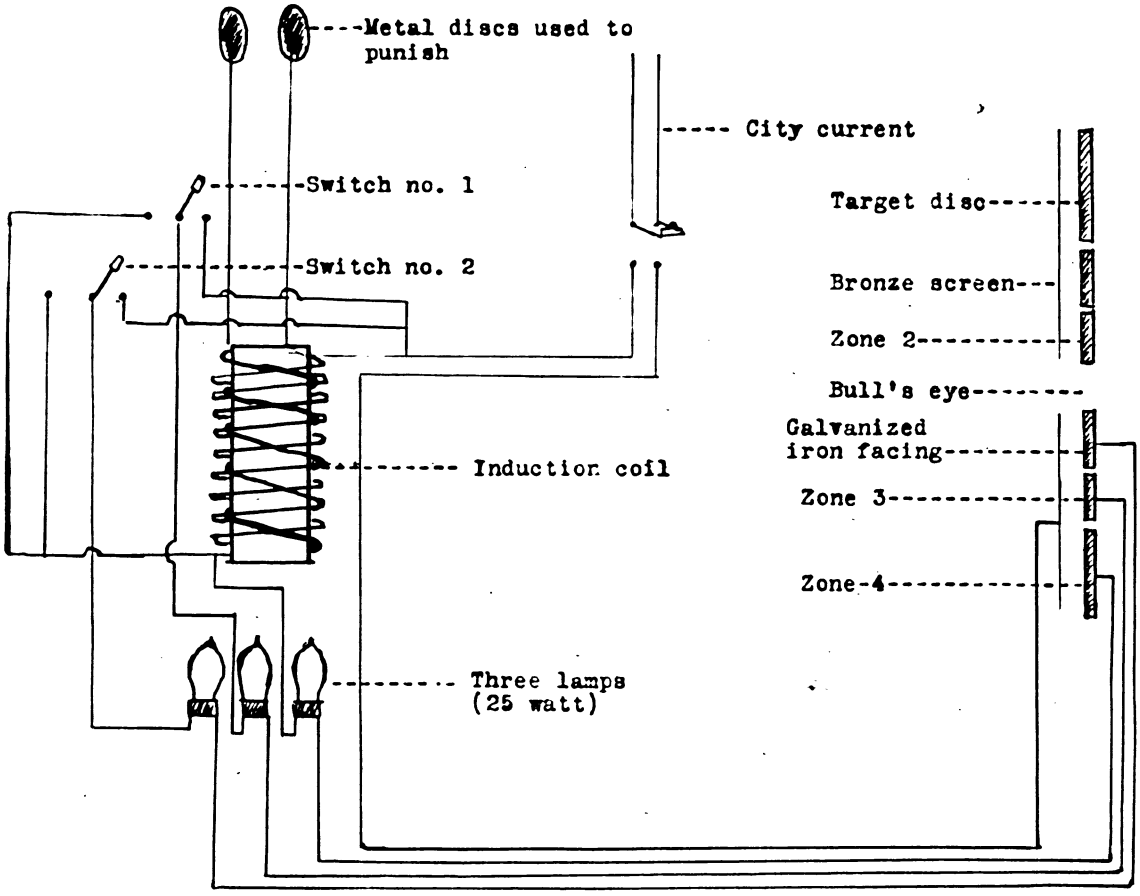


Figure 3.--Wiring Diagram of Signal and Punishment Circuits

6. Location and Operation of the Switchboard and Inductorium

The shock was controlled by a switchboard assembled on the experimenter's desk. The inductorium was placed adjacent the switchboard.

If no punishment was desired the coils of the inductorium were simply moved apart. If it was desired to punish for hits in zone four, the secondary of the inductorium was moved into place and double throw switches, nos. 1 and 2 (see Figure 3) were thrown to the right. If it was desired to punish for hits in zones three and four, the secondary of the inductorium was moved into place, double throw switch no. 1 was thrown to the left, and double throw switch no. 2 was thrown to the right. If it was desired to punish for hits in zones two, three, and four - that is, to punish unless the subject made a bull's eye - the secondary was moved into place and switches nos. 1 and 2 were thrown to the left.

7. Regulating the Electric Shock Used for Punishment

The intensity of punishment was kept fairly constant for all subjects. The needle indicator which

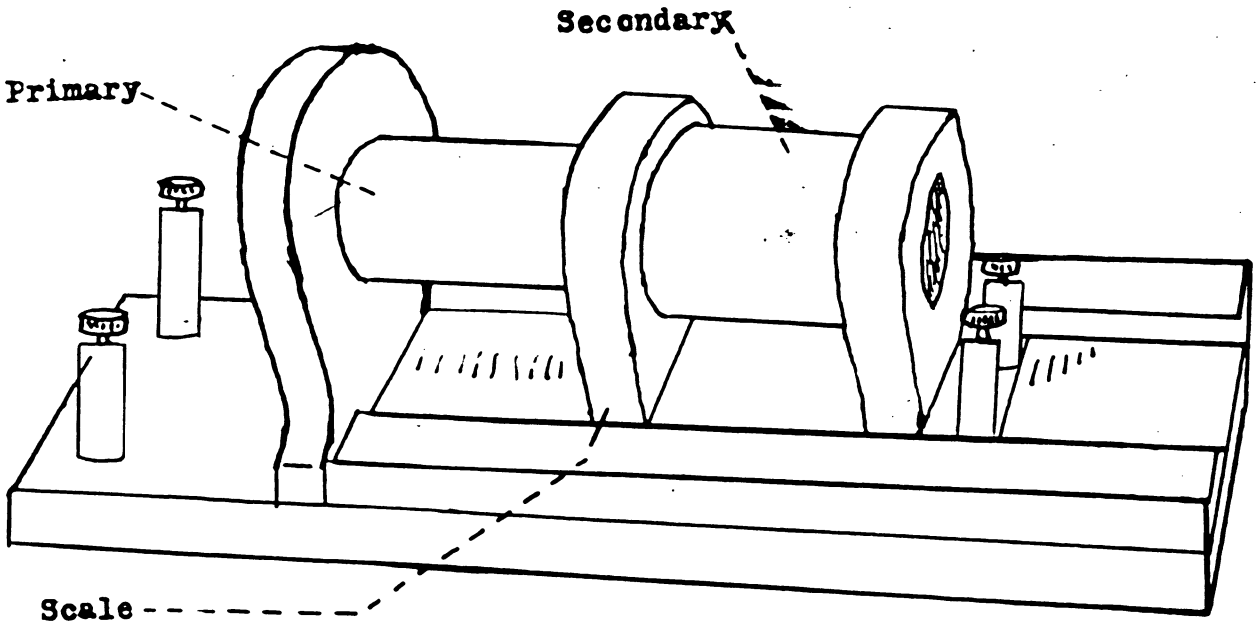


Figure 4.--The Inductorium

moves across the graduated scale on the inductorium was set, when punishment was administered, at the point marked five. With the instrument set at this point, the shock was intense and rather severe. There was invariably a jerking of the hand and arm when punishment was given, and likewise a frequent jerking movement when punishment was expected. Ordinary city current, 110 volts, A.C., was used, although the voltage across the induction coil was somewhat less, there being a 25-watt lamp and about 50 feet of ordinary bell wire in series with the coil. Some fluctuation in intensity of the shock was caused, no doubt, by the manner in which the contact was made between the metal-faced target and the bronze screen. This factor was uncontrolled in the experiment. A second factor which tended to cause the intensity of the shock to vary was perspiration of the hand. On the whole, the variability in the intensity of the shocks was slight, and of little consequence except for the study of individual differences in relation to punishment.

8. Setting the Interval Between Tosses

The interval between tosses was set by use of

a gong. A single stroke of the hammer of an electric bell against the gong produced the signal, the bell being wired so as to throw the vibrator out of the circuit. A metronome with mercury cups and timing gears regulated the time interval. The metronome, to eliminate conflicting signals, was placed in an adjoining room. The bell was assembled on the experimenter's desk. An extension cord leading from the bell to the metronome completed the circuit. The apparatus was driven by two dry cell batteries, and was controlled by a switch assembled on the switchboard.

The signal was loud enough to be heard, but not so loud as to be disconcerting. Signals were given at intervals of four seconds throughout the practice periods, except for instructions I and K (see page 29). For these instructions the signals were given at intervals of six and two seconds respectively.

9. Arrangement of Apparatus

The experiment was conducted in an isolated room of the laboratory so that there would be nothing to distract the subject's attention during the experiment. The experimenter and the subject were the only individuals

present.

B. Method

1. Use of Instructions

In order to apply the factors of punishment, direction of attention in various ways, knowledge of exact result, and varied interval between tosses to efficiency in tossing balls at a target, subjects were given instructed practice in the activity. Eleven forms of instruction which embody the factors were used, and the learning situation was modified where necessary in conformity with the instructions. The designations of instructions, factor investigated, and interval between trials are as follows:

Instruction	Factor Investigated	Interval
A	Simple positive instruction	4 sec.
B	Attention to idea of success	4 "
C	Minimum punishment	4 "
D	Attention removed	4 "
E	Attention on bull's eye	4 "
F	Limited punishment	4 "
G	Knowledge of results	4 "
H	Attention on accompanying sensations	4 "
I	Long interval between trials	6 "
J	Maximum punishment	4 "
K	Short interval between trials	2 "

A major concern throughout the experiment was to maintain uniformity of learning conditions for each factor.

Each subject was given practice with each instruction (except for the subjects in the control group, for which see page 107). An equal number of practice trials was allowed with each instruction and such variable factors as practice, fatigue, individual differences, etc., were equalized by the order of giving the instructions.

2. The Method of Giving Instructions

The order in which instructions were given to the 66 individuals who served as subjects in the six experimental groups is shown below:

First Group of Subjects

Subject	Instructions
1	A B C D E F G H I J K
2	B C D E F G H I J K A
3	C D E F G H I J K A B
4	D E F G H I J K A B C
5	E F G H I J K A B C D
6	F G H I J K A B C D E
7	G H I J K A B C D E F
8	H I J K A B C D E F G
9	I J K A B C D E F G H
10	J K A B C D E F G H I
11	K A B C D E F G H I J

Second Group of Subjects

Subject	Instructions
1	J I H B G K F A C D E
2	I H B G K F A C D E J
3	H B G K F A C D E J I
4	B G K F A C D E J I H
5	G K F A C D E J I H B
6	K F A C D E J I H B G
7	F A C D E J I H B G K
8	A C D E J I H B G K F
9	C D E J I H B G K F A
10	D E J I H B G K F A C
11	E J I H B G K F A C D

Third Group of Subjects

Subject	Instructions
1	K C G I F E H B J A D
2	C G I F E H B J A D K
3	G I F E H B J A D K C
4	I F E H B J A D K C G
5	F E H B J A D K C G I
6	E H B J A D K C G I F
7	H B J A D K C G I F E
8	B J A D K C G I F E H
9	J A D K C G I F E H B
10	A D K C G I F E H B J
11	D K C G I F E H B J A

Fourth Group of Subjects

Subject	Instructions
1	D C H E F I B J K G A
2	C H E F I B J K G A D
3	H E F I D J K G A D C
4	E F I B J K G A D C H
5	F I B J K G A D C H E
6	I B J K G A D C H E F
7	B J K G A D C H E F I
8	J K G A D C H E F I B
9	K G A D C H E F I B J
10	G A D C H E F I B J K
11	A D C H E F I B J K G

Fifth Group of Subjects

Subject	Instructions
1	K C H B G F E D A J I
2	C H B G F E D A J I K
3	H B G F E D A J I K C
4	B G F E D A J I K C H
5	G F E D A J I K C H D
6	F E D A J I K C H B G
7	E D A J I K C H B G F
8	D A J I K C H B G F E
9	A J I K C H B G F E D
10	J I K C H B G F E D A
11	I K C H B G F E D A J

Sixth Group of Subjects

Subject	Instructions
1	E I K F D H A C G B J
2	I K F D H A C G B J E
3	K F D H A C G B J E I
4	F D H A C G B J E I K
5	D H A C G B J E I K F
6	H A C G B J E I K F D
7	A C G B J E I K F D H
8	C G B J E I K F D H A
9	G B J E I K F D H A C
10	D J E I K F D H A C G
11	J E I K F D H A C G B

This method is known as the counterbalanced order of giving instructions.

The experiment was organized in six cycles, for six groups of subjects. In each cycle were eleven subjects to correspond with the number of instructions. All subjects went through the eleven conditions or instructions

once, each in his own order. Subject 1 began with the first of the instructions as listed above, went through the second, third, and so on. Subject 2 began with the second of the listed instructions, then took the third, and finally, went through the first. This scheme was carried through so that each instruction appeared equally often in each serial position.

C. Experimental Procedure

1. Subjects

Sixty-six subjects were used in the six experimental groups, and eleven in a control group.[1] They were unselected except that they were adult students, and in all but one or two cases did not know the nature of the experiment until brought into the laboratory.

2. Conduct of the Experiment

Each subject was allowed sixty trials under each instruction. About seventy-five minutes was required for a subject to complete the eleven practice periods.

---

1. The purpose and results of the control group are reported on page 108.

On entering the laboratory the subject was instructed to remove coat or sweater. While the subject observed the objects in the room, the target, balls, etcetera, the experimenter adjusted the electrical devices to the left hand (right if the subject was left handed), and inserted it into a glove. The subject was then told to observe the bull's eye and the zones on the target. After pressing the switch to start the signals, the experimenter tossed a half dozen balls at the bull's eye, saying "Now, this is the manner of tossing the balls, a trial for each signal." The subject was shown the mark on the floor that indicated the place where he was to stand. He was next asked to toss a half dozen balls at the target to get used to the manner of tossing and the signals. Following this he was given the preliminary instructions, the instructor saying, "Here are the instructions that tell you what you are going to do. You should look at them carefully for they tell you exactly what you are to do." When the preliminary instructions had been read, the subject was given instruction for his first practice period, and after he had read it, was told to begin. As the experiment proceeded the other instructions were

given. The subject was given as much time between the practices as was needed to read the instructions. Exact copies of the verbal instructions follow in section 3.

The experimenter manipulated the switches and inductorium, set the interval between tosses, or announced the error as the instructions required. A record was made of the position of the hits. The method of keeping the record will be described in section D, on page 37.

3. Verbal Instructions

Preliminary Instruction: In the ball tossing that you are about to begin you will learn to hit the bull's eye that you see in the center of the target. The instructions that will be given you will tell you what to do to learn to hit the bull's eye. Follow the instructions and do not under any circumstance use your own method. It is absolutely necessary that you do just as you are told to do in the instructions. There are 11 instructions. You will take 60 trials for each of the 11 instructions. Throw six balls in succession, that is, one right after another. When you begin throwing have 6 balls ready in your left hand (right hand if you are left handed). When throwing have only the ball to be thrown in the hand you throw with. Signals will be given so that you will know how fast to throw. Throw a ball after each signal. You will not be punished unless the instruction says that you will be punished.

Instruction A (Simple positive instruction): Throw at the bull's eye. Take 60 trials.

Instruction B (Attention to the idea of success): Say to yourself just as you take each trial, "Now, this one is going in." Take 60 trials.

Instruction C (Minimum punishment): Be accurate in throwing. You will be punished if you hit in the outer zone. You will not be punished if you hit the bull's eye, or in the area between the bull's eye and the outer zone. Take 60 trials.

Instruction D (Attention removed): Say the letters of the alphabet as you throw. When you get to "z", start at "a" again. Say a letter for each trial. Take 60 trials.

Instruction E (Attention on the bull's eye): Fix your attention on the center. Keep your eye on the center and try to hit the bull's eye. Take 60 trials.

Instruction F (Limited punishment): Be accurate. You will be punished if you hit in either of the two outer zones. You will not be punished if you hit the bull's eye, or in the area between the bull's eye and the two outer zones. Take 60 trials.

Instruction G (Knowledge of exact result): You will be told how much you miss the bull's eye after each trial. Try to do better each time. Take 60 trials.

Instruction H (Attention to accompanying sensations): Fix your attention on your hand. Note the feel of the ball in the hand as you throw. Try to remember how the ball felt when you missed, and how it felt when you made a good throw. Take 60 trials.

Instruction I (Long interval between trials): Throw 60 balls at the bull's eye. Throw a ball for each signal (signal every 6 seconds).

Instruction J (Maximum punishment): Be very accurate. You will be punished if you hit in any of the zones lying around the bull's eye. You will not be punished if you hit the bull's eye. Take 60 trials.

Instruction K (Short interval between trials): Throw 60 balls at the bull's eye. Throw a ball for each signal (signal every 2 seconds).

D. Scoring and Tabulating the Results

1. Method of Keeping Record

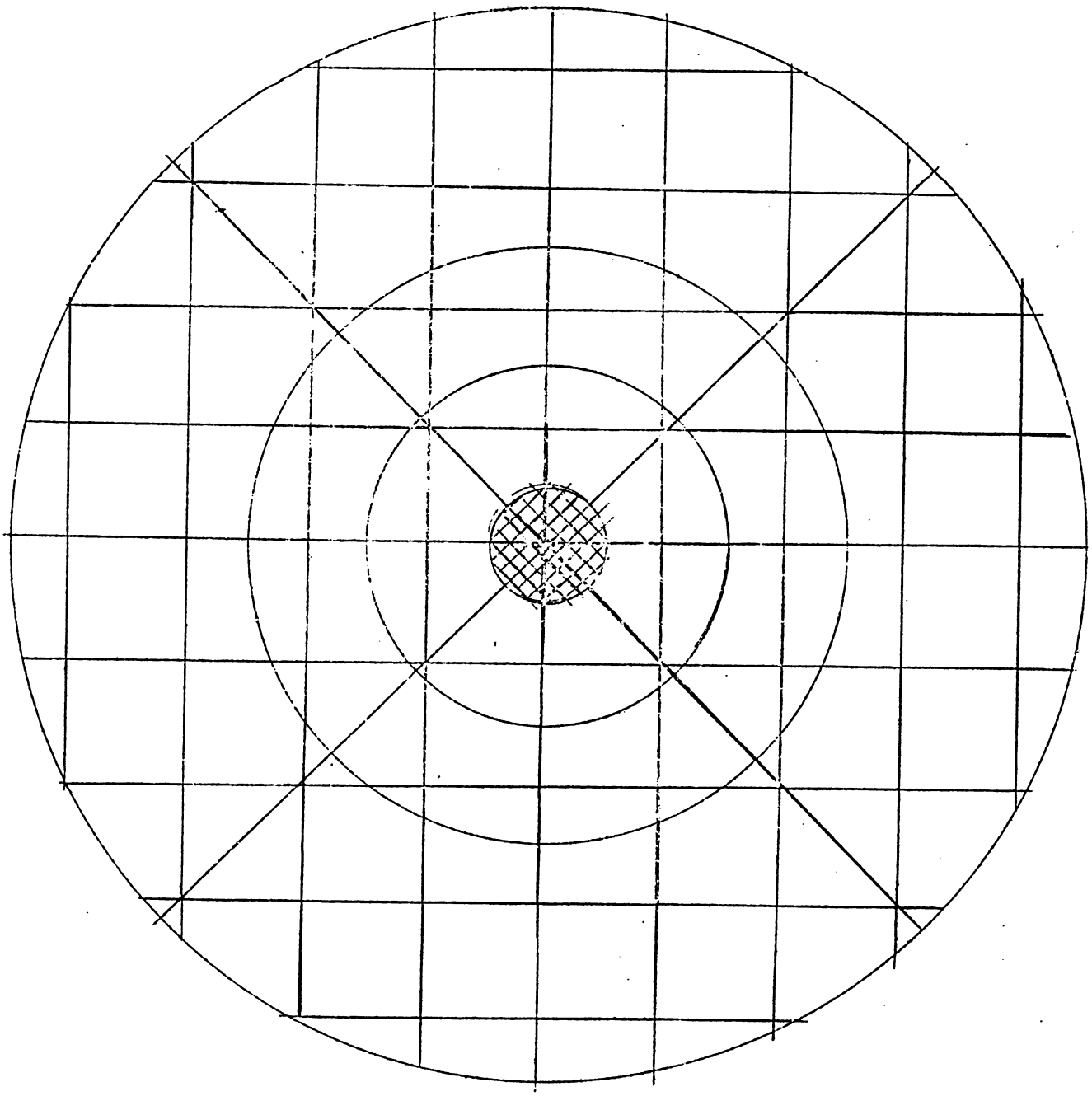
Before experimenting began, the experimenter practiced scoring to gain the necessary skill and to see that everything was in order. Several individuals tossed at the target while the experimenter practiced marking the position of the hits on the record sheet.

To make the record the experimenter took a position at the desk to the left and rear of the subject, with the three vertical lamps and the target in a direct line of vision. With a single sweep of the eye the flash of the light that indicated the zone hit, the impact of the ball against the target, and the movements of the subject could be seen. After each toss the position of the hit was recorded.

The record was made on mimeographed diagrams of the target. A blank record is included in Figure 5. Twelve hits were recorded on a diagram. A 60 trial practice period required five diagrams. A subject's complete record of 660 trials required 55 diagrams. The experiment required 4235 diagrams.

The record gave the position of each hit, and the results of the experiment are tabulated in terms

Name_____Age____Grade___Handedness_____Time___Male___
Female_____



Ball's eye; 1st zone ; 2nd zone ; 3rd zone ; all Error; x x x

x+ x- y+ y-

Figure 5.--Diagram of the Target Used in recording the "Hits".

of zones. The position of each hit was assumed to be at the midpoint of the zone. Actually the hits tended to concentrate near the inner margin of the zone, and the record is not strictly accurate; but since the error is constant, affecting the scoring for all conditions alike, the method of scoring yielded fairly satisfactory results. A more accurate method would have been to measure the distance of each hit from the center of the target, but this method would have been very laborious.

2. Criteria of Success

Two criteria are used in reporting the quantitative results of the experiment. These are the average score per subject and the distribution of hits.

The total score, which represents for an instruction the total achievement for the 66 subjects, was obtained by weighting the hits in the zones and by adding the five resulting quantities. The following weightings were used: An attempt in which the ball hits zone one is weighted 0; zone two, 5; zone three, 10; zone four, 17.5; and zone five, 25. The width of zone five is arbitrarily reckoned at ten inches. These

weightings correspond to the distance in inches from the center of the target to the midpoint of the respective zones. Thus the total score is approximately the sum in inches of the errors for all the single trials. It may be observed that the smaller the total score the greater the degree of accuracy, and vice versa.

The average score per subject for an instruction was obtained by dividing the total score by 66, the number of subjects. The average score per subject for an instruction may be thought of as the average subject's gross error in inches (approximately) for 60 trials. The smaller the average score per subject the greater the degree of accuracy.

The weightings used tend to accentuate the importance of "wild hits". The results would have been slightly different had the distribution of hits been weighted so as to accentuate the importance of bull's eye hits. However, any partiality in evaluating the instructions that may have resulted from the weightings is overcome by parallel use of the two criteria.

The distribution of hits is a reliable criterion, although inconvenient for comparing the effects of the various instructions. Graphs are used to show the dis-

tribution of hits for each instruction. These graphs aid in analyzing the effects of the conditioning factors.

3. Simple Positive Instruction Used as Basis of Comparison

In the report of results next to follow in Chapter III the record for each experimental factor will be compared with the record for simple positive instruction (Instruction A). This instruction sets the problem in simplest terms, whereas the other instructions add various conditioning factors. Use of one instruction as a common basis of comparison serves also to simplify the treatment of results.

The general results of the experiment will first be reported by comparing the record for each instruction with that for simple positive instruction and by comparing the records for the various instructions with one another. This will be followed by a detailed study of the results for each of the factors under investigation.

Chapter III

RESULTS

A. Introduction

The effect produced by punishment, direction of attention in various ways, etc. may be estimated by comparing the record for these factors with that for simple positive instruction. The latter instruction introduces no guidance or direction. These comparisons thus tend to reveal the worth of the special learning situations set up in this experiment.

For convenience in reporting results the various learning situations are referred to as "instructions". The reader should therefore keep in mind that the record for any learning situation was the result, not only of the instruction written on the card, but also of other stimuli, e.g., pain as a result of punishment, knowledge of extent of error, and the like.

In order to make the discussion of results easy to follow, the instructions will be distinguished as

follows:

Instruction	Factor Investigated
A	Simple positive instruction
B	Attention to idea of success
C	Minimum punishment
D	Attention removed
E	Attention on the bull's eye
F	Limited punishment
G	Knowledge of exact result
H	Attention on accompanying sensations
I	Long interval between trials
J	Maximum punishment
K	Short interval between trials

Copies of instructions are found on pages 35 and 36.

Results are reported in such a way as to apply them to the solution of the problem stated, for convenience, in question form at the beginning of the sections. The sections deal with the following topics: (1) comparison of all instructions with simple positive instruction, (2) comparison of instructions with one another, (3) punishment, (4) knowledge of exact result, (5) role of attention, (6) effect of different intervals between trials, (7) variability among individuals, and (8) reliability of the results.

B. Comparison of All Instructions with Simple Positive Instruction

Problems: Is anything to be gained by use of such special

learning situations as punishment for different types of errors, direction of attention in various ways, knowledge of exact result, etc.? What are the relative effects of the eleven instructions used in the experiment?

The data which bear upon these problems are reported in Tables I, II, and III, which give the general results of the experiment. Figures 6 - 19 represent these data graphically. Table I gives the number of times each of the target zones was hit under each instruction. Zone one is the bull's eye, and the zones number from the bull's eye outward. There were an equal number of hits (3960) for each instruction.

Table I is read thus: For simple positive instruction, for example, there were 432 hits in zone one, 2071 hits in zone two, 1026 hits in zone three, 396 hits in zone four, and 35 hits in zone five. The data for the other instructions are read in the same manner. Thus the instructions may be compared by the number of hits in the zones.

Eight instructions yielded more successful hits (hits in zone one) than simple positive instruction. These are attention to the idea of success (493), minimum punishment (456), attention on the bull's eye (445), limited punishment (475), knowledge of exact result (514),

Table I

A TABLE GIVING FOR EACH INSTRUCTION THE DISTRIBUTION OF 3960 HITS IN THE FIVE TARGET ZONES*

Factor Investigated		Target Zones 1	2	3	4	5
Simple positive instruction	(A)	432	2071	1026	396	35
Attention to the idea of success	(B)	493	2088	1022	325	32
Minimum punishment	(C)	456	2116	960	407	21
Attention removed	(D)	388	2098	1058	388	28
Attention to the bull's eye	(E)	445	2130	988	368	29
Limited punishment	(F)	475	2172	1003	293	17
Knowledge of exact result	(G)	514	2102	983	347	14
Attention to accompanying sensations	(H)	451	2090	1030	355	24
Long interval between trials	(I)	453	2109	1032	346	20
Maximum punishment	(J)	500	2152	976	318	14
Short interval between trials	(K)	411	1947	1087	474	41

* Each of 66 subjects made 60 attempts with each instruction

attention on accompanying sensations (451), long interval between trials (453), and maximum punishment (500). Two instructions yielded fewer successful hits than simple positive instruction: attention removed (388) and short interval between trials (411). Similar, but not identical results are obtained by comparing the instructions by the record of wild hits - hits in zones three, four, and five.

Table II simplifies the comparison of all instructions with simple positive instruction. The data in this table are obtained by weighting the distributions of hits in Table I. (See page 39 for weighting scheme). Reading from left to right, the table gives for each instruction the total score (defined on page 39), the average score per subject (defined on page 40), and the probable error of the average.

The eleven instructions may be ranked according to the average score per subject (second column, Table II) to show the relative degree of efficiency of the eleven conditioning factors. The ranks are as follows, beginning with the instruction that yielded highest efficiency: maximum punishment (400.5), limited punishment (400.6), knowledge of exact result (405.5), attention

Table II

A TABLE GIVING FOR EACH INSTRUCTION THE TOTAL SCORE, AVERAGE SCORE PER SUBJECT (MEAN), AND THE PROBABLE ERROR OF THE MEAN. DATA OBTAINED BY WEIGHTING THE DATA IN TABLE I

Factor Investigated		Total Score	Mean per Subject	P.E. Mean
Simple positive instruction	(A)	28420.0	430.6	9.17
Attention to the idea of success	(B)	27147.5	411.3	7.86
Minimum punishment	(C)	27827.5	421.6	7.84
Attention removed	(D)	28560.0	432.7	7.76
Attention to the bull's eye	(E)	27695.0	419.6	8.68
Limited punishment	(F)	26442.5	400.6	7.49
Knowledge of exact result	(G)	26762.5	405.5	8.18
Attention to accompanying sensations	(H)	27737.5	420.2	6.78
Long interval between trials	(I)	27420.0	415.4	8.63
Maximum punishment	(J)	26435.0	400.5	7.23
Short interval between trials	(K)	29925.0	453.4	10.39

to the idea of success (411.3), long interval between trials (415.4), attention to the bull's eye (419.6), attention to accompanying sensations (420.2), minimum punishment (421.6), simple positive instruction (430.6), attention removed (432.7), and short interval between trials (453.4). The range is from 400.5 to 453.4. All instructions yielded a lower average score per subject than simple positive instruction except attention removed and short interval between trials.

A more detailed comparison of the means (average score per subject) for the eleven instructions may be made by inspecting Figure 6. The data tend to show that efficiency may be increased by setting up special learning situations to punish the subject for errors, to keep him aware of his exact record, to direct his attention in certain ways, or to regulate the interval between trials. Efficiency tends to vary with the instruction used, although some instructions appear to be about equally efficacious.

The means for maximum and limited punishment differ very slightly. Likewise, the difference between the means for minimum punishment, attention on accompanying sensations, and attention on the bull's eye are small.

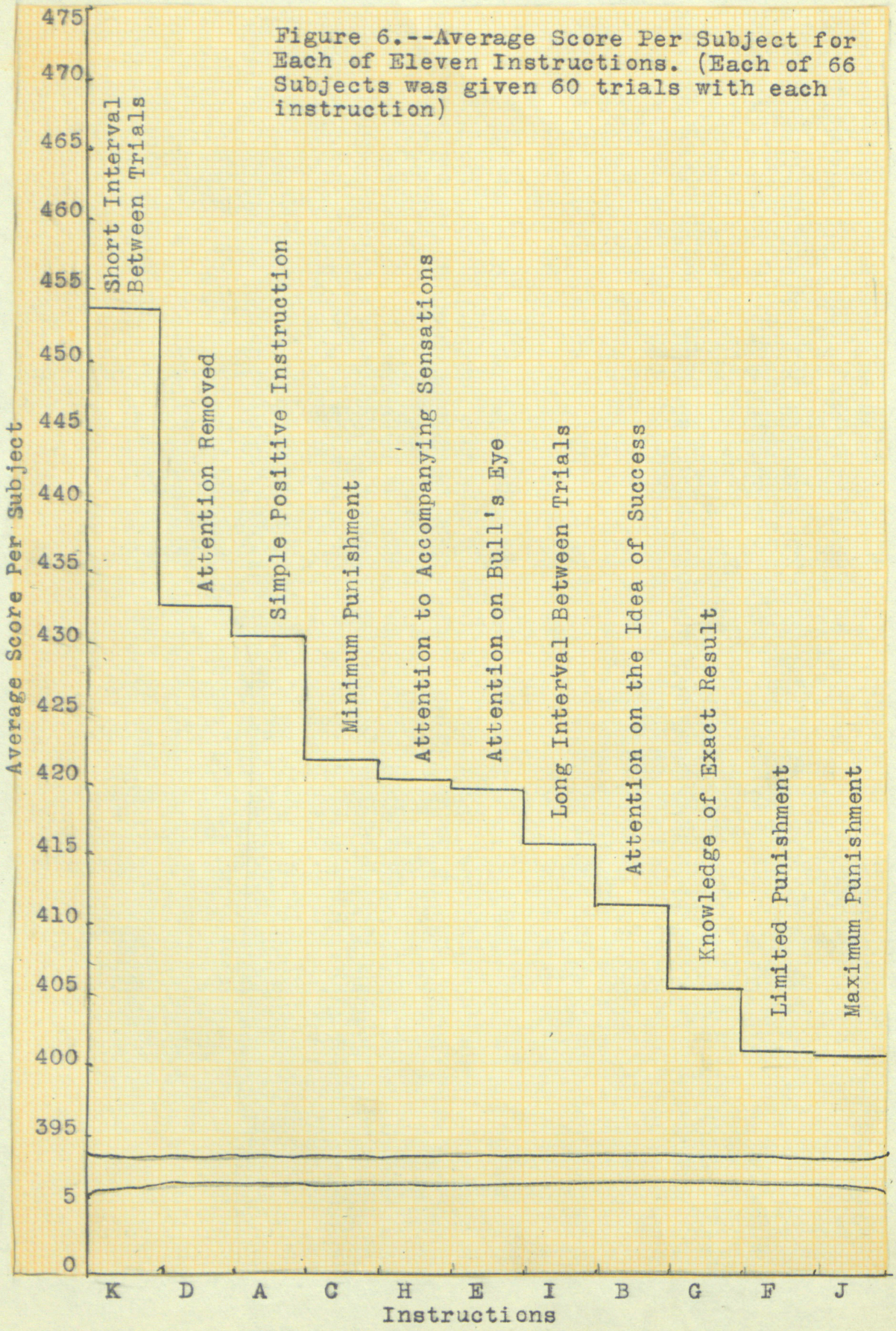


Figure 6.--Average Score Per Subject for Each of Eleven Instructions. (Each of 66 Subjects was given 60 trials with each instruction)

Reliability of these and other differences will be discussed in the next section.

C. Comparison of Instructions with One Another

Problem: How do the results for the experimental factors compare with one another?

Each instruction was compared with every other instruction by computing the differences between the means and the probable errors of the differences. The mean of each instruction and the probable error of each mean are found in Table II. The following formula [1] for correlated measures was used in computing the probable errors of the differences between the means:

$$P.E._{M_1-M_2} = \sqrt{(P.E._{M_1})^2 + (P.E._{M_2})^2 - 2r_{12}(P.E._{M_1})(P.E._{M_2})}$$

Fifty-five comparisons are made in Table III. In

1. The use of this formula is illustrated in the following references:
Holzinger, Karl J., Statistical Methods for Students in Education. Columbus:Ginn and Company, 1928, pp. 242,243.
Hall, Margaret E., "Remote Associative Tendencies in Serial Learning." Journal of Experimental Psychology, (April, 1928), pp. 65-76.
Winch, W.H., "Inductive vs. Deductive Methods of Teaching; an Experimental Research." Educational Psychology Monograph. Baltimore:Warwick & York,1913, pp. 7-10.

addition to the differences and the probable errors of the differences, this table gives for each comparison the amount of correlation between the two series of measures compared, the ratio of the difference to the probable error of the difference, and the chance in 1000 of a true difference greater than zero. [1]

The instructions are listed in alphabetical order. The instruction having the smaller average score is designated by underscoring, e.g., "A-B" means that instruction B has a smaller average "error" than instruction A. The table is read thus: The difference between the means of instruction A and instruction B is 19.9, and the probable error of the difference is 7.08. The difference is 2.81 times the probable error of the difference, and there are 971 chances in 1000 that a true difference greater than zero exists. The data for the other comparisons are read from the table similarly.

---

1. Reliability in terms of chances in 1000 of a true difference was read from Table XI, p.93, Garrett, H.E., Statistics in Psychology and Education. The method of reading the data from the table is explained on pages 131 and 132 of the same text. Measures that could not be read directly from the table were obtained by interpolating. Measures were read to the nearest whole number.

Table III

COMPARISON OF RESULTS (MEANS, TABLE II) FOR THE ELEVEN INSTRUCTIONS WITH ONE ANOTHER (55 COMPARISONS). *CORRELATION BETWEEN THE SERIES OF MEASURES COMPARED; DIFFERENCE BETWEEN THE MEANS, PROBABLE ERROR OF THE DIFFERENCE, RATIO OF THE DIFFERENCE TO THE PROBABLE ERROR, AND CHANCES IN 1000 OF A TRUE DIFFERENCE

Instructions Compared	Correlation Coefficient (r)	Diff. between Means	P.E. diff.	$\frac{D}{P.E.\ Diff.}$	Chances in 1000 of a True Diff.
A B	.664	19.9	7.08	2.81	971
A C	.530	9.0	8.32	1.08	767
A D	.672	2.1	7.02	.30	580
A E	.690	11.0	7.09	1.55	852
A F	.637	30.0	7.26	4.13	997
A G	.539	25.1	8.25	3.04	980
A H	.750	10.4	6.05	1.72	877
A I	.710	15.2	6.73	2.26	936
A J	.446	30.1	8.80	3.42	989
A K	.310	22.8	11.54	1.97	908
B C	.791	10.3	5.08	2.03	914
B D	.590	21.4	7.14	3.00	978
B E	.665	8.3	6.86	1.21	793
B F	.731	10.7	5.64	1.90	900

(Table continued on next page)

* The instruction having the smaller average error per subject is indicated with the underscore mark (_)

Table III (Continued)

Instructions Compared	Correlation Coefficient (r)	Diff. between Means	P.E. Diff.	D / P.E. Diff.	Chances in 1000 of a True Diff.
B G	.687	5.8	6.26	.93	735
B H	.765	8.9	5.17	1.72	877
B I	.735	4.1	5.94	.69	679
B J	.633	10.8	10.29	1.05	761
B K	.465	42.1	9.68	4.35	998
C D	.735	11.1	5.70	1.95	906
C E	.689	2.0	6.54	.31	583
C F	.668	21.0	6.28	3.34	988
C G	.696	16.1	6.11	2.64	963
C H	.732	1.4	5.50	.25	567
C I	.797	6.2	5.25	1.18	787
C J	.682	21.1	6.06	3.38	991
C K	.405	31.8	10.15	3.13	983
D E	.615	13.1	7.35	1.78	886
D F	.573	32.1	7.17	4.48	999
D G	.523	27.2	7.65	3.55	992
D H	.685	12.5	5.90	2.12	924
D I	.680	17.3	6.53	2.65	963
D J	.493	32.2	7.58	4.25	998

(Table continued on next page)

Table III (Continued)

Instructions Compared	Correlation Coefficient (r)	Diff. between Means	P.E. Diff.	$\frac{D}{P.E.\ Diff.}$	Chances in 1000 of a True Diff.
D K	.298	20.7	10.96	1.89	899
E F	.738	19.0	6.03	3.15	983
E G	.714	14.1	6.33	2.23	934
E H	.734	.6	5.96	.10	527
E I	.762	4.2	6.01	.70	682
E J	.742	19.1	5.91	3.23	985
E K	.362	33.8	10.87	3.11	982
F G	.690	4.9	6.02	.81	708
F H	.765	19.6	4.99	3.93	996
F I	.795	14.8	5.19	2.85	973
F J	.695	.1	5.77	.02	505
F K	.415	52.8	9.98	5.28	1000
G H	.790	15.7	4.86	3.02	979
G I	.761	9.9	5.69	1.74	880
G J	.704	5.0	5.81	.86	719
G K	.379	47.9	10.40	4.61	999
H I	.809	4.8	5.05	.95	739
H J	.763	19.7	5.04	3.91	996
H K	.542	33.2	8.86	3.75	994
I J	.710	14.9	6.10	2.44	950
I K	.445	38.0	10.06	3.78	995
J K	.289	52.9	10.79	4.90	999

Four degrees of reliability may be distinguished as follows[1]: (1) A reliability of 996 to 1000 (inclusive) chances in 1000, or a difference between the means at least four times the probable error; (2) a reliability of 978 to 995 (inclusive) chances in 1000, or a difference between the means from three to four times the probable error; (3) a reliability of 911 to 977 (inclusive) chances in 1000, or a difference between the means from two to three times the probable error; (4) a reliability of 759 to 910 (inclusive) chances in 1000, or a difference between the means from one to two times the probable error; and (5) a reliability of 500 to 749 (inclusive) chances in 1000 or a difference between the means from zero to one times the probable error.

Table III shows that for nine comparisons of means there are from 996 to 1000 chances in 1000 that a true difference exists. For these nine pairs of instructions the ratio of the difference to the probable error of the difference is at least four. This ratio insures practically complete reliability. The nine pairs of instructions are: Simple positive instruction

---

1. Based on Table XI, Garrett, H.E., Statistics in Psychology and Education, p. 93.

and limited punishment; attention to the idea of success and short interval between trials; attention removed and limited punishment; attention removed and maximum punishment; limited punishment and short interval between trials; knowledge of exact result and short interval between trials; limited punishment and attention to accompanying sensations; maximum punishment and attention to accompanying sensations, and maximum punishment and short interval between trials.

For thirteen pairs of instructions there are from 978 to 995 (inclusive) chances in 1000 that a true difference exists. For nine pairs of instructions there are from 911 to 977 (inclusive) chances in 1000 that a true difference exists. For thirteen pairs of instructions there are from 750 to 910 (inclusive) chances in 1000 that a true difference exists. For eleven pairs of instructions there are from 500 to 749 (inclusive) chances in 1000 that a true difference exists.

The general results of the experiment reported in Tables I, II, and III and Figure 6 have been described by comparing the records for all the instructions with the record for simple positive instruction, and by comparing the records for the instructions with

one another. The factors investigated will next be taken up one at a time for a more detailed study.

D. Punishment (Instructions C,F and J)

Problem: What is the effect of punishing for large errors? Of punishing for small errors? Of punishing for both large and small errors, i.e., for each unsuccessful attempt? Is it more economical to use a learning situation which does not involve punishment?

1. Introduction

It has been shown that subjects tend to be more efficient when punished for inaccuracy than when simple positive instruction was used. This was not equally true for each of the three punishment instructions. The effects of administering punishment for three degrees of error will now be considered.

a. The subjects were automatically given an electric shock for each hit in target zone four. This is distinguished as minimum punishment (instruction C).

b. The subjects were automatically given an electric shock for each hit in zones three and four. This is distinguished as limited punishment (instruction F).

c. The subjects were automatically given an electric shock for each hit in zones two, three and

four. This is distinguished as maximum punishment (instruction J).

2. General Comparisons

The average score per subject for minimum punishment was 421.6; for limited punishment, 400.6; and for maximum punishment, 400.5 (Table II). These figures tend to show that increasing the requirements up to a given limit causes the subject to be more accurate, but that increasing the requirements beyond this limit does not increase the accuracy. The subjects were no more accurate when punished for hits in zones two, three, and four than when punished only for hits in zones three and four. There are only 505 chances in 1000 that a true difference exists between the means for limited punishment and maximum punishment. There are 988 chances in 1000 that a true difference exists between the means for minimum and limited punishment, and 991 chances in 1000 of a true difference between the means for minimum and maximum punishment (Table III).

By analysis of the distribution of hits for punishment for the three types of errors, other significant facts may be observed. Likewise, the effects of punishment instructions will be compared with the

effects of non-punishment instructions.

3. Minimum Punishment (Instruction C)

A detailed account of the effects produced by punishment for hits in zone four is presented in Figure 7. This diagram compares the distribution of hits for minimum punishment with that for simple positive instruction. The effect of minimum punishment was to slightly increase the hits in zones one, two, and four and to decrease slightly the hits in the other zones. The general effect was slightly to increase the degree of accuracy. The chances are 767 in 1000 that a true difference exists between the means of simple positive instruction and minimum punishment (Table III). Punishing the subjects for hits in zone four did not result in fewer hits in this zone as might be expected, although there were fewer hits in the three outer zones taken together.

4. Limited Punishment (Instruction F)

Punishment on two zones resulted in greater accuracy than punishment on one zone (Figure 8). Punishment for hits in zones three and four markedly increased the number of hits in zones one and two

Figure 7.--Comparison of Distribution of 3960 Hits for Minimum Punishment and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)

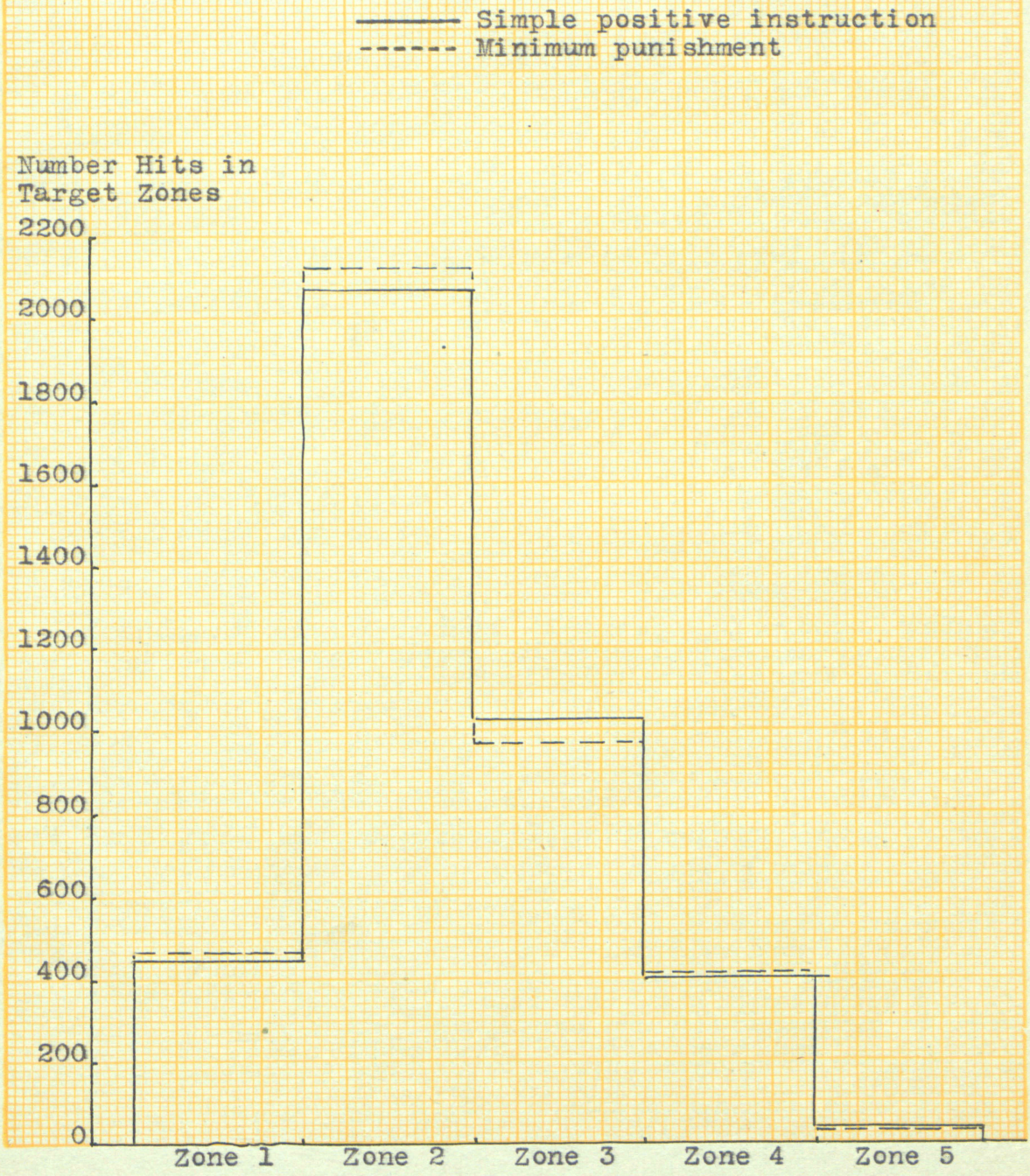
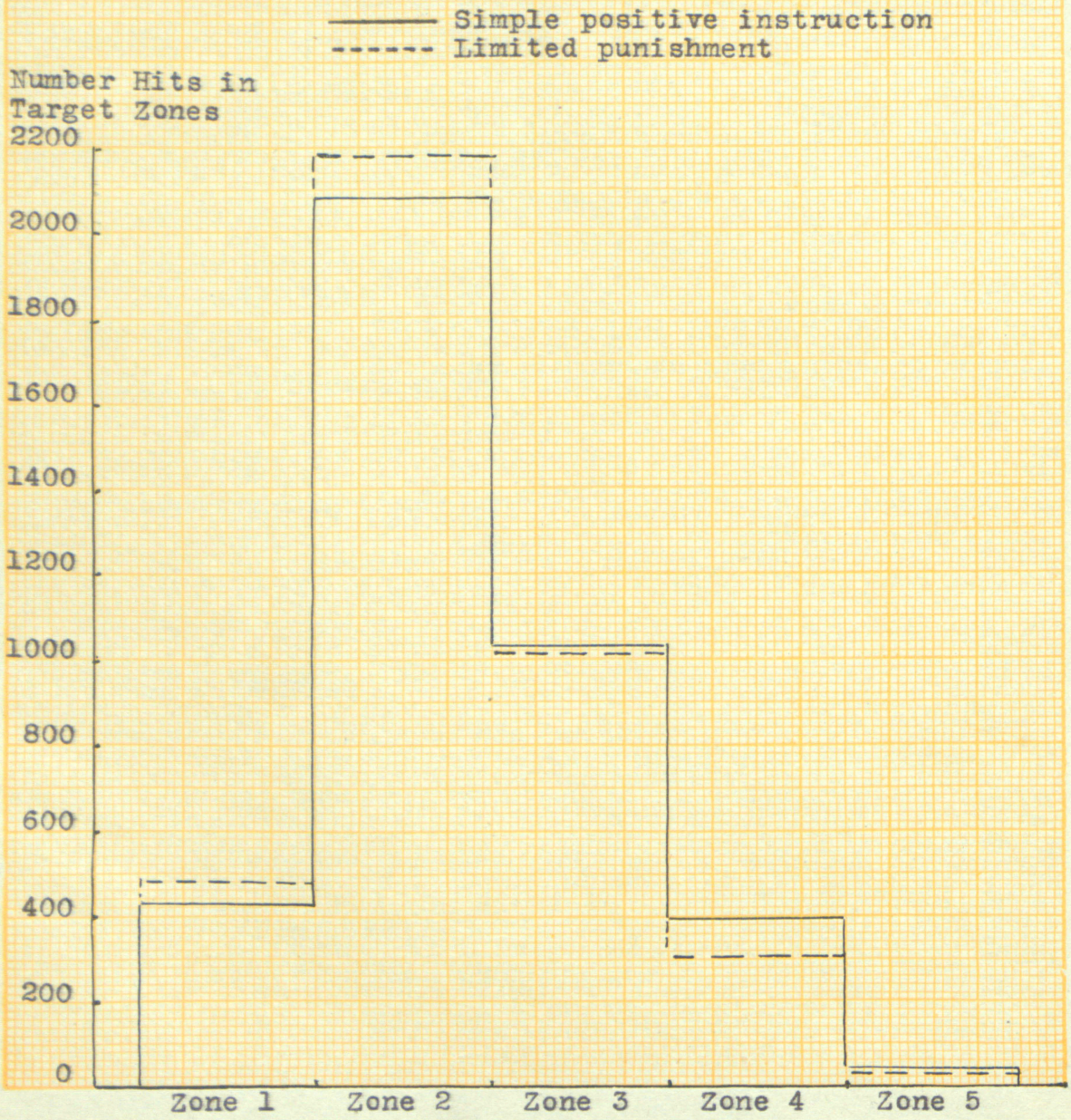


Figure 8.--Comparison of Distribution of 3960 Hits for Limited Punishment and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



(Figure 8). There were more hits in zone two with limited punishment than with any other instruction, the number being 2172. The next highest was 2152 for maximum punishment.

Two general effects of punishing the subject for hits in zones three and four may be noted, namely, a general increase in accuracy and a slight concentration of hits in the area between the punishment zones and the bull's eye.

These results for limited punishment tend to show that the effect of punishment is to cause individuals to respond with an avoidance reaction. Attention appears not to have been fixed on the bull's eye, but on the area inside the danger zone. This view is supported by the introspective reports of the subjects. The most common answer to the question, "What did you try to do when punishment was used?" was, "I was trying to keep from getting shocked." One subject reported that under the limited punishment condition he "pitched as if the bull's eye were everything inside the danger zone." Other facts that tend to indicate that punishment produces an avoidance reaction are reported in the paragraphs that follow.

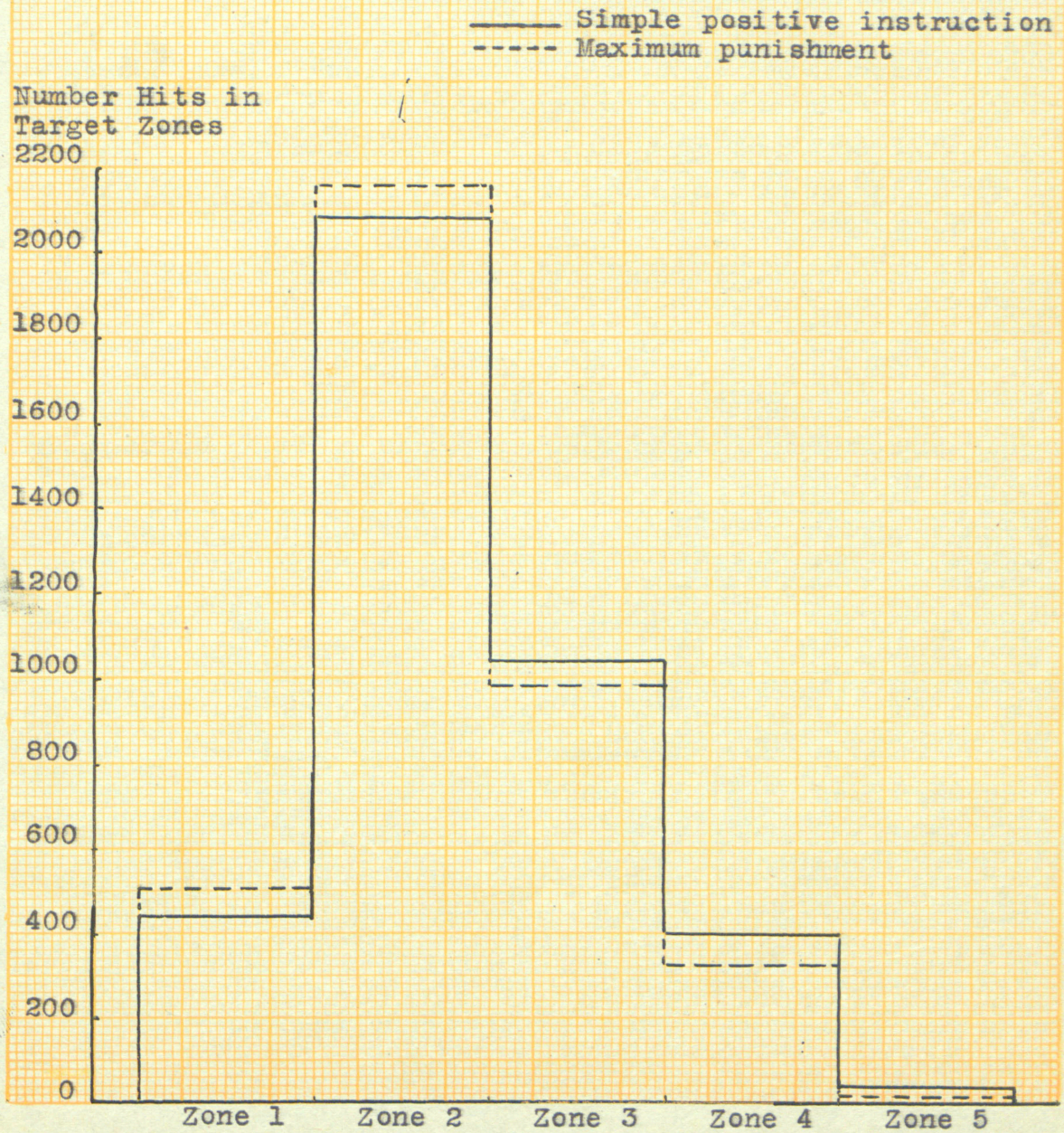
5. Maximum Punishment (Instruction J)

The results for the maximum punishment condition, now to be reported, show what happened when the subject was punished for hits in all the zones except the bull's eye. The distribution of hits for this instruction is shown in Figure 9. The effect was to decrease the number of hits in the three outer zones and to increase the number of hits in the bull's eye and second zone. There were fewer hits in the three outer zones than with any other instruction. This means that there were more hits in zones one and two than with any other instruction.

If the effect of punishment is to cause an avoidance reaction, one would expect this instruction to yield a large number of bull's eye hits. Actually, there were 500 such hits, a larger number than were obtained with any other instruction except knowledge of exact result.

Another interesting fact is that the average score per subject for limited punishment was very slightly smaller than that for maximum punishment, yet there were 25 more bull's eye hits with maximum punishment than with limited punishment. These effects could

Figure 9.--Comparison of Distribution of 3960 Hits for Maximum Punishment and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



easily be the result of chance, but they are in support of the avoidance reaction hypothesis.

Whether the subjects with maximum punishment directed attention to avoidance of punishment or to an effort to hit the bull's eye is a theoretical question, since to avoid the danger zone was to hit the bull's eye. Naturally, attention was divided between the painful shocks and the effort to hit the bull's eye. The subjects appeared to be "wrought up". Some stated that the shocks "interfered", while others said they thought the shocks made them "do better". The chances of tossing a steel ball through a five inch hole at a distance of eighteen feet are small, e.g., the average number of successful tosses per subject was about five for the sixty trial practice period, with a range from 1 to 24. This is about one successful toss in twelve trials. For the subjects who feared the shocks this task must have been very discouraging. Such disruptive effects as were observed were in the form of general resistance to the task rather than negligence in any particular attempt, although one or two subjects reported that they tried to avoid the shocks by making "easy tosses", so as not to close the circuit. These attempts were rarely if

ever successful. A subject could have avoided the shock by tossing so as to miss "everything", but the records show that "wild tosses" were no more frequent with maximum punishment than with other instructions (Table I). The ball appeared to hit the edge of the bull's eye oftener than with other instructions, although no record was kept of these hits. One individual said he thought the shock was less intense when he hit near the bull's eye.

6. Comparison of the Best Punishment and the Best Non-Punishment Instruction - (Instructions J - G)

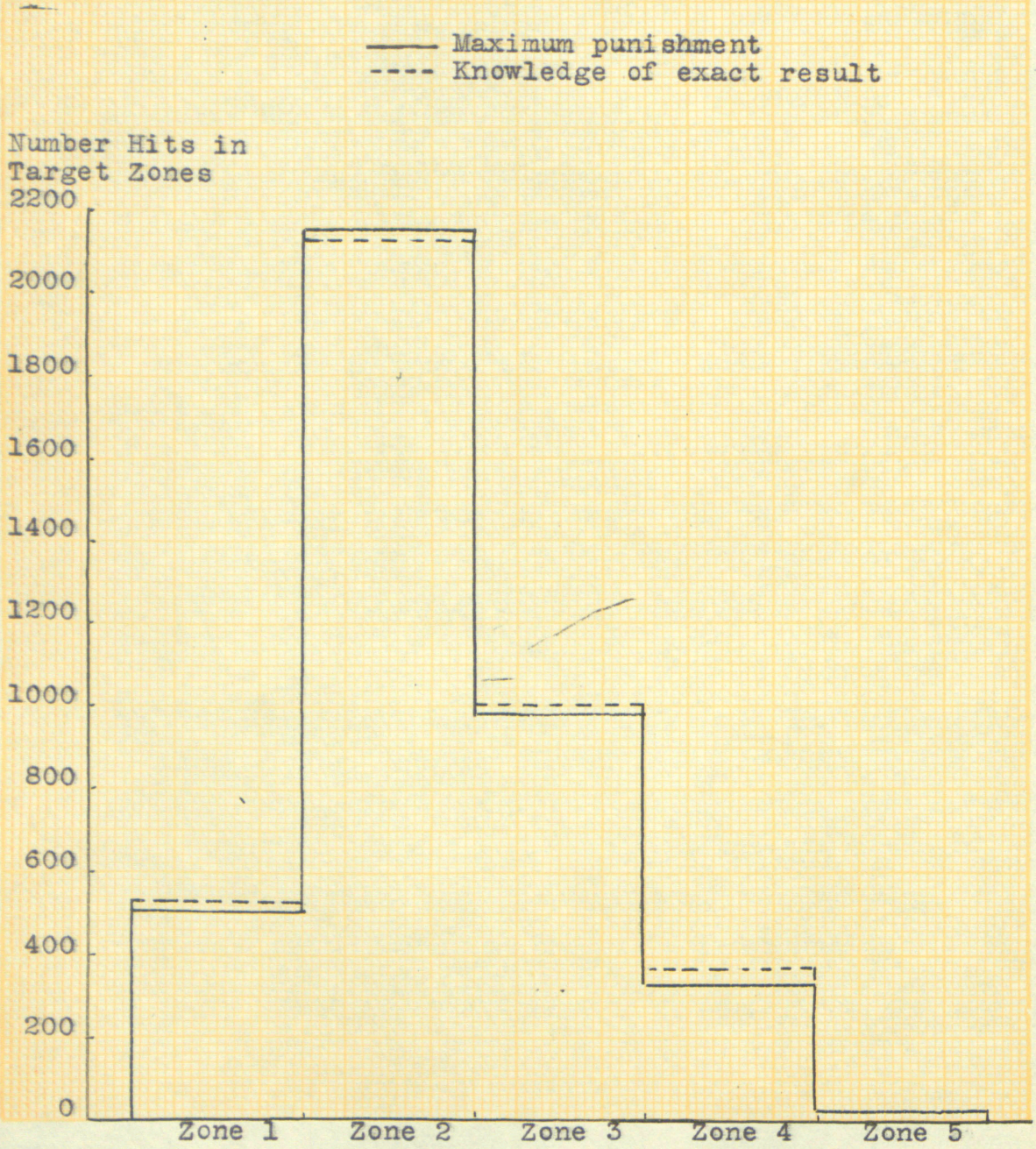
One of the aims of making a comparison of the best punishment and the best non-punishment instruction is to discover whether it is more economical to use punishment or some other incentive. Comparison of the results for limited punishment (mean, 400.6) and maximum punishment (mean, 400.5) with that for knowledge of exact result, the most efficient of the non-punishment instructions (mean, 405.5), shows that the average score per subject was slightly smaller when these punishment instructions were used, but that the non-punishment yielded slightly more bull's eye hits (non-punishment, 514; maximum punishment, 500;

limited punishment, 475). A direct comparison of maximum punishment and knowledge of exact result is provided in Figure 10, which shows the number of hits in all zones for the two instructions.

Table III shows a reliability of only 708 chances in 1000 for the difference between the average scores for limited punishment and knowledge of exact result, and only 719 chances in 1000 for the difference between the average scores for maximum punishment and knowledge of exact result.

The fact that the non-punishment yields the largest number of bull's eye hits while at the same time punishment instruction yields a slightly better average score is in support of the conclusion that punishment causes an avoidance reaction. If the series of eleven instructions is ranked on the basis of wild hits (hits in zones three, four, and five), maximum punishment ranks first (1308 hits); limited punishment, second (1313 hits); and knowledge of exact result, third (1344 hits). This fact is further evidence that punishment lessens the number of wild hits. One would expect that diminishing the number of wild hits would augment the number of bull's eye hits, but this is not the case. If the series of eleven instructions is

Figure 10.--Comparison of Distribution of 3960 Hits for the Best Punishment Instruction (Maximum Punishment) and Distribution of 3960 Hits for the Best Non-Punishment Instruction (Knowledge of Exact Result). (Each of 66 subjects was given 60 trials with each instruction)



ranked on the basis of bull's eye hits, knowledge of exact result ranks first (514 hits); maximum punishment, second (500 hits); attention to the idea of success, third (493 hits); and limited punishment, fourth (475 hits).

The interpretation of these facts seems to be that, for making bull's eye hits, non-punishment is slightly superior, but for reducing the number of wild hits, punishment instruction is slightly superior.

7. Conclusions

The conclusions concerning the effects of punishing individuals for inaccurate hits may be summarized in the following statements:

a. Punishing the subject for errors tends to result in fewer errors (small average score per subject), thus increasing efficiency. Other methods appear to be slightly more efficacious for making bull's eye hits.

b. Increasing the punishment zones up to a certain limit (from one to two zones) increases markedly the degree of accuracy. Increasing the punishment zones beyond this limit (from two to three zones) does not result in greater accuracy.

c. Punishment tends to cause individuals to react negatively; that is, to aim to avoid punishment

rather than to hit the bull's eye. When punishment was used the hits tended slightly to concentrate in the area between the punishment zone and the bull's eye. As compared with the best non-punishment instruction (i.e., knowledge of exact result) punishment is slightly inferior in terms of bull's eye hits, and slightly superior in terms of wild hits. Although these differences are not highly reliable, they suggest that punishment is a rather poor method of getting a desired task done, but is the best method (compared with other methods used in the experiment) for preventing something, not desired, from being done.

d. There appears to be no necessary antagonism between the effects of punishment instruction, which is especially potent for eradicating errors, and the various forms of positive instruction, which appears to be more potent for making successful attempts. Conceivably, punishment and non-punishment instruction may be used to supplement each other. An interesting further experiment would be to discover what would happen if certain types of punishment and non-punishment instruction were used jointly.

E. Knowledge of Exact Result Instruction (G Instruction)

Problems: What is the effect of keeping the individual fully aware of the degree of success attained? How do the results of this type of instruction differ from those of the other types?

The effect of knowledge of exact result on efficiency is shown by the record for instruction G, which informed the subject that he would be told after each trial how much he missed the bull's eye. After each toss the experimenter announced the number of inches the ball missed the bull's eye, as, "five inches", "two inches", and so on. If the ball hit the bull's eye, the experimenter announced, "zero".

The effect of this learning situation was simply to make the degree of success explicit. The subject throughout the series of practice periods could see the approximate extent of each error, but under this instruction the extent of each error was made explicit. The subject was of course not working "blindly" under those instructions which did not give him knowledge of the exact result; he knew when he made a successful toss or when he missed the target. Most situations in ordinary life are like this. Seldom do we work completely "in the dark", and yet we are seldom fully aware of

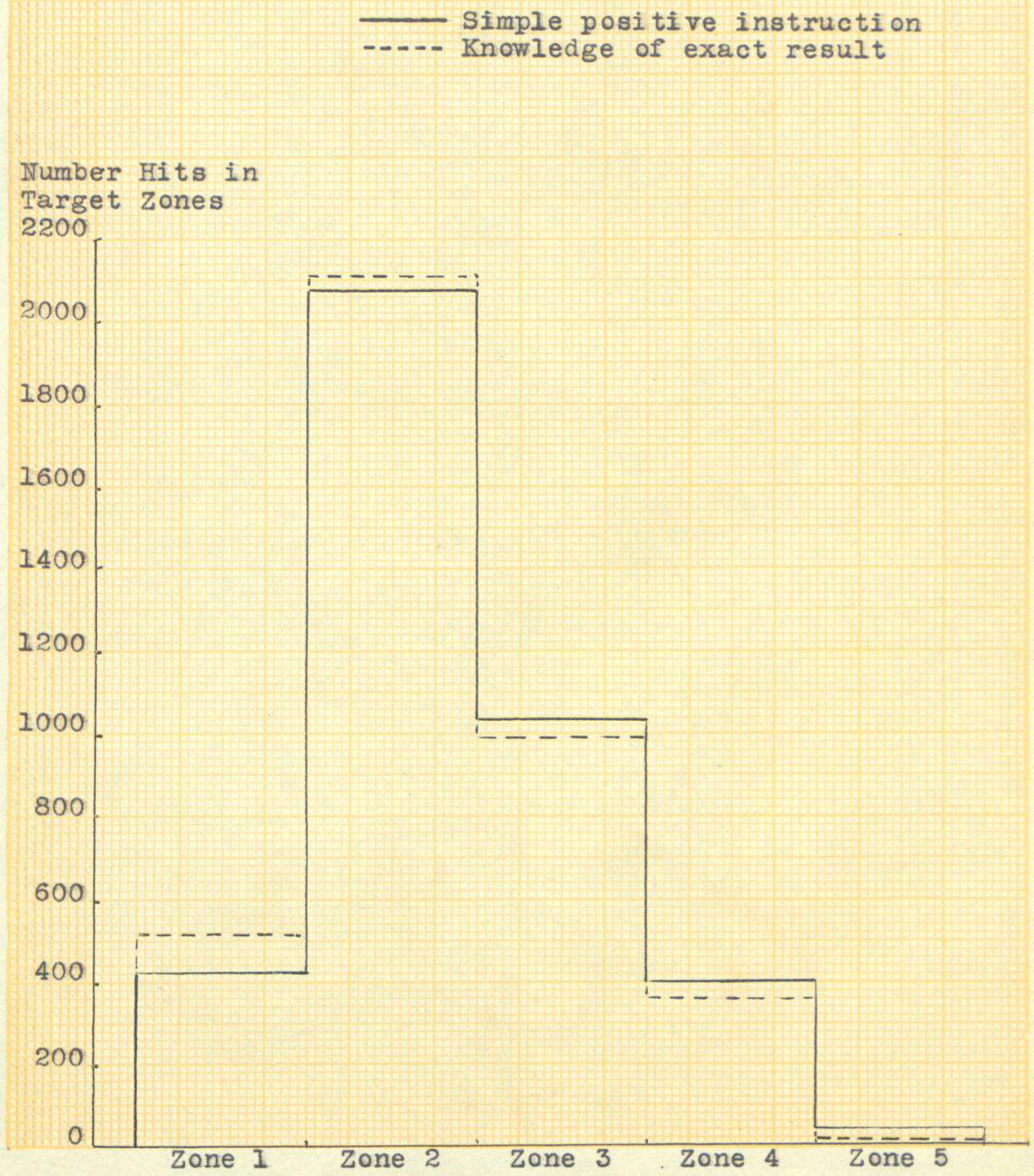
the degree of success attained. The following results reveal the value of increasing one's awareness of the results of his effort.

An average score per subject of 405.5 was made with knowledge of exact result as compared with 430.6 for simple positive instruction, the decrement being 25.1 ± 8.25. There are 980 chances in 1000 of a true difference. This instruction ranks third in the series of eleven instructions (Tables II and III).

Figure 11 shows the effect of this instruction on the distribution of hits. The general effect was to decrease the number of hits in the three outer zones and to increase the hits in the two inner zones. With this instruction, there were 514 hits in the bull's eye zone, compared with 432 such hits for simple positive instruction (Table I). This was the largest number of bull's eye hits for any instruction.

Comparison of Figure 11 and Figure 13 shows that knowledge of exact result and instruction to say, "Now, this one is going in," produce similar effects. Both of these instructions tended to direct attention to the net result of the act. The central tendency of hits for knowledge of exact result instruc-

Figure 11.--Comparison of Distribution of 3960 Hits for Knowledge of Exact Result Instruction and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



tion is only slightly nearer the bull's eye zone than that for the instruction which required the subjects to repeat the sentence quoted above, indicating that the general degree of accuracy was only slightly greater for the former instruction than for the latter. The difference between the average score per subject for these instructions is not very reliable (735 chances in 1000 of a true difference, Table III). Knowledge of exact result and punishment instruction are compared on pages 66-68.

The results of the study of knowledge of exact result may be summarized in the following statements:

a. Individuals are slightly more successful in hitting the bull's eye when they are told how much they missed the bull's eye than when punished for errors or when instructed to direct attention in specific ways. Knowledge of exact result yielded slightly more bull's eye hits than any other instruction studied. (There were 514 bull's eye hits for knowledge of exact result compared with 500 for maximum punishment. The difference is almost negligible).

b. Although knowledge of exact result instruction yielded greatest efficiency by successful hits,

maximum and limited punishment yielded greatest efficiency by the average score per subject. However, the differences between the average scores for knowledge of exact result and these two punishment instructions are not very reliable.

The high standing of the method of keeping the subject fully aware of the degree of success attained may be a result of directing attention specifically to errors and successes, that is, to the net results of effort. Directing attention to modifiable results of effort somehow gives greater accuracy. Attention was less frequently shifted to irrelevant matters. Several factors may have contributed to this, such as competition with one's own record, the stimulating effects of the experimenter's voice in announcing the error, the satisfyingness of being informed of the degree of success, or knowledge that the experimenter was checking the hits.

F. Role of Attention (Instructions B, E, H, and D

Problems: Where should attention be directed for greatest efficiency during the performance of a motor act? What are the comparative effects of directing attention to the idea of success, to the task itself,

to the sensations that accompany the act, or away from the act?

1. Introduction

Certain of the data relating to the effects of directing attention in various ways have already been presented. Those data furnish some evidence on the comparative effects of (1) directing attention to the danger zone and (2) directing attention to the objective results of effort. If was shown that the subjects were more efficient in avoiding the danger zone with punishment instruction, i.e., when attention was directed to the danger zone, than with any other instruction, and that they were more efficient in hitting the bull's eye when attention was directed to the objective result than with any other instruction.

Data will now be reported to show the comparative effects of directing attention in the following additional ways:

a. Attention removed (Instruction D). The subject was instructed to say the letters of the alphabet as he tossed the balls, a letter for each trial.

b. Attention to the idea of success (Instruction B). The subject was instructed to say as he took each

trial, "Now, this one is going in."

c. Attention to the bull's eye (Instruction E). The subject was instructed to fix attention on the bull's eye.

d. Attention to accompanying sensations (Instruction H). The subject was instructed to fix attention on his hand and to note the "feel" of the ball when he missed and when he made a good hit.

What happened as a result of using these instructions is shown by comparing the scores for each of them with that for simple positive instruction, and by comparing them with one another.

1. Effect of Practice with Attention Removed (D Instruction)

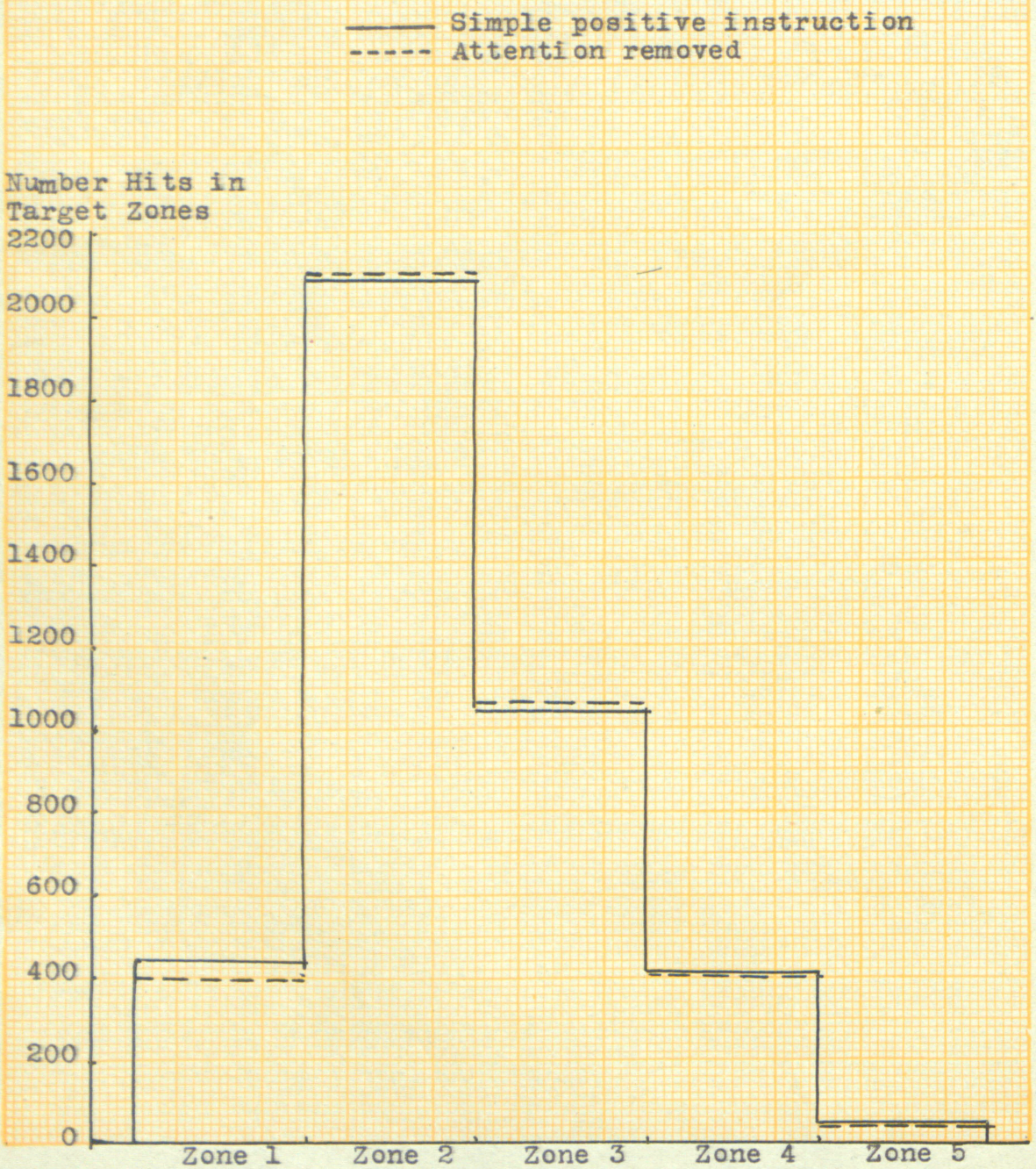
Saying the letters of the alphabet no doubt caused the individual to direct attention to both tasks. Perhaps attention shifted from one to another, or in some cases the problem of hitting the bull's eye was in the margin of consciousness. The subjects reported that it was extremely difficult to be accurate under the circumstances, and the results of the experiment tend to bear out this conclusion. The average score per subject is 432.7 compared with 430.6 for simple

positive instruction. The difference here is not significant (580 chances in 1000 of a true difference - Table III). But fairly reliable differences appear if the average score for attention removed (432.7) is compared with that for attention to one idea of success (411.3), minimum punishment (421.6), attention on the bull's eye (419.6), limited punishment (400.6), knowledge of exact result (405.5), attention on accompanying sensations (420.2), long interval between trials (415.4), maximum punishment (400.5), and short interval between trials (453.4). For each comparison there are at least 886 chances in 1000 of a true difference (Table III). It may be concluded that the subjects were relatively inefficient under attention removed instruction.

Figure 12 which makes the comparison between the distribution of hits for attention removed practice and simple positive instruction, shows that injecting this form of instruction decreased the number of successful trials, but did not increase the number of hits in zones four and five. There is a very slight increase in zones two and three.

It seems probable that the task of simultaneously

Figure 12.--Comparison of Distribution of 3960 Hits for Attention Removed Instruction and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



tossing at the target and saying the letters of the alphabet created a mental state of divided or fluctuating attention, the result of which was to block or inhibit the proper motor adjustments.

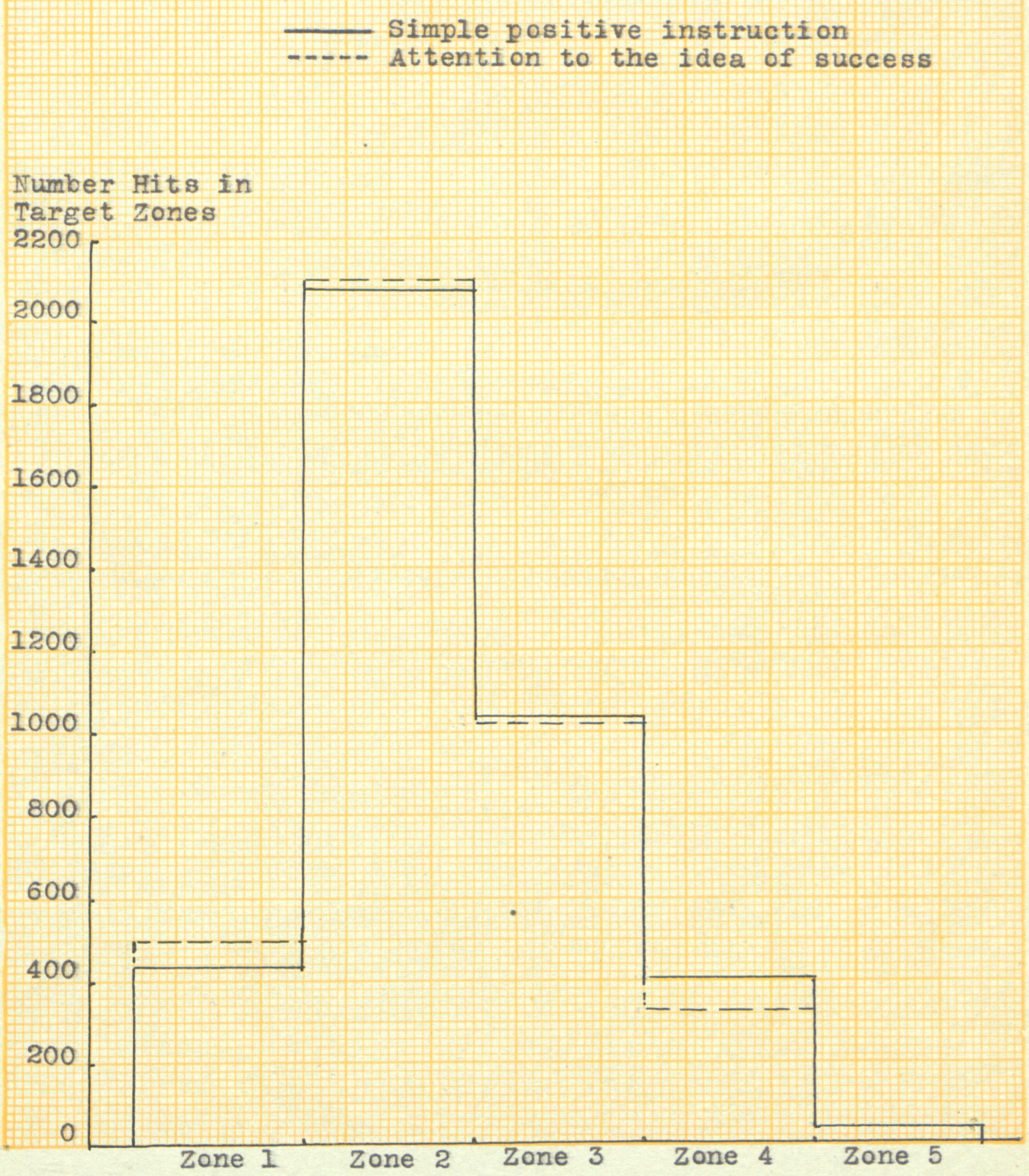
2. Attention to the Idea of Success (B Instruction)

In this series of four instructions, efficiency was greatest when the subjects were directed to pay attention to the idea of success. The instruction read, "Say to yourself as you take each trial, 'Now, this one is going in.'"

The average score per subject is 411.3, compared with 430.6 for simple positive instruction (Table II). The difference has a reliability of 971 chances in 1000 (Table III). The rank in the series of eleven instructions is fourth. Figure 13 shows that the main effect of directing attention to the idea of success was fewer hits in zone four and more hits in zone one.

Comparison of the average score per subject for the instructions that directed attention in various ways tends to show the relative importance of directing attention to the idea of success. Attention removed yielded an average score per subject of 432.7;

Figure 13.--Comparison of Distribution of 3960 Hits for Attention to the Idea of Success Instruction and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



attention on the bull's eye, 419.6; and attention on accompanying sensations, 420.2. Attention to the idea of success is seen to be superior to each of these instructions. The difference between the average score for attention to the idea of success and attention removed has a reliability of 978 chances in 1000; the difference for attention to the idea of success and attention to accompanying sensations, a reliability of 877 chances in 1000; and the difference for attention to the idea of success and attention to the bull's eye, a reliability of 793 chances in 1000.

The facts presented in this section tend to show that instruction to repeat the simple sentence while making each toss definitely increased the degree of efficiency. This is perhaps because repeating the sentence made the individual more confident. Feelings of confidence in this particular form of behavior are perhaps more important than in many forms of behavior, and appear to be conducive to steadiness.

It is interesting to note that in the performance of a motor feat the repetition of a verbal formula, similar to the famous formula advocated by Coue a few

years ago, has a definitely favorable effect.

3. Attention to the Bull's Eye (Instruction E)

Directing the subject to fix attention on the bull's eye while tossing is somewhat similar to directing him to pay attention to the details of a task. Simple positive instruction, which merely directed the subject to toss at the bull's eye, is less definite. No doubt some subjects paid attention to the bull's eye under simple positive instruction. Fixing attention on the bull's eye is probably largely a matter of keeping the bull's eye in the center of the visual field. Greater steadiness in the posture of the subject and better coordination of eye and hand may result from this visual fixation.

Attention on the bull's eye yielded an average score per subject of 419.6 compared with 430.6 for simple positive instruction (Table II). The difference has a reliability of only 852 chances in 1000 (Table III). In the series of eleven instructions, attention on the bull's eye ranks sixth and simple positive instruction ninth (Table II).

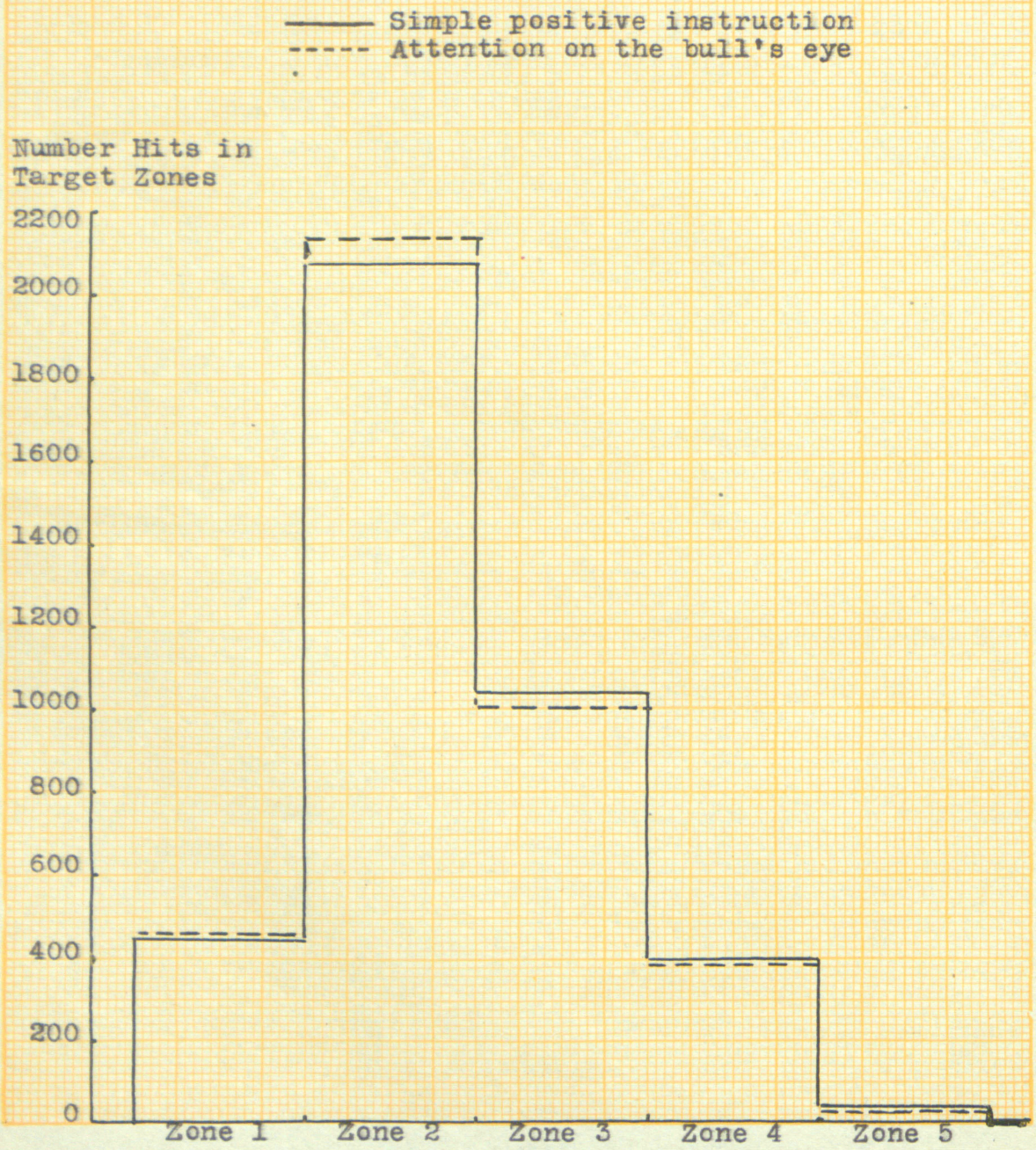
Further comparison of the records for attention

on the bull's eye and simple positive instruction may be made by use of Figure 14. Attention on the bull's eye resulted in a definite increase in the number of hits in zone two and a noticeable decrease in zone three.

Figure 6 shows that the average scores for attention on the bull's eye, attention on accompanying sensations, and minimum punishment are approximately equal. Differences between the average scores have a reliability of only 527, 567, and 583 chances in 1000.

The general conclusion which issues from all these comparisons is that making instructions more specific by directing attention to the bull's eye tends very slightly to increase efficiency. When the subjects were merely told to toss at the bull's eye they did not hit near the bull's eye as many times as when told to pay attention to the bull's eye. When merely instructed to toss at the bull's eye, some individuals may not have aimed definitely at it; they may have attended to the area around the bull's eye. It is a plausible hypothesis that when the subjects were instructed to fix attention on the bull's eye, the effect was to limit the range of atten-

Figure 14.--Comparison of Distribution of 3960 Hits for Attention on the Bull's Eye Instruction and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



tion.

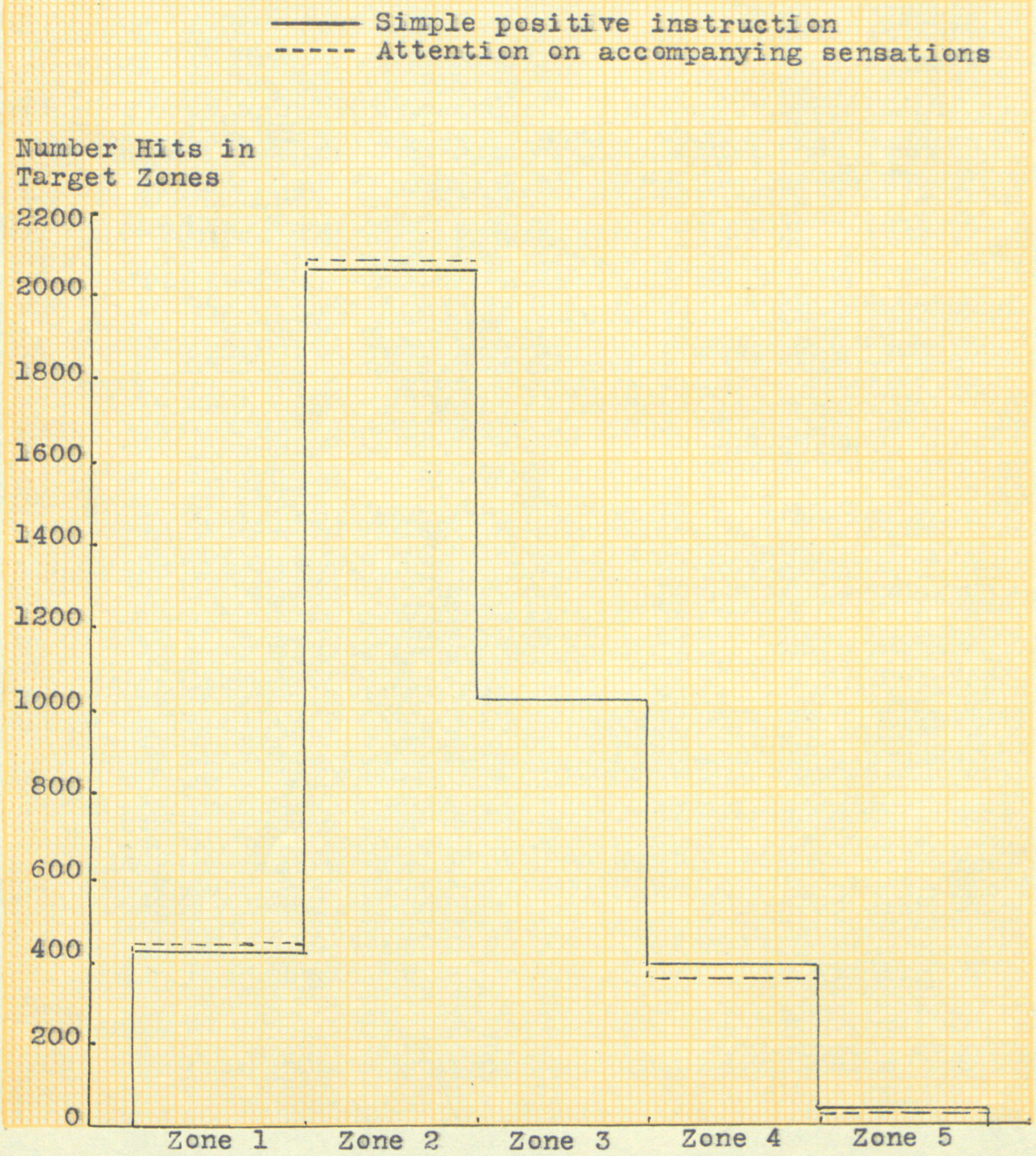
4. Attention on Accompanying Sensations (H Instruction)

This instruction yielded slightly lower efficiency than attention to the bull's eye, but greater efficiency than simple positive instruction. The average score per subject is 420.2 compared with 430.6 for simple positive instruction (Table II). The difference has a reliability of 877 chances in 1000 (Table III). The rank in the series of eleven instructions is seventh (Table II).

The effect of this instruction (Figure 15) was to increase very slightly the hits in zones one and two and to decrease very slightly the hits in zones four and five.

Although attention on accompanying sensations yields better results than simple positive instruction, other ways of directing attention are more efficient. Higher efficiency (i.e., lower score) resulted from maximum punishment, limited punishment (attention presumably on the danger zone), knowledge of exact result (attention presumably to the net results of the act), attention to the idea of success, and

Figure 15.--Comparison of Distribution of 3960 Hits for Attention on Accompanying Sensations Instruction and Distribution of 3960 Hits for Simple Positive Instruction. (Each of 66 subjects was given 60 trials with each instruction)



attention on the bull's eye (Table II). The chances in 1000 of a true difference between attention to accompanying sensations and each of these instructions are 996 for maximum punishment, 996 for limited punishment, 979 for knowledge of exact result, 877 for attention to the idea of success, and 527 for attention on the bull's eye (Table III). The difference is insignificant in the last named case.

Directing attention to the acompanying sensations yields results superior to attention removed instruction (directing attention to an irrelevant problem). The difference has a reliability of 924 chances in 1000. The average scores for attention to accompanying sensations and minimum punishment are practically equal (420.2, 421.6, Table II). The difference has a reliability of only 567 chances in 1000 (Table III). It is reasonable to believe that attention with minimum punishment was not so definitely fixed on the danger zone as with maximum and limited punishment, since punishment was more easily avoided with minimum punishment instruction. Hence the comparison with minimum punishment is perhaps not so significant as that with maximum and limited punishment.

There seem to be some beneficial effects of pay-

ing attention to the kinaesthetic and cutaneous sensations which accompany the act, although other ways of directing attention seem to be far superior. It seems better to think of the "feel" of the ball than just to pitch at the bull's eye. Possibly this instruction would be a good addition to a combination of instructions - or perhaps at a certain stage in the learning process it may be helpful to think of the "feel" of the ball.

5. Conclusions

The conclusions concerning the effect of directing attention away from the task, to the idea of success, to the bull's eye, and to the sensory accompaniments of the act may be stated as follows:

a. All four instructions increased effieiency except instruction to say the letters of the alphabet while taking the trials, i.e., attention directed away from the task. This instruction, which ranks tenth in the series of eleven instructions, appears to have inhibited the desired responses.

b. The most efficient of the four ways of directing attention was instruction to say, "Now, this one is going in", as each trial was taken. Directing

attention to the idea of success may have created feelings of confidence, which resulted in increased efficiency. This method yielded slightly better results than directing attention to the bull's eye, which in turn was slightly superior to attention to the sensations accompanying the act.

c. Attention to accompanying sensations was slightly superior to simple positive instruction.

The study of direction of attention seems to indicate that for greatest efficiency in the form of behavior involved in tossing at a target, attention should be fixed on the objective result of the act, or on a danger zone so arranged that the act is accomplished, or tends to be accomplished, in the attempt to avoid punishment. Attention to the idea of success ranks next in importance. Third in the series are attention on the bull's eye and attention to the accompanying sensations. The reliability of the difference between attention on the bull's eye and attention to accompanying sensations is only 527 chances in 1000. It is relatively undesirable to direct attention to the bull's eye, to the "feel" of the ball (or to the movements). Fourth in the series is attention

removed. Directing attention to an irrelevant matter actually hinders the performance. Subjects are relatively inefficient when not instructed to pay attention, as with simple positive instruction.

G. Interval Between Tosses (Instructions K,A,I)

Problem: What is the relationship between interval between tosses and accuracy?

For three of the eleven instructions (K, A, and I) the interval was set at two, four, and six seconds respectively, the subjects being instructed to take a trial for each signal. No other instruction was given. The records may be compared to discover the interval that yielded greatest efficiency.

An average score per subject of 453.4 was made with the two second interval, 430.6 with the four second, inberval, and 415.4 with the six second interval. (Table II). The average score for the two second interval exceeded that of the four second interval. The reliability of the difference is 908 chances in 1000. The average score for the four second interval exceeded that of the six second interval. The reliability of the difference is 936 chances in 1000. For the two

and six second intervals the reliability of the difference is 995 chances in 1000. The superiority of the six second interval is probably greater than these figures indicate, since a four second interval was used for each of the other eight instructions, and the subjects had more practice with the four second interval.

The distribution of hits in the zones for the three intervals is shown in Figures 16 and 17. Figure 16 shows that the four second interval, when compared with the two second interval, yielded a marked increase of hits in zone two, and a noticeable decrement in the three outer zones. Thus the four second interval appears decidedly superior to the two second interval.

Figure 17 shows that for the six second interval the hits tend to increase very slightly in zones one and two, and to diminish noticeably in zone four.

Conclusions

The data for the three intervals between trials tend to show, so far as this study goes, that the greater the interval the greater the degree of accuracy.

Figure 16.--Comparison of Distribution of 3960 Hits for an Interval Between Tosses of Two Seconds and Distribution of 3960 Hits for Simple Positive Instruction (four second interval). (Each of 66 subjects was given 60 trials with each instruction)

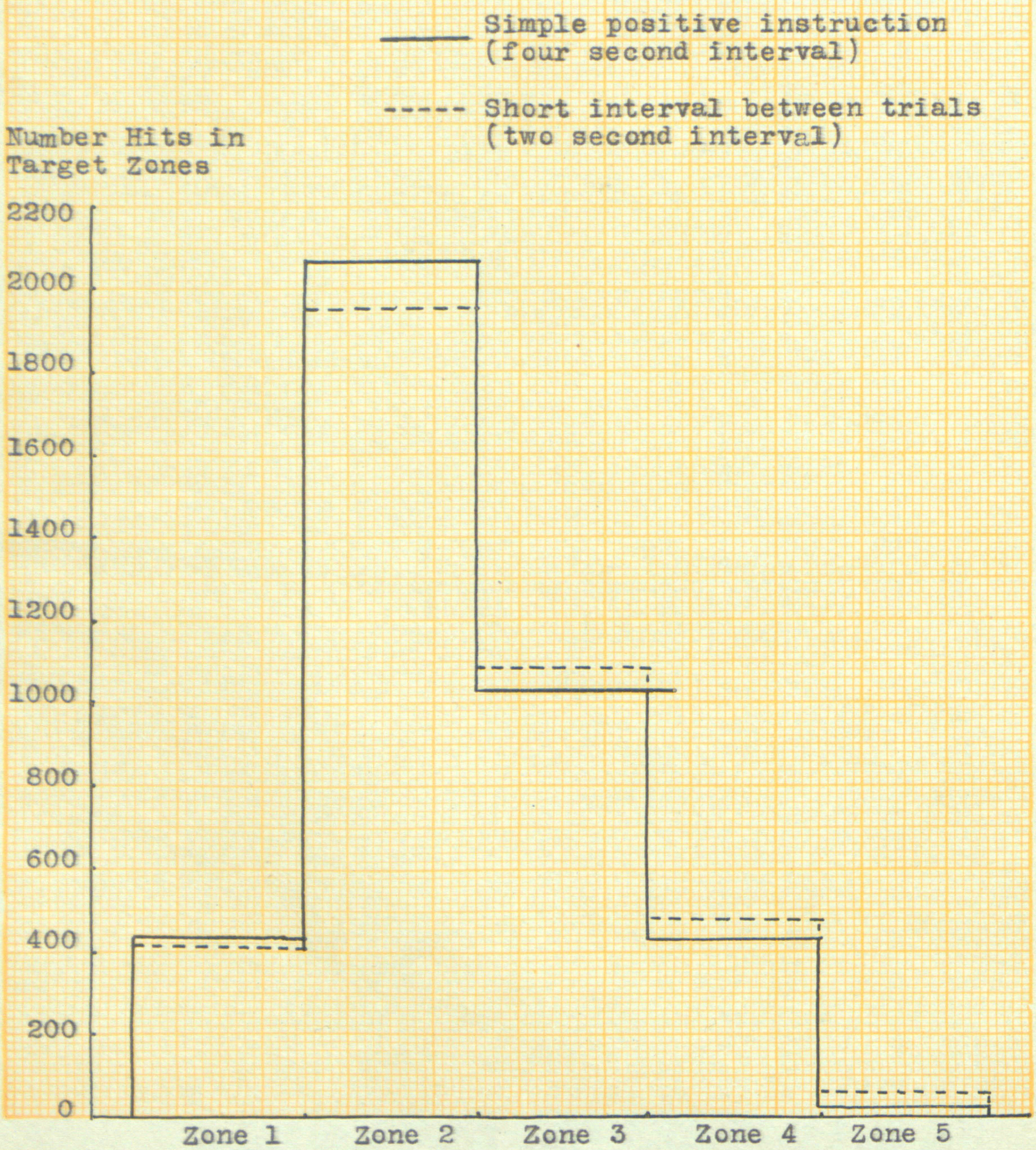
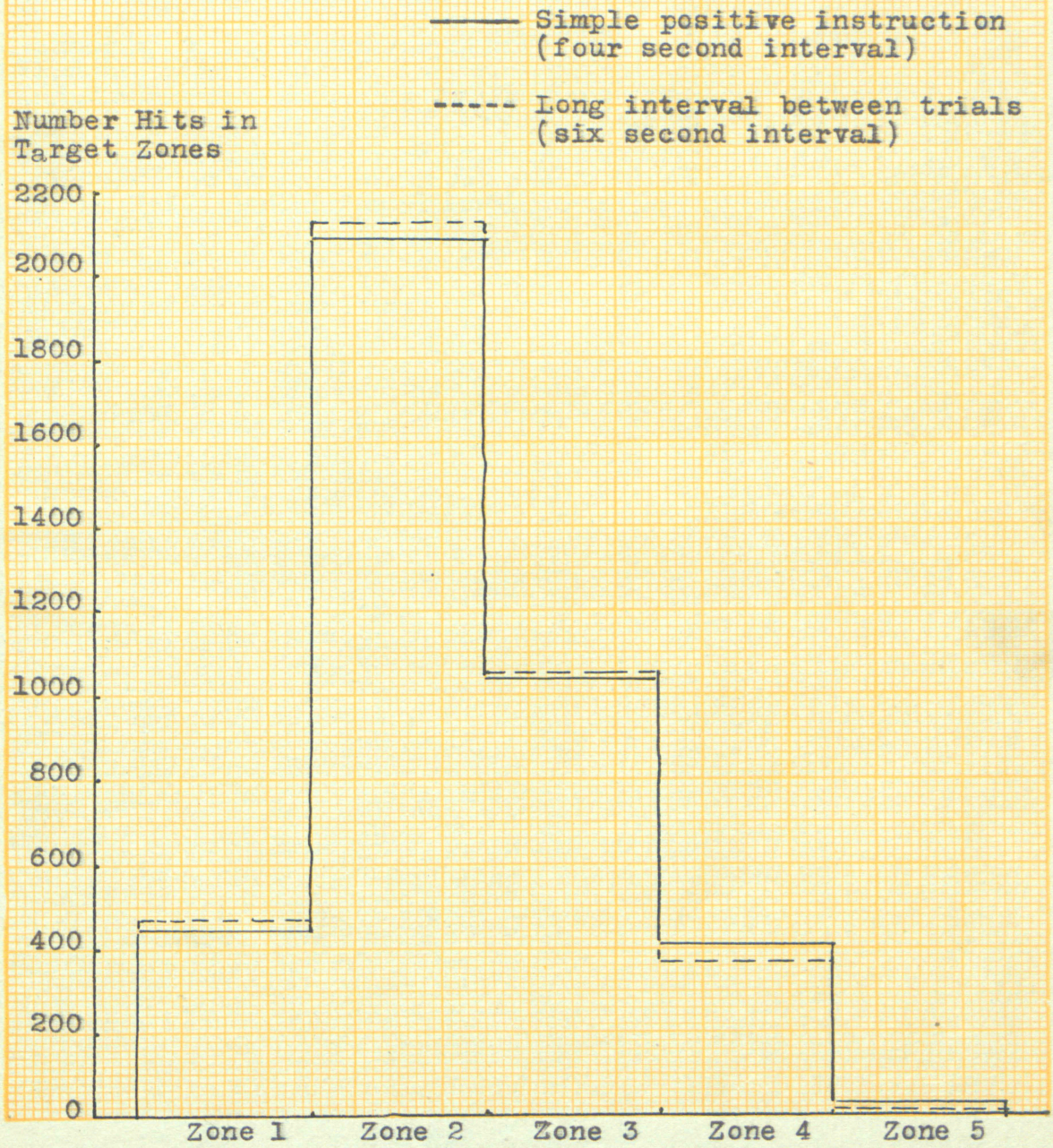


Figure 17.--Comparison of Distribution of 3960 Hits for an Interval Between Tosses of Six Seconds and Distribution of 3960 Hits for Simple Positive Instruction (four second interval). (Each of 66 subjects was given 60 trials with each instruction)



Giving the subject more time to make the movements tends to enable him to make them more accurately. This was not equally true for all individuals, however, as will be shown in the section on variation among individuals.

Perhaps the only significant fact resulting from the data for different intervals between trials is that the interval in such a feat is one of many factors conditioning efficiency.

This will conclude the discussion of the results pertaining to the relative effect of the conditioning factors on efficiency. Certain facts relative to the extent of variation among individuals will next be presented.

H. Variability Among Individuals

Problems: With what degree of uniformity do individuals react to the various factors of punishment, direction of attention in various ways, knowledge of exact result, and interval between tosses? What factors cause individuals to vary most? Least?

Nothing has been said in reporting the data concerning the degree in which individuals varied under the instructions. For example, it is yet to be shown whether the subjects were uniformly efficient with

punishment instruction, or whether for some individuals punishment was an efficient method and for others an inefficient method.

The method used to discover this uniformity or lack of uniformity was to compute the standard deviation of the subjects' scores for each instruction.

The standard deviations show the spread of the 66 scores on a scale of efficiency for each instruction. A small standard deviation for an instruction indicates that that instruction was relatively uniformly efficient or inefficient for all subjects. A large standard deviation indicates lack of uniformity.

The following steps were involved in the computation of a standard deviation: (1) computation of the score made by each of the 66 subjects with an instruction (each subject's 60 "hits" were weighted according to the scheme on page 39); (2) tabulation of the distribution of 66 measures obtained by step "(1)"; (3) computation of the mean of this distribution; (4) computation of the standard deviation of the distribution.

The standard deviations for each instruction are reported in Table IV. The table is read thus: For instruction A, the average score per subject is 430.6

and the standard deviation is 110.5. This means that with instruction A approximately two-thirds of the subjects made a gross score of 430.6 ± 110.5, i.e., between 320.1 and 541.1. The data for the other instructions are read from the table in the same manner.

The standard deviations given in Table IV, column two, are shown graphically in Figure 18. This graph shows the following facts: (1) Four instructions show almost identical variation (Attention to the idea of success, minimum punishment, attention removed, knowledge of exact result). (2) Three instructions show less variation than those having almost equal variation (limited punishment, maximum punishment, attention on accompanying sensations). (3) Four instructions show greater variation than those having almost equal variation (attention to the bull's eye, long interval between trials, simple positive instruction, short interval between trials).

The fact that there was most variation among individuals when the interval between trials was short indicates that the range of achievement was greater with this instruction than with the others.

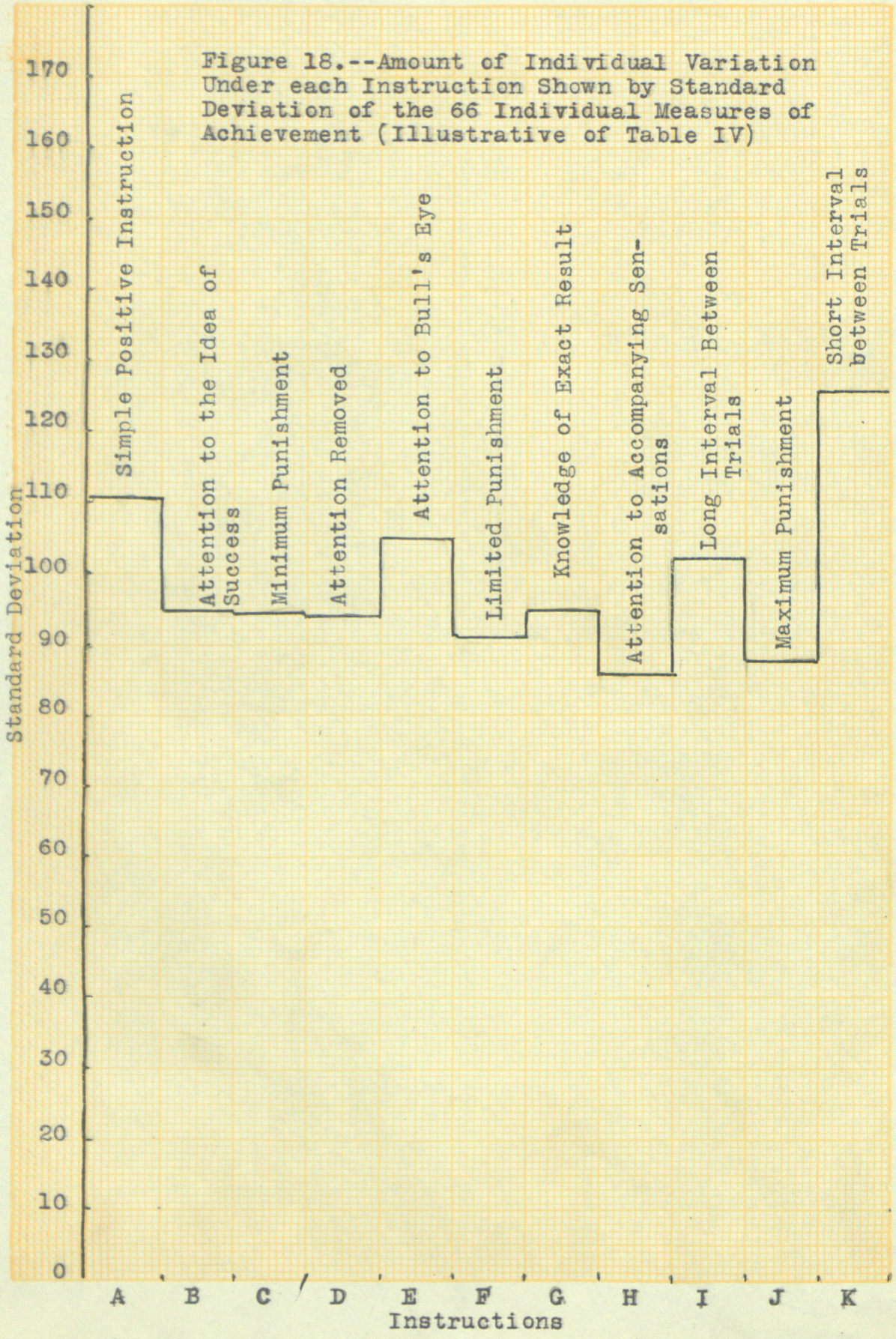
The high standard deviation for simple positive instruction suggests that when the subjects were

Table IV

A TABLE GIVING FOR EACH INSTRUCTION THE AVERAGE SCORE PER SUBJECT, THE STANDARD DEVIATION OF THE 66 INDIVIDUAL SCORES, AND THE RANK ON THE BASIS OF THE STANDARD DEVIATION

Factor Investigated		Average Score per Subject	S. D.	Rank
Simple positive instruction	(A)	430.6	110.5	2
Attention to idea of success	(B)	411.3	94.5	5.5
Minimum punishment	(C)	421.6	94.0	7
Attention removed	(D)	432.7	93.5	8
Attention on bull's eye	(E)	419.6	104.5	3
Limited punishment	(F)	400.6	90.5	9
Knowledge of exact result	(G)	405.5	94.5	5.5
Attention to accompanying sensations	(H)	420.2	85.5	11
Long interval between trials	(I)	415.4	102.0	4
Maximum punishment	(J)	400.5	87.5	10
Short interval between trials	(K)	453.4	125.5	1

Figure 18.--Amount of Individual Variation Under each Instruction Shown by Standard Deviation of the 66 Individual Measures of Achievement (Illustrative of Table IV)



merely told to toss at the bull's eye, some tended to perform the task very efficiently, and others tended to be very careless and inefficient. Some indication of this was revealed in the introspective report of one subject who said, when asked which instruction helped him most, that he thought he could do better when he was left free to do as he pleased. The record of this subject is in striking contrast with that of certain other subjects who were noticeably careless under simple positive instruction.

The comparatively high individual variation for certain instructions may be a result of the subjects' general attitude toward the experiment. Certain individuals may have consistently put forth their maximum effort throughout the experiment, while others may have varied the amount of effort in accordance with the nature of the instruction. In the latter case, punishment instruction and instructions that were satisfying in effect may have acted to increase effort. The factor of general attitude would thus tend to produce relatively less variability on punishment and certain non-punishment instructions than on instructions that gave the subjects greater freedom,

e.g., simple positive instruction, long interval between trials, etc.

Some evidence is found in Table IV and Figure 18 to show that individuals are less variable under punishment than under non-punishment instruction. The standard deviations for maximum, limited, and minimum punishment are 87.5, 90.5, and 94.0 respectively. In comparison, the standard deviation for attention on the bull's eye and knowledge of exact result are 104.5 and 94.5. The individuals in this experiment varied no more under instruction with punishment than with non-punishment. In fact, there appears to have been more variability with non-punishment. The average of the standard deviations for the three punishment instructions is 90.66, compared with 97.16 for six comparable non-punishment instructions (instructions A, E, G, B, D, H).

Increasing the number of punishment zones tended to make the achievement of the various individuals more uniform. This may have been because the subjects tended to put forth an amount of effort commensurate with the requirements of the situation.

The fact that all the subjects were so nearly on an equal with attention removed and attention on

accompanying sensations is interesting. A plausible explanation is that these instructions may be more definite, and hence easier to follow than the other instructions. If all the subjects did precisely as directed, i.e., repeated the alphabet and gave attention to the "feel" of the ball in the hand, one should expect less variability than with less definite instruction.

Of the instructions which directed attention in various ways, greatest variability existed when attention was directed to the bull's eye (S.D., 104.5). Attention to the net results and attention to the idea of success are next highest and equal in rank (S.D., 94.5). Fourth in the series is attention removed (S.D., 93.5). Fifth in the series is attention to the danger zone (S.D., 90.66, average of the S.D.'s for the three punishment instructions). Sixth, and final, in the series is attention to the sensations accompanying the act (S.D., 85.5).

There appears to be a small negative correlation between the efficiency of an instruction and the amount of variation among individuals under the instruction. Correlation of these factors by the method of rank difference yields a coefficient of $-.466 \pm .159$. This negative correlation tends to indicate that

variation among individuals is greater with poor instructions than with good instructions.

Conclusions

There is more variation among individuals when they tossed with short intervals between trials than when they performed the task with the other forms of instructions. Variation is next highest under simple positive instruction. Least variation exists under instruction to pay attention to the sensations accompanying the act.

Individual variation is somewhat greater under non-punishment than under punishment instruction. Variation becomes less marked as the number of punishment zones is increased. More variation exists when attention is directed to the bull's eye than when attention is directed in any other way.

Individual variation is approximately equal for attention to the idea of success, minimum punishment, attention removed, and knowledge of exact result.

A fairly reliable negative correlation exists between the efficiency of the instructions and variability among individuals under the instructions. That is, variation tends to be less with good instructions than with poor ones.

I. Reliability of the Results

The reliability of the foregoing results may be shown: (1) by the stabilizing effect on the results of increasing the number of cases, (2) by the probable errors of the differences between the means (results), and (3) by comparing the results of the control and experimental groups.

1. Stabilizing Effect on Results of Increasing the Number of Cases

In the conduct of the experiment, subjects were added in groups of eleven (See page 30). Following the addition of a group the eleven results were computed, and the stabilizing effect of the added group noted. Groups were added until the addition of a group produced no significant change in the results, or until the results became stable. The graph used for determining the number of groups needed to stabilize results is included in Figure 19.

The result for each instruction is indicated in Figure 19 by a plotted line. The plotted line shows the effect on the average score per subject of adding more groups of subjects. The stabilizing effect of increasing the number of cases may be noted by ob-

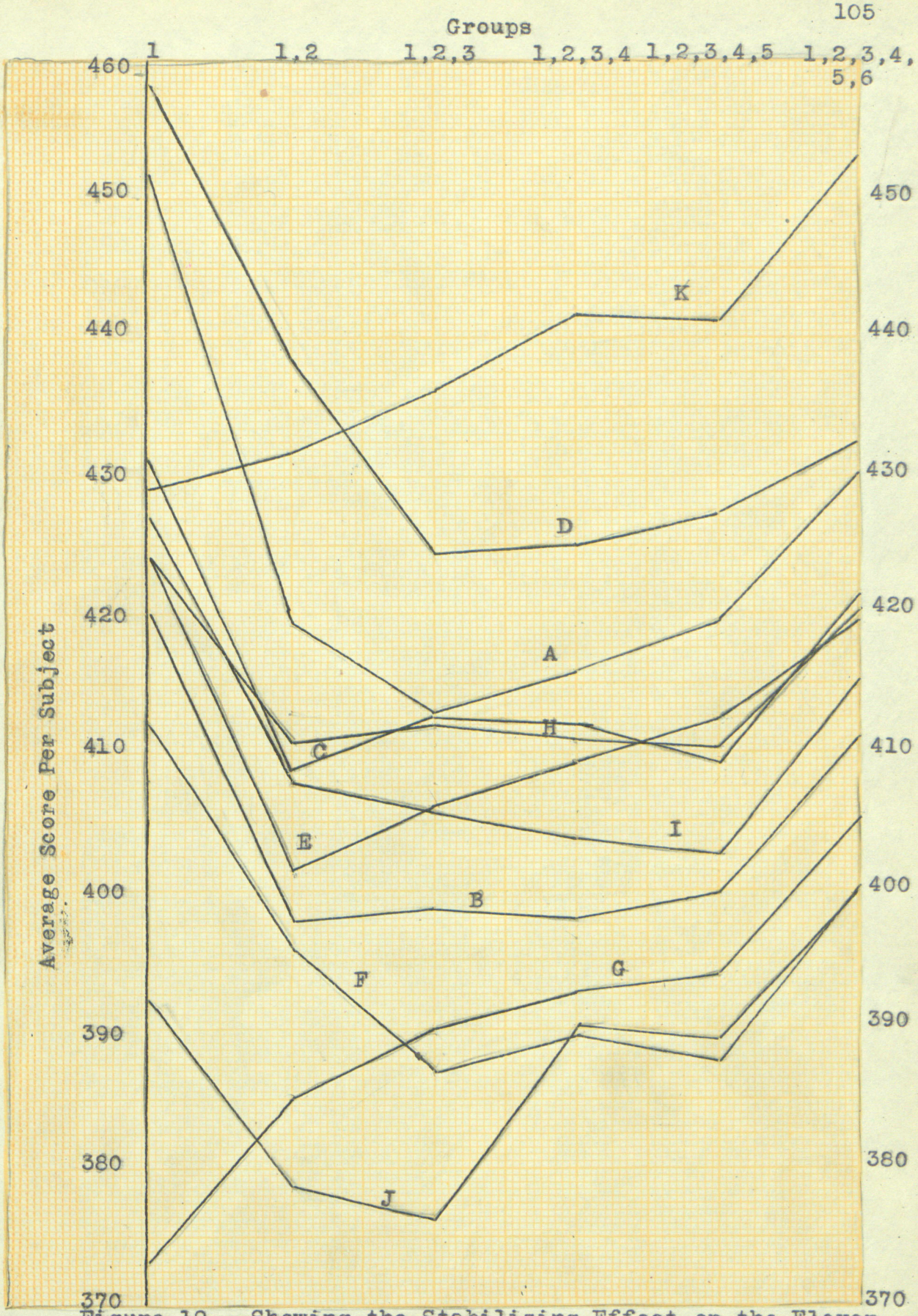


Figure 19.--Showing the Stabilizing Effect on the Eleven Results of Increasing the Groups of Subjects

serving the direction of the lines as they extend from left to right across the page. Crossing of lines indicates lack of stability. Parallel, or nearly parallel lines indicate stability. The last group as a whole made a higher score per subject than other groups, and so tended to pull all lines up on the graph - but without changing the relative standing of the instructions. With few exceptions, this graph shows that the result for each of the eleven instructions was fairly consistent for each group of subjects. The essential fact shown by the graph, however, is that the addition of the sixth group of subjects produced a very slight change in the eleven results. If the average scores for instructions C, H, and E are assumed approximately equal, and if F and J are assumed approximately equal, no significant change in rank occurred when each of the last two groups was added. This means that the results are fairly stable, and it seems likely that with many subjects, 1000 for example similarly chosen, the results would show no material variation.

The fact that cases were added in the conduct of the experiment as long as results fluctuated and until the fluctuation practically ceased tends to show

that the eleven results are fairly reliable. Addition of a great many more cases could conceivably change these results, but such is highly improbable.

2. Probable Errors

The probable errors found in Table III indicate the significant and insignificant differences between the records for the eleven instructions. The data in this table have already been quoted and need not be repeated in detail here. It was shown that the chances of a true difference between the results for the pairs of instructions range from 500 chances in 1000, a mere guess, to 1000 chances in 1000, practical certainty. For nine comparisons the reliability of the difference is from 996 to 1000 (inclusive) chances in 1000; for thirteen comparisons the reliability is 978 to 995 (inclusive) chances in 1000; for nine comparisons the reliability is 911 to 977 (inclusive) chances in 1000; for thirteen comparisons the reliability is 750 to 910 (inclusive) chances in 1000; and for eleven comparisons the reliability is 500 to 749 (inclusive) chances in 1000. Where differences between results were discussed the degree of reliability was stated.

3. Control Group

An experimental check on reliability was made by use of a control group of eleven subjects. The subjects in the control group were selected in the same manner as those in the six experimental groups. This group was "put through" the experiment in the same manner as the other groups, except that the instructions were not rotated, i.e., the subjects were given the same instruction throughout the series of 660 trials. The instruction was as follows:

> Instruction: In the ball tossing that you are about to begin you will learn to hit the bull's eye that you see in the center of the target. Throw six balls in succession, that is, one right after another. When you begin throwing have six balls ready in your left hand. When throwing have only the ball to be thrown in the hand you throw with. Signals will be given so that you will know how fast to throw. Throw a ball after each signal. Now, throw at the bull's eye.

The eleven results for the control group (eleven subjects) were tabulated in the same manner as for an experimental group. That is, for the first result there were taken the first 60 trials of subject one, the second 60 trials of subject two, the third 60 trials of subject three, etc., ending on the eleventh 60 trials of the eleventh subject. For the second result there were taken the second 60 trials of subject

one, the third 60 trials of subject two, the fourth 60 trials of subject three, etc., ending on the first 60 trials of the eleventh subject. This scheme was followed out until eleven results were obtained. The data were thus so grouped that each result is made up of eleven units of 60 trials each - one unit for each subject, and one unit for each serial position of the subjects.

The distribution of hits and the average scores per subject (means) are found in Tables V and VI.

There should be no difference between the eleven results of the control group (Table VI) except differences due to chance, since the same instruction was used throughout. Thus the difference in the eleven results may be said to be due to chance. The magnitude of the difference is shown by the range of the eleven results - 440.7 to 486.

The eleven results of the control group (Table VI) correspond with and are comparable to the results of a single experimental group, but are not comparable to the combined results of the six experimental groups (Table II). Comsequently, it is necessary to compare the control group results with those for each experimental group separately.

Table V

CONTROL GROUP (11 SUBJECTS). DISTRIBUTION OF 660 HITS FOR EACH OF 11 RESULTS. RESULTS TABULATED TO CORRESPOND WITH EXPERIMENTAL GROUP RESULTS.

Eleven Results	Zones				
	1	2	3	4	5
1	68	296	195	87	14
2	75	300	197	78	10
3	71	315	209	59	6
4	56	329	206	64	5
5	43	313	214	81	9
6	63	320	204	60	13
7	53	318	208	73	8
8	65	312	213	66	4
9	64	309	200	77	10
10	63	305	214	68	10
11	64	297	204	85	10

Table VI

AVERAGE SCORE PER SUBJECT FOR EACH OF THE 11 RESULTS. DATA OBTAINED BY WEIGHTING THE DATA IN TABLE V

Eleven Results	Average Score per Subject
1	482.0
2	462.3
3	440.7
4	450.0
5	486.1
6	455.9
7	467.9
8	449.5
9	467.5
10	464.9
11	478.4

Table VII gives the eleven results for each of the six experimental groups, with which the control group results are to be compared. Pearson's coefficient of variation [1], $v = \frac{100 \text{ Sigma}}{\text{Mean}}$, may be used to compare the distributions of control and experimental group results. If the distribution of results for experimental groups is found to have greater variability than the distribution of results for the control group, it may be assumed that the greater variability in experimental group results is due to the effects of instruction.

The relative amount of variation in control and experimental group results is found in Table VIII. This table is read thus: For the control group the mean of the eleven results is 463.8; the standard deviation of the eleven results is 13.47; and the coefficient of variability is 2.90. For Group I, the mean of the eleven results is 421.9; the standard deviation of the eleven results is 23.41; the coefficient of variability is 5.55; and the variation of the results of Group I is 191% as great as the variation in results for the control group. The data for

---

1. Garrett, H.E., Statistics in Psychology and Education, p.41.

Table VII

RESULTS IN TERMS OF AVERAGE SCORE (MEAN) PER SUBJECT PER INSTRUCTION FOR EACH OF THE SIX EXPERIMENTAL GROUPS

Instructions		Average Score per Subject				
	Group I	Group II	Group III	Group IV	Group V	Group VI
A	451	387	401	425	433	486
B	420	376	400	395	407	469
C	431	386	420	411	398	484
D	458	419	497	426	436	460
E	424	379	407	428	424	456
F	412	380	368	397	379	466
G	372	397	400	400	411	452
H	424	398	414	407	408	470
I	427	389	401	397	397	482
J	392	365	372	432	386	456
K	429	434	445	458	438	515

the other groups are read from the table in the same manner. The column on the right gives the per cent the variation in results of each experimental group is of the variation in results of the control group.

The results for Group I vary 191% as much as those of the control group; Group II, 171% as much; Group III, 174% as much; Group IV, 159% as much; Group V, 161% as much; and Group VI, 143% as much. The average of the five percentages is 155.8%.

Two conclusions may be drawn from these comparisons. First, an obtained difference between results for any two instructions may vary somewhat from the true difference because of chance. The amount of such variation is unknown. The total variation for the experimental group results is approximately 155.8% of the total variation for the control group results. Second, the comparatively high degree of variability of the experimental group results furnishes rather conclusive proof that some of the special conditioning factors used in the experiment definitely modified the degree of efficiency of the subjects, and that certain of the conditioning factors produced greater efficiency than others. If all conditioning factors had produced an equal positive effect

Table VIII

COMPARISON OF CONTROL AND EXPERIMENTAL GROUP RESULTS BY MEANS OF THE COEFFICIENT OF VARIABILITY (THE COEFFICIENT OF VARIABILITY IS COMPUTED FOR EACH OF THE DISTRIBUTIONS OF ELEVEN RESULTS).

Groups	Mean of Eleven Results	Sigma of Eleven Results	Coefficient of Variability (V)	$\frac{V(\text{Exp. Group}}{V(\text{Control Group}}$
Control	463.8	13.47	2.90	
Group I	421.9	23.41	5.55	191%
Group II	391.8	19.48	4.97	171%
Group III	402.2	20.30	5.05	174%
Group IV	416.0	19.27	4.63	159%
Group V	410.7	19.24	4.68	161%
Group VI	463.2	19.33	4.17	143%

or an equal negative effect, the variability of results for the experimental and control groups would have been approximately equal. Likewise, if all the conditioning factors had produced zero effect, the variability of control and experimental group results would have been approximately equal. There is, therefore, reason to believe, because of the greater variability for experimental than for control group results, that certain factors increased efficiency more than others, and that the results of the experiment reported earlier in this chapter are fairly reliable.

Each of the three means of checking results, (increasing the number of groups, use of probable errors, control group) tends to support, in the main, the conclusions drawn in this thesis. The control group check lacks the flexibility of the probable errors, which give the degree of reliability of each detailed result. The control group serves only to check the major conclusions.

Chapter IV

SUMMARY AND CONCLUSIONS

The experiment reported in the foregoing pages was undertaken for the purpose of discovering the potency of certain factors in modifying a learner's efficiency in acquiring a motor skill. A preliminary survey revealed that learning may be modified in the following ways:

1. By mere instruction to perform the act;
2. By punishing for errors;
3. By giving exact knowledge of result;
4. By directing attention in various ways;
5. By regulating the interval between trials.

Eleven forms of instruction, embodying these five factors, were devised and used to give instructed practice in tossing balls at a specially constructed target. The target was so constructed that an electric shock could be automatically administered when the subject hit outside of certain prescribed

zones. The nature of the eleven instructions is as follows:

Simple positive instruction merely directed the subjects to toss at the bull's eye. The record for this instruction was used as a partial basis for evaluating the other instructions. Punishment was used for three types of errors, namely, punishment for hits in zone four (minimum punishment) [1], punishment for hits in zones three and four (limited punishment), and punishment for hits in zones two, three and four, i.e., punishment for failure to hit the bull's eye (maximum punishment). Under knowledge of exact result instruction, the subject was informed after each attempt the number of inches he missed the bull's eye. With this instruction the subjects tended to pay attention to the objective result of effort. With punishment they tended to pay attention to the danger zone. Four other instructions were designed to require the subject to direct his attention in certain definite ways. These are attention to accompanying sensations, attention to the idea of success, attention to the bull's eye, and attention to an

---

1. For position of the target zones, see Figure 1, page 19; also, page 18.

irrelevant mental problem. For three instructions the interval between trials was set at two, four, and six seconds respectively. For these three instructions the subjects were merely instructed to toss at the bull's eye. (Exact copies of the eleven instructions are found on pages 35,36).

All instructions were given to each of the 66 subjects according to the method of counterbalanced order, and each subject was allowed 60 practice trials with each instruction. The records for the instructions were compared with one another and with the record for simple positive instruction.

The results show very clearly that certain of the special conditions introduced tended to increase efficiency more than others.

Efficiency in terms of decrement of "wild hits" was slightly higher for maximum and limited punishment than for any other conditioning factor used. Efficiency in terms of successful hits was slightly higher for knowledge of exact result than for any other factor used.

Under certain conditions punishment was more effective than under others. For example, when it was possible to hit between the danger zone and the

bulls's eye, there were fewer bull's eye hits than when this was not possible. Comparison of the records for punishment on one, two, and three zones tends to show that general efficiency was increased by increasing the punishment zones from one to two, but that use of an additional third punishment zone did not give added efficiency. Making the requirements more rigid beyond a certain limit failed to increase the degree of accuracy. Punishing the subjects for hits in one zone yielded only slightly greater efficiency than simple positive instruction.

This study takes practically no account of the effects on the individual of the emotional disturbance resulting from punishment, e.g., such effects as would modify one's attitude toward the problem, or create personality difficulties. The various factors were evaluated entirely with reference to efficiency in a restricted sense. A truer evaluation would take into account any lasting undesirable effects of the conditioning factor. Any application to practical problems of the findings here reported should take account of the undesirable effects that may result from the use of punishment. The results relating to punishment may have wider application in

the training of animals than in the training of human beings.

It is possible to arrange the instructions that directed attention in various ways in the order of their effectiveness. First in the series are maximum and limited punishment, which tend to direct attention to the danger zone (approximately equal in rank). Second in the series is knowledge of exact result, which tends to direct attention to the net result of effort. Third in the series is instruction to pay attention to the idea of success. Fourth in the series are attention to the bull's eye, attention to sensory accompaniments of the act, and minimum punishment (approximately equal in rank). With minimum punishment the subject's attention was probably divided between the danger zone and the bull's eye. Fifth, and final, is instruction to pay attention to an irrelevant mental problem.

While the instructions may be grouped in a series on the basis of direction of attention, the position of an instruction in the series is determined somewhat by factors other than direction of attention, e.g., punishment instruction was efficient because of the stimulating effect of the punishment and because

of the way attention was directed. Degree of intensity of attention no doubt exerted as much influence as direction of attention.

Efficiency is slightly greater with a six second interval between trials than with a two or four second interval. The interval between trials is one of many factors conditioning efficiency in such a feat as tossing balls at a target.

Variation among individuals is slightly greater on inferior than on superior instructions, and is greater on non-punishment than on punishment instructions.

General Conclusions

The following general statements issue from the foregoing chapters:

1. Punishment for errors, knowledge of exact result, direction of attention, and regulation of interval between trials are modifying factors in learning a motor skill. Punishment and knowledge of exact result are the most potent of these factors for increasing efficiency.

2. Punishment tends to cause the individual to react negatively, and,

among the factors studied, is most efficient for developing an avoidance reaction. When punishment is used, instead of attending to the required task, the individual tends to pay attention to the source of the punishment. This may or may not result in efficiency. Punishment is most efficiently used when the individual must perform the task in order to avoid punishment. If the learning situation is so arranged that the individual may not avoid punishment without performing the task, a high degree of efficiency will most likely result. But if the learning situation is so arranged that the individual may easily avoid punishment without performing the task, the demand made on his attention by punishment may prevent a high degree of efficiency. Because of its efficacy for eliminating errors, punishment has its greatest use in a learning situation where the problem is to learn to avoid doing something.

3. The most efficient method of developing a positive reaction (e.g., for hitting the bull's eye in contrast to hitting the outer zones of a target) is to keep the individual fully aware of the degree of success attained. If the individual is made aware of his record he tends to make more successful attempts

than when other conditioning factors are used. The effect of knowledge of exact result, in comparison with the effect of punishment, is slightly to increase both the number of successful attempts and the errors. This conditioning factor appears to have its greatest application in learning situations where the problem is to develop an act of skill, and where errors are permissible. (This general conclusion is only tentative, and is based upon a comparison of the record of "hits" for knowledge of exact result and punishment instructions. Further research with other types of learning problems is needed to verify the hypothesis).

4. The comparative effects of directing attention in various ways may be shown by the following classification:

a. Modes of directing attention that in general yield the best results are attention to the painful consequences of errors, attention to the net results of the act, and attention to the idea of success.

b. Modes of directing attention that appear to be slightly beneficial are attention to

the bull's eye and attention to the sensations accompanying the act.

c. Modes of directing attention that give poorest results are attention to an irrelevant mental problem and attention free, as when the learner is merely told what is to be done.

d. Slightly greater individual variation exists with instructions yielding low efficiency than with instrctions yielding high efficiency.

BIBLIOGRAPHY

Arps, G. F., "Work with Knowledge Against Work without Knowledge of Result". Psychological Review Monograph, XXVIII (1920) No. 125, p.41.

Bair, J. H., "The Practice Curve". Psychological Review Monograph Supplement, Vol. V (1902) No. 19, pp. 1-70.

" "The Development of Voluntary Control". Psychological Review, Vol. VIII, pp.474-510.

Book, W. V., Learning to Typewrite. New York: Gregg Publishing Company, 1925.

" Psychology of Skill, New York: Gregg Publishing Company, 1925.

" Learning How to Study and work Effectively. New York: Ginn and Company, 1926.

Brunner, A. F., "Attitude as it Affects Performance on Tests." Psychological Review, XXIII (1916), pp.303-331.

Bryan, W. L., and Harter, N., "Studies in the Physiology and the Psychology of the Telegraphic Language." Psychological Review, IV (1897), pp.27-53 and VI (1899), pp.345-375.

Carr, H., "Voluntary Control of the Distance Location of the Visual Field." Psychological Review, XV (1908), pp.139-149.

Colvin, S. S., The Learning Process. New York: Macmillan Company, 1911. pp.10-23.

Costeil, D. B., "The Discriminative Ability of the Painted Turtle." Journal of Animal Behavior, I (1911) 1.

Dearborn, W. F., "Experiments in Learning." Journal of Educational Psychology, I, (1910) pp.373-388.

Edwards, W. G., Improvability in Typewriting. Toronto: The Ryerson Press, 1923.

Freeman, F. N., How Children Learn. Boston: Houghton Mifflin Company, 1917.

" The Teaching of Handwriting. New York: Houghton Mifflin Company, 1914.

Garrett, H. E., Statistics in Psychology and Education. New York: Longmans, Green and Company, 1926.

Gates, G. S. and Rissland, L. Q., "The Effect of Encouragement and Discouragement on Performance." Journal of Educational Psychology, XIV, (Jan., 1923), pp. 21-26.

Hall, Margaret E., "Remote Associative Tendencies in Serial Learning." Journal of Experimental Psychology, (April 1928), pp. 65-76.

Herrick, C. J., "Some Reflection on the Origin and Significance of the Cerebral Cortex." Journal of Animal Behavior, 1913, pp. 228-229.

Hoge, N., and Stocking, Ruth J., "A Note on the Relative Value of Punishment and Reward as Motives". Journal of Animal Behavior, II (1912), p.43

Holzinger, Karl J., Statistical Methods for Students in Education. Columbia: Ginn and Company, 1928.

James, William, Principles of Psychology, Vol. I and II. Henry Holt and Company, 1890.

Johanson, "The Influence of Incentive and Punishment on Reaction." Archives of Psychology, No. 54, 1923, p.53.

Johnson, Buford, "Practice Effects in a Target Test." Psychological Review, XXVI (1919).

Judd, C. H., Psychology of Secondary Education. Columbus: Ginn and Company, 1927.

" "Practice Without Knowledge of Result". Psychological Review Monograph Supplement, VII (1905), pp.185-198.

" "Relation of Special Training to General Intelligence". Educational Review, XXXVI (June, 1908), pp. 28-42.

" "Movement and Consciousness". Psychological Review Monograph Supplement, VII (1905), p. 198

Kline, L. W., "Habit Formation and Feeling Qualities of Voluntary Movement". Psycho-biology, II (1920) The Williams and Wilkins Company.

Koch, Helen L., "Influence of Mechanical Guidance Upon Maze Learning." Psychological Review Monograph Supplement, XXXII (1923).

Koehler, Wolfgang, "The Mentality of Apes." (Translated by Ella Winter) New York: Harcourt, Brace and Company, 1925.

Koffka, Kurt, The Growth of the Mind (Translated by R. M. Ogden) Harcourt, Brace and Company, 1925.

Ladd, D. T. and Woodworth, R. S., Elements of Physiological Psychology, New York: Charles Scribner and Sons, 1911, pp. 555-565

Langfeld, H. S., "Facilitation and Inhibition of Motor Impulses." Psychological Review, XXII (1915) pp.453-478.

" "Consciousness and the Motor Response". Psychological Review, XXXIV (Jan., 1927).

Langfeld, H. S., "Suppression with Negative Instruction". Psychological Bulletin, VIII (June 15, 1910) No. 6, pp. 200-208.

" "Voluntary Movement Under Positive and Negative Instruction." Psychological Review, XX (1913), No. 6, p.459.

Lashley, K. S., "The Behavioristic Interpretation of Consciousness." Psychological Review, XXX (1923), p. 341 ff.

Lindley, E. H., "A Preliminary Study of Some of the Motor Phenomena of Mental Effort." American Journal of Psychology, (1895), pp.491-517

Munsterberg, Hugo, Psychotherapy. Moffitt, Yard and Company, 1909, pp. 95-106.

Nock, A. J., "Efficiency and the High Brow." American Magazine, (March, 1913), pp. 48-50.

Ogden, R. M., Psychology and Education. New York: Harcourt, Brace and Company.

Ordahl, L. E., "Consciousness in Relation to Learning", American Journal of Psychology, XXII (1911) pp. 158-213.

Parker, S. C., Methods of Teaching in High School. New York: Ginn and Company, 1915.

Pechstein, L. A., and McGregor, L., Psychology of the Junior High School Pupil. New York: Houghton Mifflin Company, 1924.

Peterson, Joseph, "Completeness of Response as an Explanation Principle in Learning." Psychological Review, (1916) Vol. XXIII, 153-162.

Pyle, W. H., The Psychology of Learning, 1921. Ch.IV.

Rexroad, C. N., "Administering Electric Shock for Inaccuracy in Continuous Multiple Choice Reaction". Journal of Experimental Psychology, IX (Feb., 1926) No. 1.

Richardson, R. F., "The Learning Process in the Acquisition of Skill." Pedagogical Seminary, XIX (Sept., 1912) pp. 376-394.

Robinson, E. S., "Factors Affecting Human Efficiency". Annals of American Academy of Political and Social Science, 1923, 110, pp. 94-104.

Robinson, E. S., and Bills, A. G., "Two Factors in the Work decrement." Journal of Experimental Psychology, IX (Dec., 1926) No. 6, pp. 416-443.

Robinson, E. S., and Heron, W. T., "The Warming-up Effect." Journal of Experimental Psychology, VII (April, 1924) No. 2, pp. 81-97.

Rugg, H. O., Statistical Methods Applied to Education. New York: Houghton Mifflin Company, 1917.

Ruger, H. A., The Psychology of Efficiency. New York: The Science Press, 1910.

Sherrington, C. S., Integrative Action of the Nervous System. New York, 1906, p. 389.

Skinner, Gast, and Skinner, Readings in Educational Psychology, New York: D. Appleton and Company, Ch. IX.

Starch, Daniel, Educational Psychology, 1927.

Swift, E. J., Mind in the Making. New York: Charles Scribners Sons, 1908. pp. 169-218.

" "Studies in the Psychology and Physiology of Learning". American Journal of Psychology, Vol. XVI, 1903.

Thorndike, E. L., Educational Psychology. Vols. I and II. New York: Published by Teachers College, Columbia University, 1913.

" Principles of Teaching. New York: A. G. Seiler Company, 1905. pp. 219-234.

Thorndike, E. L., "The Curve of Work." Psychological Review, XIX (May, 1912), pp. 165-194.

" "Ideo-motor Action." Psychological Review, XX (1913), pp. 91-106.

Thurstone, L. L., The Nature of Intelligence.

Vaughn, James, Positive Versus Negative Instruction. New York: National Bureau of Casualty and Surety Underwriters, 1908.

Watson, J. B., Behaviorism. New York: Harcourt, Brace and Company, 1926.

" "Kinaesthetic and Organic Sensations". Psychological Review Monograph Supplement, VIII (1907).

Watson, Rosalie Raynor, "Experiment Throwing Darts at a Target." Unpublished Thesis. Johns Hopkins University. Quoted in Watson's "Behaviorism".

Winch, W. H., "Inductive Versus Deductive Methods of Teaching; an Experimental Research". Educational Psychology Monograph. Baltimore: Warwick and York, 1913, pp. 7-10

Woodworth, R. S., Dynamic Psychology, 1911.

" "Accuracy of Voluntary Movement". Psychological Review Monograph Supplement, Vol. III, No. 13, 1899. pp. 1-114.

APPENDIX

The raw data upon which the study is based are included in Tables IX to XXX. Tables IX to XIX inclusive give the number of hits in each target zone for each sixty trial practice period. The data are so arranged that the record of any one of the subjects on any one of the instructions may easily be found. Tables XX to XXX give similar data for the control group.

Table IX

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH A INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	4	31	19	6	0
2	12	35	10	3	0
3	4	35	14	7	0
4	8	30	17	5	0
5	3	24	17	14	2
6	2	13	11	28	6
7	7	33	15	5	0
8	7	35	11	7	0
9	11	33	12	4	0
10	3	38	16	3	0
11	5	40	12	3	0
	Second Group				
1	13	40	7	0	0
2	15	27	12	5	0
3	7	36	11	6	0
4	5	23	21	11	0
5	5	36	13	5	1
6	5	29	18	8	0
7	8	33	14	5	0
8	6	35	16	3	0
9	6	36	15	3	0
10	11	38	11	0	0
11	8	36	12	2	2
	Third Group				
1	8	33	15	4	0
2	5	31	22	2	0
3	7	33	19	1	0
4	7	26	16	10	1
5	9	36	11	3	1
6	4	41	14	1	0
7	7	29	22	2	0
8	4	26	16	14	0
9	13	31	13	3	0
10	7	32	17	4	0
11	10	35	12	3	0

Table IX (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH A INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	10	22	15	12	1
2	12	39	9	0	0
3	1	34	15	10	0
4	2	36	18	4	0
5	7	28	20	5	0
6	2	38	13	7	0
7	2	39	14	4	1
8	6	36	11	7	0
9	7	44	9	0	0
10	3	36	17	4	0
11	5	22	21	12	0
	Fifth Group				
1	8	34	18	0	0
2	8	36	14	2	0
33	3	16	21	18	2
4	12	37	10	1	0
5	7	23	25	5	0
6	14	43	3	0	0
7	3	18	22	12	5
8	12	36	11	1	0
9	4	37	14	5	0
10	2	26	26	6	0
11	5	23	19	11	2
	Sixth Group				
1	10	31	17	2	0
2	3	17	17	21	2
3	3	31	18	8	0
4	2	16	24	13	5
5	12	26	16	6	0
6	16	38	6	0	0
7	3	22	21	11	3
8	2	30	20	8	0
9	4	31	20	5	0
10	2	23	24	10	1
11	3	34	17	6	0

Table X

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH B INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	8	36	14	2	0
2	7	33	12	7	1
3	9	32	16	3	0
4	5	31	15	9	0
5	7	22	11	16	4
6	4	18	21	9	8
7	6	39	7	7	1
8	9	43	6	2	0
9	12	34	13	1	0
10	7	34	17	2	0
11	7	42	10	1	0
	Second Group				
1	13	37	8	2	0
2	4	29	18	9	0
3	9	32	16	3	0
4	6	26	15	13	0
5	9	38	10	3	0
6	4	40	16	0	0
7	10	33	14	3	0
8	18	34	7	1	0
9	6	38	15	1	0
10	5	36	16	3	0
11	7	31	17	5	0
	Third Group				
1	7	34	14	5	0
2	7	30	20	3	0
3	9	39	10	2	0
4	3	23	21	12	1
5	7	39	10	4	0
6	7	40	12	1	0
7	7	25	21	7	0
8	8	26	18	6	2
9	6	33	18	3	0
10	10	34	12	4	0
11	9	35	12	4	0

Table X (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH B INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	31	22	1	0
2	8	47	4	1	0
3	2	41	14	3	0
4	2	38	15	5	0
5	10	32	16	2	0
6	6	32	18	4	0
7	4	27	14	14	1
8	11	34	12	3	0
9	14	23	22	1	0
10	5	36	14	5	0
11	4	33	19	4	0
	Fifth Group				
1	12	23	14	1	0
2	5	31	22	2	0
3	7	18	25	9	1
4	12	24	19	5	0
5	5	32	20	3	0
6	14	37	8	1	0
7	2	16	33	7	2
8	8	43	8	1	0
9	10	41	8	1	0
10	8	38	12	2	0
11	6	18	22	10	4
	Sixth Group				
1	8	37	12	3	0
2	4	24	19	12	1
3	2	11	26	17	4
4	5	23	25	6	1
5	8	23	17	12	0
6	15	37	8	0	0
7	2	29	17	11	1
8	5	26	18	11	0
9	7	31	15	7	0
10	6	27	22	5	0
11	12	25	19	4	0

Table XI

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH C INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	4	4	14	1	0
2	6	30	14	10	0
3	4	31	15	10	0
4	4	33	15	8	0
5	3	21	17	16	3
6	3	26	15	11	5
7	4	41	11	4	0
8	9	40	9	2	0
9	8	36	13	3	0
10	10	38	9	3	0
11	12	34	9	5	0
	Second Group				
1	10	45	4	1	0
2	8	30	14	8	0
3	5	34	15	6	0
4	4	31	15	10	0
5	6	25	17	11	1
6	8	37	12	2	1
7	6	39	14	1	0
8	8	37	13	1	1
9	8	35	11	6	0
10	12	39	7	2	0
11	8	37	13	2	0
	Third Group				
1	5	30	16	9	0
2	6	40	12	2	0
3	8	42	9	1	0
4	4	22	19	14	1
5	5	28	23	4	0
6	7	40	12	1	0
7	4	36	16	4	0
8	6	21	26	7	0
9	6	31	16	7	0
10	13	31	13	3	0
11	7	30	13	9	1

Table XI (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH C INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	33	14	7	0
2	10	38	9	2	1
3	2	27	23	8	0
4	5	34	17	4	0
5	6	34	14	6	0
6	10	26	17	7	0
7	3	29	19	9	0
8	7	37	9	7	0
9	8	40	7	5	0
10	7	36	14	3	0
11	13	28	12	7	0
	Fifth Group				
1	17	26	16	1	0
2	12	28	16	4	0
3	7	19	19	15	0
4	13	37	9	1	0
5	4	27	18	10	1
6	14	36	10	0	0
7	1	22	17	19	1
8	8	35	15	2	0
9	13	33	11	3	0
10	3	29	22	6	0
11	1	23	24	12	0
	Sixth Group				
1	7	35	16	2	0
2	1	22	20	14	3
3	3	11	24	20	2
4	2	30	20	8	0
5	5	30	19	6	0
6	19	35	6	0	0
7	4	25	21	10	0
8	1	20	28	11	0
9	5	34	13	8	0
10	6	22	20	12	0
11	9	30	15	5	1

Table XII

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH D INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	5	39	15	1	0
2	6	33	18	3	0
3	4	30	19	6	1
4	5	22	22	19	2
5	2	22	13	9	4
6	4	19	15	15	7
7	7	38	13	2	0
8	5	36	16	3	0
9	8	38	9	4	1
10	4	42	10	3	1
11	4	36	17	3	0
	Second Group				
1	12	41	6	1	0
2	8	30	12	9	1
3	3	31	19	7	0
4	3	27	23	7	0
5	1	34	18	7	0
6	5	33	17	5	0
7	4	40	12	3	1
8	11	30	15	4	0
9	6	38	13	3	0
10	1	36	17	6	0
11	7	30	16	7	0
	Third Group				
1	10	29	16	5	0
2	7	39	13	1	0
3	7	34	13	6	0
4	5	28	18	9	0
5	7	34	16	2	1
6	10	33	17	0	0
7	6	37	16	1	0
8	1	27	24	7	1
9	12	33	13	2	0
10	5	43	12	0	0
11	8	22	22	8	0

Table XII (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH D INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	32	17	5	0
2	9	42	9	0	0
3	5	28	19	8	0
4	4	31	23	2	0
5	4	33	18	5	0
6	5	34	19	2	0
7	5	36	15	4	0
8	8	32	14	6	0
9	10	30	12	8	0
10	1	35	19	5	0
11	4	17	24	15	0
	Fifth Group				
1	9	33	15	3	0
2	7	35	17	1	0
3	6	20	15	17	2
4	11	37	10	2	0
5	4	27	18	10	1
6	14	36	10	0	0
7	1	22	17	19	1
8	8	35	15	2	0
9	13	33	11	3	0
10	3	29	22	6	0
11	1	23	24	12	0
	Sixth Group				
1	6	38	14	2	0
2	4	19	25	11	1
3	4	24	16	15	1
4	1	24	16	17	2
5	7	37	14	2	0
6	13	37	8	2	0
7	6	22	22	10	0
8	3	36	13	8	0
9	7	31	13	9	0
10	3	32	20	5	0
11	3	34	19	4	0

Table XIII

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH E INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	6	42	10	2	0
2	9	28	17	6	0
3	4	32	19	5	0
4	6	30	15	9	0
5	2	17	16	17	8
6	3	19	13	18	7
7	12	38	8	2	0
8	2	51	6	1	0
9	12	39	6	3	0
10	11	40	8	1	0
11	12	36	11	1	0
	Second Group				
1	11	41	7	1	0
2	9	30	12	7	2
3	7	34	17	2	0
4	3	29	16	11	1
5	9	35	12	3	1
6	7	35	14	4	0
7	10	33	12	5	0
8	6	42	8	4	0
9	9	28	20	3	0
10	5	43	9	3	0
11	12	40	5	3	0
	Third Group				
1	5	25	20	10	0
2	3	31	20	6	0
3	9	37	13	1	0
4	2	31	18	9	0
5	3	32	19	6	0
6	7	38	13	2	0
7	8	42	10	0	0
8	3	23	23	10	1
9	8	32	16	4	0
10	9	37	12	2	0
11	13	37	9	1	0

Table XIII (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH E INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	2	23	20	15	0
2	12	34	11	3	0
3	3	29	19	9	0
4	3	34	16	7	0
5	8	31	12	9	0
6	13	30	16	1	0
7	7	39	11	3	0
8	4	35	19	2	0
9	3	33	15	9	0
10	7	31	20	2	0
11	5	29	17	9	0
	Fifth Group				
1	9	35	15	1	0
2	7	35	18	0	0
3	3	16	31	9	1
4	7	33	17	3	0
5	5	25	20	10	0
6	15	39	6	0	0
7	3	18	24	13	2
8	6	42	11	1	0
9	8	35	16	1	0
10	4	30	21	5	0
11	5	28	14	13	0
	Sixth Group				
1	10	35	14	1	0
2	4	23	23	10	0
3	2	24	18	14	2
4	4	17	25	11	3
5	5	34	14	7	0
6	10	44	6	0	0
7	10	31	13	6	0
8	5	23	26	6	0
9	6	35	11	8	0
10	10	26	21	3	0
11	3	27	14	15	1

Table XIV

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH F INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	5	42	12	1	0
2	6	30	22	2	0
3	1	30	24	5	0
4	8	33	13	6	0
5	2	24	14	14	6
6	4	21	14	21	0
7	6	34	17	3	0
8	7	43	9	1	0
9	10	36	14	0	0
10	5	45	9	1	0
11	10	46	4	0	0
	Second Group				
1	9	46	5	0	0
2	9	34	9	7	1
3	5	37	16	2	0
4	5	30	17	8	0
5	2	32	16	10	0
6	5	37	12	6	0
7	7	36	12	4	1
8	8	42	10	0	0
9	10	40	9	1	0
10	7	41	10	2	0
11	6	32	20	2	0
	Third Group				
1	10	26	18	6	0
2	8	35	16	1	0
3	13	34	11	2	0
4	6	24	28	2	0
5	4	36	17	3	0
6	8	36	15	1	0
7	5	38	15	2	0
8	3	31	20	6	0
9	7	35	16	2	0
10	9	43	8	0	0
11	13	37	10	0	0

Table XIV (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH F INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	10	24	21	5	0
2	13	42	4	1	0
3	3	27	21	9	0
4	5	23	26	6	0
5	5	38	14	3	0
6	10	33	14	3	0
7	5	26	21	8	0
8	10	35	14	1	0
9	11	35	12	2	0
10	7	29	19	4	1
11	8	26	26	0	0
	Fifth Group				
1	11	29	17	3	0
2	8	36	13	3	0
3	4	22	21	13	0
4	8	35	16	1	0
5	7	31	19	3	0
6	13	38	8	1	0
7	8	24	21	7	0
8	10	41	8	1	0
9	17	35	7	1	0
10	3	36	18	3	0
11	6	30	19	5	0
	Sixth Group				
1	7	37	12	4	0
2	3	35	12	10	0
3	5	19	19	16	1
4	1	16	21	16	6
5	5	19	20	15	1
6	15	36	8	1	0
7	7	26	22	5	0
8	7	30	18	5	0
9	6	33	18	3	0
10	5	29	18	8	0
11	9	31	14	6	0

Table XV

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH G INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	19	39	2	0	0
2	8	34	16	2	0
3	9	35	13	3	0
4	11	33	13	3	0
5	3	21	19	16	1
6	4	26	14	14	2
7	6	35	16	3	0
8	9	35	12	4	0
9	11	36	11	2	0
10	17	37	5	1	0
11	9	40	9	2	0
	Second Group				
1	14	40	6	0	0
2	8	24	18	10	0
3	6	28	17	9	0
4	5	19	24	12	0
5	6	24	19	11	0
6	5	44	10	1	0
7	10	36	12	2	0
8	12	44	3	1	0
9	7	39	7	7	0
10	4	31	17	8	0
11	8	41	10	1	0
	Third Group				
1	10	27	18	5	0
2	6	32	19	3	0
3	10	32	16	2	0
4	6	28	15	10	1
5	4	32	14	9	1
6	10	34	13	3	0
7	7	35	15	3	0
8	3	22	26	9	0
9	9	31	17	3	0
10	12	39	9	0	0
11	8	28	11	3	0

Table XV (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH G INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	23	23	8	0
2	6	43	11	0	0
3	5	38	15	2	0
4	6	42	10	2	0
5	7	37	12	4	0
6	4	35	19	2	0
7	5	32	15	8	0
8	2	29	20	8	1
9	7	43	8	2	0
10	6	36	15	3	0
11	9	24	23	4	0
	Fifth Group				
1	11	33	16	0	0
2	8	37	10	5	0
3	5	22	17	14	2
4	5	29	23	3	0
5	3	28	19	10	0
6	10	36	10	4	0
7	7	24	20	7	2
8	12	32	14	2	0
9	10	42	8	0	0
10	7	38	13	2	0
11	5	25	22	7	1
	Sixth Group				
1	9	30	7	4	0
2	7	21	22	10	0
3	1	19	20	19	1
4	3	22	24	10	1
5	7	24	21	8	0
6	24	32	4	0	0
7	12	31	8	8	1
8	3	33	18	6	0
9	3	27	19	11	0
10	9	22	22	7	0
11	12	26	17	5	0

Table XVI

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH H INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	9	40	1	0	0
2	8	32	19	1	0
3	4	33	14	8	1
4	5	34	15	5	1
5	2	29	13	13	3
6	4	18	15	23	0
7	6	41	9	4	0
8	3	30	18	8	1
9	11	42	4	3	0
10	13	29	18	0	0
11	7	40	7	6	0
	Second Group				
1	9	41	9	1	0
2	6	30	14	10	0
3	5	33	17	5	0
4	3	27	20	8	2
5	5	32	16	7	0
6	6	39	10	5	0
7	8	34	10	7	1
8	8	38	14	0	0
9	8	38	13	1	0
10	3	35	19	4	0
11	10	40	9	1	0
	Third Group				
1	5	30	20	5	0
2	7	29	19	5	0
3	6	37	16	1	0
4	5	29	19	6	1
5	10	29	19	2	0
6	10	30	19	1	0
7	2	30	21	7	0
8	4	18	26	11	1
9	7	28	21	4	0
10	6	40	13	1	0
11	12	33	14	1	0

Table XVI (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH H INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	4	31	21	4	0
2	12	34	12	1	1
3	3	36	12	7	2
4	12	28	14	6	0
5	4	29	22	5	0
6	5	34	15	6	0
7	4	27	24	4	1
8	3	20	12	5	0
9	12	40	7	1	0
10	9	31	15	5	0
11	8	26	21	5	0
	Fifth Group				
1	9	37	11	3	0
2	8	31	17	4	0
3	2	19	20	18	1
4	8	35	16	1	0
5	8	27	22	3	0
6	15	37	8	0	0
7	3	25	16	15	1
8	14	34	11	1	0
9	14	34	11	1	0
10	4	35	19	2	9
11	10	23	10	16	1
	Sixth Group				
1	8	34	16	2	0
2	5	21	20	14	0
3	1	26	17	14	2
4	5	15	26	12	2
5	6	31	15	7	1
6	18	32	7	2	1
7	2	28	16	14	0
8	5	33	17	5	0
9	8	33	16	3	0
10	4	15	29	12	0
11	5	36	14	5	0

Table XVII

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH I INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	10	36	12	2	0
2	5	37	14	4	0
3	3	21	23	13	0
4	6	36	14	4	0
5	4	23	13	18	2
6	1	24	17	16	2
7	5	35	17	3	0
8	5	32	19	4	0
9	7	43	7	3	0
10	14	40	6	0	0
11	6	40	10	4	0
	Second Group				
1	11	40	9	0	0
2	6	25	20	9	0
3	8	31	15	6	0
4	2	29	15	12	2
5	2	34	19	5	0
6	6	38	13	3	0
7	8	31	18	3	0
8	11	38	8	3	0
9	11	42	7	0	0
10	6	36	16	2	0
11	9	36	12	3	0
	Third Group				
1	11	28	16	5	0
2	8	32	15	5	0
3	6	41	12	1	0
4	3	26	23	8	0
5	4	33	16	7	0
6	12	36	9	3	0
7	9	32	17	2	0
8	5	16	30	8	1
9	6	35	15	4	0
10	9	38	12	1	0
11	10	33	11	6	0

Table XVII (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH I INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	30	17	7	0
2	11	40	9	0	0
3	5	30	20	5	0
4	2	42	14	2	0
5	5	28	24	3	0
6	8	26	22	4	0
7	10	30	17	3	0
8	6	36	14	4	0
9	13	31	12	4	0
10	4	27	23	5	1
11	9	28	22	1	0
	Fifth Group				
1	11	30	16	3	0
2	8	39	11	2	0
3	2	22	20	13	3
4	13	38	9	0	0
5	5	37	10	8	0
6	15	43	2	0	0
7	2	27	17	13	1
8	9	34	14	3	0
9	10	41	9	0	0
10	11	28	17	4	0
11	4	24	22	10	0
	Sixth Group				
1	4	34	18	4	0
2	1	22	24	13	0
3	3	17	26	10	4
4	2	22	18	16	2
5	1	26	27	5	1
6	14	41	5	0	0
7	3	22	24	1	0
8	3	25	23	8	1
9	7	27	18	8	0
10	6	34	12	8	0
11	11	21	16	12	0

Table XVIII

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH J INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	7	38	14	1	0
2	14	32	13	1	0
3	5	33	19	3	0
4	4	35	16	5	0
5	5	28	8	18	1
6	4	28	16	12	0
7	11	34	12	3	0
8	6	40	10	4	0
9	6	37	13	4	0
10	10	36	12	2	0
11	10	41	5	4	0
	Second Group				
1	8	36	13	3	0
2	8	28	12	12	0
3	10	35	13	2	0
4	5	29	21	5	0
5	7	38	12	3	0
6	8	44	6	2	0
7	5	42	10	3	0
8	11	35	13	1	0
9	7	32	21	0	0
10	3	47	8	2	0
11	10	37	12	1	0
	Third Group				
1	9	28	19	4	0
2	10	38	11	1	0
3	12	38	9	1	0
4	1	31	20	8	0
5	6	42	10	2	0
6	10	41	9	0	0
7	10	31	15	4	0
8	9	22	17	12	0
9	4	35	16	5	0
10	8	41	11	0	0
11	9	38	11	2	0

Table XVIII (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH J INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	9	25	23	3	0
2	12	33	12	3	0
3	2	19	26	9	4
4	3	35	20	2	0
5	5	38	15	2	0
6	8	36	15	1	0
7	3	24	22	11	0
8	1	25	18	16	0
9	11	35	12	2	0
10	8	32	12	7	1
11	7	31	17	5	0
	Fifth Group				
1	10	36	12	2	0
2	10	44	5	1	0
3	4	22	18	15	1
4	5	49	6	0	0
5	7	23	24	6	0
6	14	43	2	1	0
7	5	25	21	9	0
8	14	32	13	1	0
9	12	35	13	0	0
10	11	21	18	10	0
11	6	28	18	7	1
	Sixth Group				
1	11	35	13	1	0
2	8	20	20	9	3
3	3	20	20	15	2
4	4	26	17	11	2
5	6	21	26	7	0
6	17	35	7	1	0
7	13	24	20	3	0
8	6	31	15	8	0
9	5	31	19	5	0
10	4	29	25	2	0
11	3	19	25	13	0

Table XIX

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH K INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	First Group				
1	11	35	10	1	0
2	5	33	16	6	0
3	3	35	17	4	1
4	6	32	16	6	0
5	6	26	13	12	3
6	2	15	24	17	2
7	4	35	16	5	0
8	1	37	16	6	0
9	12	37	8	3	0
10	10	36	9	5	0
11	8	38	10	4	0
	Second Group				
1	6	47	7	0	0
2	3	29	12	15	1
3	2	28	17	11	2
4	3	27	19	11	0
5	5	36	11	8	0
6	4	19	28	8	1
7	7	35	14	4	0
8	10	30	13	7	0
9	9	34	12	5	0
10	6	38	14	2	0
11	8	38	11	3	0
	Third Group				
1	3	30	16	11	0
2	10	26	18	6	0
3	12	27	19	2	0
4	7	25	17	11	0
5	5	27	18	10	0
6	7	39	11	3	0
7	4	31	15	10	0
8	2	27	17	12	2
9	8	24	24	3	1
10	8	34	17	1	0
11	6	28	20	6	0

Table XIX (Continued)

DISTRIBUTION OF "HITS" FOR 60 TRIALS WITH K INSTRUCTION

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
	Fourth Group				
1	6	24	19	11	0
2	10	36	13	1	0
3	2	37	16	5	0
4	3	30	22	5	0
5	8	28	16	7	1
6	12	29	12	7	0
7	3	17	25	13	2
8	6	20	22	11	1
9	5	31	18	5	1
10	4	36	16	4	0
11	6	29	15	9	1
	Fifth Group				
1	4	38	15	3	0
2	9	30	15	6	0
3	5	23	20	10	2
4	10	28	19	3	0
5	5	27	22	6	0
6	21	30	9	0	0
7	2	17	17	24	0
8	10	30	17	3	0
9	6	43	7	4	0
10	2	32	20	6	0
11	2	24	24	10	0
	Sixth Group				
1	5	33	17	4	1
2	6	20	20	14	0
3	4	12	17	16	11
4	4	26	22	8	0
5	7	20	19	12	2
6	15	30	11	4	0
7	4	12	25	16	3
8	4	26	20	9	1
9	9	30	13	8	0
10	4	32	17	7	0
11	5	26	22	5	2

Table XX

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS **

First Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	2	30	22	6	0
2	6	35	16	3	0
3	6	25	21	6	2
4	4	32	12	8	4
5	1	20	27	12	0
6	3	16	25	16	0
7	2	15	20	13	10
8	3	36	17	4	0
9	7	33	16	4	0
10	1	20	28	11	0
11	5	23	23	9	0

Table XXI

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Second Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	8	37	14	1	0
2	9	31	17	3	0
3	6	28	21	5	0
4	5	28	21	6	0
5	5	26	20	9	0
6	3	16	25	16	0
7	2	15	20	13	10
8	3	36	17	4	0
9	7	33	16	4	0
10	1	20	28	11	0
11	5	23	23	9	0

Table XXII

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Third Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	8	31	18	3	0
2	9	35	13	3	0
3	2	34	12	12	0
4	10	19	21	10	0
5	5	26	20	8	1
6	8	26	21	5	0
7	3	24	20	9	4
8	6	34	15	5	0
9	8	30	20	2	0
10	2	24	19	15	0
11	4	35	16	5	0

Table XXIII

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Fourth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	3	35	20	2	0
2	10	38	9	3	0
3	7	28	21	4	0
4	9	32	14	4	1
5	4	27	19	10	0
6	5	30	21	4	0
7	3	16	19	18	4
8	9	29	16	6	0
9	5	32	20	2	1
10	4	21	25	9	1
11	8	30	21	1	0

Table XXIV

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Fifth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	4	36	16	4	0
2	13	32	14	1	0
3	10	30	18	2	0
4	10	31	12	6	1
5	5	22	22	11	0
6	9	27	19	5	0
7	4	22	16	12	6
8	4	31	19	6	0
9	5	33	17	5	0
10	2	31	19	8	0
11	6	3 6	16	2	0

Table XXV

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Sixth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	4	36	18	2	0
2	5	39	11	5	0
3	5	33	18	4	0
4	4	29	19	8	0
5	5	23	26	6	0
6	10	21	24	4	1
7	1	12	13	25	9
8	6	34	12	8	0
9	7	33	16	3	1
10	2	26	23	9	0
11	4	31	19	6	0

Table XXVI

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Seventh Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	6	23	27	4	0
2	7	32	18	3	0
3	3	22	28	7	0
4	2	32	18	8	0
5	8	29	20	3	0
6	6	30	20	4	0
7	4	18	16	21	11
8	4	30	14	11	1
9	7	31	20	2	0
10	5	24	20	10	1
11	8	30	21	1	0

Table XXVII

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Eighth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	5	29	21	5	0
2	5	40	10	5	0
3	8	33	14	5	0
4	6	26	21	6	1
5	3	31	20	6	0
6	6	31	19	4	0
7	1	11	18	23	7
8	6	31	18	5	0
9	6	39	13	2	0
10	8	21	21	10	0
11	3	37	18	2	0

Table XXVIII

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Ninth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	6	26	21	7	0
2	11	28	17	4	0
3	4	41	14	1	0
4	4	25	20	10	1
5	3	30	21	6	0
6	4	26	25	4	1
7	3	17	19	15	6
8	6	33	16	4	0
9	10	30	16	4	0
10	5	24	23	8	0
11	10	29	19	1	1

Table XXIX

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Tenth Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	5	28	20	7	0
2	9	31	15	5	0
3	7	35	16	2	0
4	6	27	22	5	0
5	9	26	19	6	0
6	3	25	27	5	0
7	3	15	17	21	4
8	8	29	19	4	0
9	13	23	17	6	1
10	3	26	19	12	0
11	8	29	22	1	0

Table XXX

CONTROL GROUP. DISTRIBUTION OF HITS FOR 60 TRIALS

Eleventh Result

Subjects	Distribution of Hits by Zones				
	1	2	3	4	5
1	5	27	23	5	0
2	2	31	23	4	0
3	10	27	19	4	0
4	8	31	16	5	0
5	9	30	17	4	0
6	5	28	22	5	0
7	0	12	18	23	17
8	7	34	17	2	0
9	6	33	16	5	0
10	5	26	16	12	1
11	8	31	15	5	1