RELATIONSHIP OF CHOICE REACTION TIME AND INTELLIGENCE

by

Barbara Sue Stitt Bowlby

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PHYSICAL EDUCATION FOR WOMEN

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 3

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Barbara Sue Bowlby

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Patricia C. Fairchild
PATRICIA C. FAIRCHILD
Associate Professor of
Physical Education for Women

January 2, 1973
Date

TABLE OF CONTENTS

TABLE OF CONTENTS--Continued

LIST OF TABLES

LIST OF ILLUSTRATIONS

ABSTRACT

A Stitt-Stough choice reaction time apparatus and an Otis-Lennon Mental Ability Test were used to determine the correlation of choice reaction to intelligence. The subjects were a non-random sample of 32 high school girls. The Stitt-Stough apparatus was designed by the experimenter and consisted of an indicator panel, keyboard and control panel connected to a Dekan Automatic Performance Analyzer. Eight lights of four different colors allowed for response to color rather than position when the subject pressed one of the four color coded micro-switches on the keyboard. The subjects were given 25 trials on four consecutive days. The choice reaction time score was the mean score of the third and fourth day median scores. A Pearson Product-Moment correlation of .42 at the .05 level of significance was found. This suggested a possible advantage of athletes with higher intelligence in sports requiring a fast choice reaction time. The possibility of grouping students in physical education classes on the basis of their intelligence should be examined.

CHAPTER I

INTRODUCTION

The speed with which an individual can react in a game situation has always been of interest to those concerned with physical education and athletics. For example, in a track or swimming start, the coach is interested in a quick start, or simple reaction time. Choice reaction time (when a decision has to be made before the resulting action can take place), becomes important for a baseball player, a basketball player or a tennis player. If a player has quick reactions, he will do better in most athletic contests, particularly dual and team sports.

Most reaction time in sports events involves choice reaction time, that is, reaction time with decision time added to it, or the time it takes to react when a decision has to be made first. Choice reaction time can be improved by becoming more familiar with the choices and their results.

Because of the additional factor of decision making, it would appear that intelligence plays an important role in the phenomenon of choice reaction time. Psychologists believe intelligence to be many-faceted but cannot agree on the manner in which the various facets are related, organized and described. Intelligence must not be confused with amounts of knowledge and information, but rather how these are applied in problem situations (Bernard and Huckins 1967).

Research has been inconclusive regarding the relationship between choice reaction time and intelligence. Scott (1940) wrote that reaction time is one of the earliest phenomenon of human behavior to which experimental psychologists turned their attention. She stated that there is still disagreement among investigators as to whether a relationship does exist between reaction time and intelligence and that there are no conclusive experimental data to confirm or deny the existence of such a relationship. Lemmon (1927) concluded from his own research and that of others that the relation between reaction time and the higher abilities (intelligence, memory and learning) is not yet settled. This study was undertaken to further the understanding of these two variables and to determine if a significant relationship existed between the two.

Statement of the Problem

This study sought to discover the relationship between choice reaction time, as measured by the Stitt-Stough Choice Reaction Time Apparatus (SSCRTA), and intelligence, as measured by the Otis-Lennon Mental Ability Test (OLMAT) for high school girls.

Hypotheses

For the purpose of the present study the following hypothesis was formulated.

HO: The correlation coefficient obtained between scores of the OLMAT and the choice reaction time scores on the SSCRTA of high school girls will differ from zero only by chance at the .05 level of significance.

Research Hypothesis: A significant negative correlation (at the .05 level of significance) will be found between the scores of the OLMAT and the choice reaction time scores on the SSCRTA for high school girls.

Scope of the Study

As many variables as possible were controlled; however, the study was limited by the following factors:

1. The subjects were high school girls who were enrolled in six Tucson public schools, grades ten through twelve.

2. The subjects formed a nonrandom sample of volunteers.

Definition of Terms

In order to clarify the meaning of the terminology used in this study, the following definitions were used.

Choice Reaction Time

Choice reaction time is the time elapsing from the initiation of a stimulus (when two or more are possible) to the initiation of a response (when there is a specific response for each possible stimuli), as measured by the SSCRTA. Thus, choice reaction time includes the time necessary to recognize the specific stimulus and the decision time necessary to decide upon the appropriate response.

Intelligence

Intelligence, as measured in this study, is the subject's facility in reasoning and in dealing abstractly with verbal, symbolic

and figural test content. Intelligence, as measured by the OLMAT, is a measure of broad reasoning abilities (Otis and Lennon 1967).

Significance of the Study

If a relationship between intelligence and choice reaction time can be established, important consequences, both practical and scientific, would follow (Peak and Boring 1926). The fact that a significant relationship existed between the two would add to scientific knowledge and would serve as a stepping stone for further research. Hopefully, this study will add some insight into the relationship between choice reaction time and intelligence.

There also would be many implications for athletics. Most sport events require quickness of decision making, and one of the components of intelligence, agreed upon by most psychologists, is speed. Coaches could seek highly intelligent athletes or possibly could even train young men and women who, although not active in sports, because of high intelligence, would become good prospects. It must be remembered, however, that fast choice reaction time is only one requirement of a good athlete.

CHAPTER II

REVIEW OF THE LITERATURE

Literature relevant to this study is reviewed in this chapter. Choice reaction time experiments are explained, and the controversy regarding the relationship between choice reaction time and intelligence is examined. Also, information relating to different choice reaction time test equipment and the number of alternatives presented to the subject is included.

Choice Reaction Time

A choice reaction time experiment consists of a series of trials, on each of which the subject is presented with a signal, chosen from a finite set of signals, and is required to make a response as soon as possible after the signal appears. There is a different response for each alternative signal, and the subject is requested to make the response which corresponds to the signal presented. Although the subject knows approximately when the signal will come, he does not know which signal will appear. Therefore, he is necessarily uncertain about which response he will be required to make. The measurement of choice reaction time includes the time necessary to perceive one of a certain set of changes in the environment and the time necessary to decide upon and initiate the desired resulting action. A choice reaction time, therefore, includes a decision time (Laming 1968).

Smith (1968) stated that choice reaction time experiments are characterized by the following: a set of possible stimuli, a set of possible responses, and a 1:1 mapping (one response for each stimulus) of the stimuli into the response that is specified by the instructions. He defined choice reaction time as the time elapsing between the onset of the stimulus and the initiation of the response. Snodgrass and Luce (1967) concluded that information processing (the process of recognition) rather than motor factors is primarily responsible for the difference between simple reaction time (a single signal and one response) and choice reaction time. The major part of the increase in time and variability between simple and choice reaction time is contributed by the process of recognition.

Donders, in 1868, distinguished between three types of reactions, the "a," "b" and "c" reactions (Smith 1968, pp. 77-110). Smith explained Donders' "a" reaction as a single stimulus and a single response which was required whenever the stimulus was presented. The "a" reaction is commonly known as simple reaction time. The "b" reaction, as related by Smith, is the prototype of the most common choice reaction time paradigm, consisting of two stimuli, two responses and a 1:1 correspondence between them. In the "b" reaction the sub-processes include discrimination of the stimulus (stimulus categorization) and choice of a response (response selection). Finally, Smith stated that Donders' "c" reaction involved two stimuli and only a single response that was required for one of the stimuli but not for the other.

Intelligence

One of the oldest and most thoroughly studied concepts in human psychology is the concept of intelligence. However, the term "intelligence" still escapes precise definition. There are so many different kinds of behavior that are indicative of intelligence that identifying the essence of all of them has seemed virtually impossible (Hunt 1972). Most psychologists believe that intelligence has many components but cannot agree on the manner in which the components are related. Part of the difficulty in arriving at a common definition lies in the dynamic nature of the concept of intelligence (Bernard and Huckins 1967).

There are many definitions of intelligence which have been proposed; however, most of these are too narrow in scope. Some of them are:

1. An individual is intelligent in proportion to his ability to carry on abstract thinking (Tyler 1969).

2. An individual possesses intelligence insofar as he has learned, or can learn, to adjust to his environment (Tyler 1969).

3. Intelligence is the ability of an individual to adapt himself adequately to relatively new situations in life (Tyler 1969).

4. Intelligence is intellect, plus knowledge gained (Tyler 1969).

5. Intelligence is really "coping behavior" or applying knowledge in problem situations and being able to cope with life (Bernard and Huckins 1967).

6. General intelligence is probably not a separate or constant factor, but a composite of many different abilities (Tyler 1969).

7. Intelligence does not denote a single mental process capable of exact analytic definition. Intelligence is composed of such mental processes as sensation, perception, association, memory, imagination, discrimination, judgment and reasoning (Tyler 1969).

The measurement of intelligence has been one of psychology's most outstanding accomplishments. Intelligence as a measurable capacity must be defined as the capacity to do well on an intelligence test. Intelligence is what the specific test measures (Tyler 1969). One reason there is a controversy about the dimensions of intelligence is that individual intelligence tests may not measure all of the components of intelligence. Intelligence is commonly measured by an intelligence quotient (IQ), which is the individual's mental age times 100 divided by his chronological age. It is hoped an IQ score closely approximates intelligence, but it cannot be proven (Bernard and Huckins 1967).

IQ tests are based upon the measurement of what are believed to be the components of intelligence. Knowledge of the components of human intelligence has been acquired mostly in the last 25 years through the use of the statistical technique of factor analysis. The five general concepts identified as part of intelligence are learning, memory, problem solving, invention and decision making (Tyler 1969). Guilford (1967, pp. 79-81) stated that there are approximately 80 factors of intelligence known and 120 predicted. Measurement of intelligence is,

therefore, complex due to the number of factors involved. Psychologists have not yet decided if speed of decision making is a factor of intelligence. However, most IQ tests with a time limit do measure speed.

It is difficult to measure intelligence. There are instruments which assess intelligence in terms of an IQ score. However, these tests of IQ are statistical tests utilizing measurable quantities that are believed to be the basic components of intelligence.

For many years it was believed that intelligence was fixed and had a predetermined rate of development (Hunt 1972). It is now believed that intelligence continues to grow from birth to about age 21 as the individual is affected by experiences (Hunt 1972, Tyler 1969). Experiences play a large part in IQ development. After age 21 the increase slows rapidly and almost levels off. Each individual's intelligence growth rate is different, however, often coming in spurts (Tyler 1969).

Relationship of Choice Reaction Time to Intelligence

There have been few studies dealing with choice reaction time and intelligence; the studies that have been conducted offer differing results. The studies that have considered the relationship between the two have dealt mostly with simple reaction time and choice reaction time tests with two or three choices of response. No choice reaction time tests having more than five choices were correlated with intelligence. Some correlations reported in the literature were .23, .25 (Beck 1932) and .25 (Goodenough 1935) with tests having four choices.

Beck (1932) stated that speed of reaction has frequently been regarded as a contributing factor in intelligence. In 1926 Peak and Boring observed through their research (cited in detail later) that reaction time was probably related to intelligence. Since that time, only a few studies have dealt with this issue.

In studies done using both reaction time and choice reaction time, the relationship between choice reaction time and mental ability was always higher than the relationship between simple reaction time and mental ability (Goodenough 1935, Laming, 1968). Since few studies have been done with just choice reaction time and intelligence, studies will be included in this review covering the relationship of both simple and choice reaction times to intelligence.

Simple Reaction Time and Intelligence

Peak and Boring (1926), using five subjects of high intelligence found correlations of .90 between reaction time and results of the Army Alpha Examination and the Otis Self-Administering Test of Mental Ability. They also correlated speed of answering the questions on the tests with simple reaction time and obtained correlations of .70 with the Alpha and .90 with the Otis. The speed was obtained by timing with a stop watch the amount of time spent on each question by each subject. By measuring the amount of time on each question, they did obtain a type of choice reaction time score. Peak and Boring did state that their results were not sufficient, done to a limited number of subjects, to determine conclusively the relation of intelligence to speed. However, they did

conclude that reaction time is a very important factor in intelligence and that speed of reaction is an important and probably the most important factor in individual differences in the intelligence act.

Mulhern and Baumeister (1971), whose study dealt with both mentally retarded and normal subjects, postulated that one concomitant of low intelligence was a relative deficit in the ability to process information as that information becomes more complex and uncertain. Philip (1934), who worked entirely with children, found correlations of 0.0 to .25 for girls age nine to sixteen and .36 to .42 for boys age nine to sixteen for simple reaction time and mental ability. His correlations came from subgroups as he administered a different intelligence test to almost every age group. Therefore, his correlations were all calculated on groups of small numbers.

Goodenough (1935) believed, because of his own research, that among adults there is little relationship between simple reaction speed and intelligence. He did decide that more extensive study probably would reveal a very low positive relationship between reaction-speed and scores on intelligence tests which do not require speed.

Beck (1932), when he reviewed the field, reached the conclusion that speed was only of minor, if at all, importance in intelligence.

Choice Reaction Time and Intelligence

Lemmon (1927) did research with one hundred college students and found the correlation of intelligence with simple reaction time to be positive, but negligibly small. Using the same 100 students he also

found a correlation of .25 with intelligence and choice reaction time. Beck (1932) conducted research with 30 college students and found a correlation of .23 between choice reaction time and reading rate and a correlation of .25 between choice reaction time and the results of the Thorndike IQ test. His choice reaction time test was a four-choice test where the subjects responded to a visual number display by pressing numbered keys. All four keys were pressed in the order of the lighted numbers presented.

Scott (1940), testing 100 boys and girls age eight to twelve on both simple and choice reaction times, found the group of high IQ boys (IQ = 120-194) possessed definitely greater speed than did those of the high IQ girls (IQ = 120-200). In the low group (boys, IQ = 75-94; girls, IQ = 63-90) the choice reaction time scores for the boys and girls were similar. "The group of high IQ girls were in general faster than the group of low IQ boys. Not only were the high IQ groups faster than the respective low IQ groups, but in general both high IQ groups surpassed in speed either low IQ group" (Scott 1940, p. 55). Scott used several choice reaction time tests involving varying numbers of choices up to five. The test required pressing a key in response to a light flash with the keys directly under the lights.

Comparison of Choice Reaction Time Test Results of Normal and Mentally Defective Children

It is questionable whether results of tests done between mentally retarded subjects and normal subjects have a direct bearing on the relationship of choice reaction time and intelligence in normal

subjects because the mentally retarded are a very special group. However, since several studies have been done in this area, the results will be examined.

Some studies (Mulhern and Baumeister 1971, Dingman and Silverstein 1964) suggested that retardates encounter complex situations with a relatively greater decrease in efficiency than do normals. Dingman and Silverstein (1964) stated that it is commonly held that reaction time is not related to intelligence, but that previous research has shown that the mentally retarded have longer reaction times than normals.

Caffrey, Jones and Hinkle (1971) conducted research with ten normal and ten retarded children and found that both simple and choice reaction times of retardates are about twice as slow as those of normal children. Their results were significant at the .01 level. Dingman and Silverstein stated from results of their investigation that the finding of a negative relationship between reaction time and choice reaction time and mental ability by previous investigators may be in part attributable to their failure to control the effects of motor disabilities. They believed that often subjects were used in experiments that were handicapped in their response because of physical limitations rather than mental limitations.

Through examination of the literature, however, it was found that most studies did not use subjects with major motor disabilities. Ellis and Sloan (1957) found a correlation of -.54 between simple reaction time and mental age of 79 subjects, all mentally retarded, but

of different levels of retardation. Their subjects did not have major motor disabilities.

Sommers and Joiner (1970) constructed a battery of five "kinesio-perceptual" tests, including reaction time, which was administered to 120 children with IQ's ranging from 40 to 80. The purpose of the test battery was to predict IQ from the results of the battery. For comparison purposes, the IQ was measured by the Wechsler Intelligence Scale for Children. "A linear combination of the selected items resulted in a multiple correlation of .75 with IQ"(Sommers and Joiner 1970, p. 462). Separate correlations of items with IQ were not given.

Mulhern and Baumeister (1971), in their study with 40 normal and 40 retarded subjects, observed that "complexity affected the performance of the retardates much more than that of the normals which indicates the potency of this factor for less intelligent subjects (p. 462)." Because of the results of their study, these authors believed the failure of earlier studies to demonstrate an interaction between IQ and complexity is inexplainable.

Choice Reaction Time Equipment

Many different types of choice reaction time apparatus are described in the literature. The various types are dependent upon when they were constructed and the type of choices given for the test.

Beck (1932) constructed his choice reaction time test as a serial reaction using the Seashore serial discrimeter, which visually presented four numbers in random succession. The subject responded by pressing four numbered keys in the same order as the numbers were

visually presented. Alegria and Bertelson (1970) also used a visual display with a numerical indicator and eight buttons, four for each hand. Mowbray (1960) used a visual display with lighted numbers. However, the response was monitored by an electronic voice key operated from a throat microphone. Laming (1968) required his subjects to sort two different decks of cards with long and short stripes, measuring the time it took to sort each deck. He varied the number of long and short striped cards, which changed the subjects' time in completing the task.

The following studies all contained equipment having some similarities to the SSCRTA designed by the investigator and detailed in Chapter III. Goodenough (1935) had his subjects press a key as soon as the hands of the clock they watched started to move. Beck's (1932) subjects used the four fingers on the right hand, one on each key, to respond to a visual serial reaction test. Lanier's (1934) 13 subjects responded to a white or green light by pressing a telegraph key. Mulhern and Baumeister (1971) used a red warning light and four white lights placed directly above four telegraph keys. Laming (1968) had his subjects respond to cards with vertical white stripes mounted on a black background. His subjects responded by pressing one of five keys which were constructed of varying lengths to account for the difference in the length of the fingers and thumb. Seibel's (1963) experiment involved a ten-key response board. The keys were constructed of varying lengths to fit the finger lengths. The subject placed one finger lightly on each key and responded to a visual light display.

Caffrey, Jones and Hinkle (1971) had their subjects respond to one of four lights by pressing the key directly under the light. The lights in this study were different colors, and the stimulus was preceded by a warning light. Scott's (1940) study involved pressing one of five keys in response to one of five lights presented directly over the keys. Simon and Craft (1970) used four white lights in a square pattern with an amber warning light in the center. They used a separate panel for the lights, which they placed at the subject's eye level. The response was pressing one of four keys when one of the lights flashed.

There is an unsettled controversy in the literature regarding the effect of added choices upon the choice reaction time score. Seibel (1963) wrote, after completing a complex study, that the choice reaction time score increased when from two to eight alternatives or choices were added. He found that any number of choices after eight showed no significant increase in the score. Mowbray (1960) suggested that findings similar to Seibel's were incorrect. He believed the increase in time for added alternatives was a result of insufficient practice by the subject. He said when a response is required for each stimulus presented, no increase in choice reaction time occurs as a function of the number of alternative stimuli available.

Summary

Literature relevant to this study was reviewed in this chapter. Choice reaction time was explained as the time elapsing from the initiation of a stimulus (when two or more are possible) to the

initiation of a response (when there is a specific response for each possible stimuli). Intelligence was examined and defined as the subject's facility in reasoning and dealing abstractly with verbal, symbolic and figural test content.

The relationship of reaction time and choice reaction time to intelligence was discussed. As indicated by the research, there was no conclusive evidence to support or deny the relationship of choice reaction time and intelligence. One reason for the extreme differences in test results was the wide range of equipment and methods used to measure choice reaction time. There was no consistency in equipment design, the number of choices, the intelligence tests used or the age and sex of the subjects.

It is clear from the literature that mentally retarded subjects definitely have slower reaction times and choice reaction times than normal subjects. It has yet to be proved what implications this has for subjects. It has yet to be proved what implications this has for subjects of below average intelligence. Several studies (Mulhern and Baumeister 1971, Scott 1940) have implied the results would be consistent for subjects of below average intelligence and for mentally retarded subjects when compared with subjects of normal intelligence.

CHAPTER III

RESEARCH PROCEDURES

This chapter includes a description of the apparatus used and the results of a pre-study. The specific directions for the Choice Reaction Time Test are included along with an explanation of the intelligence test used.

Description of the Apparatus

The Stitt-Stough Choice Reaction Time Apparatus (SSCRTA), similar to apparatus mentioned in the literature, was designed by the investigator and constructed by E. Lee Stough at Tucson, Arizona.

The apparatus was designed to measure "b" choice reaction time (two or more stimuli and two or more responses with a 1:1 correspondence between them) giving the subject a 1:1 mapping of eight stimuli and eight responses. The apparatus was connected to a Dekan Automatic Performance Analyzer which supplied power for the choice reaction time apparatus, measured the time score in hundredths of a second and allowed for a delay start.

The apparatus consisted of three pieces of equipment (shown in Figure 1), the indicator panel, the keyboard and the control panel. In Figure 1, Part A is the indicator panel with the various lights identified by the first letter of the color represented. The indicator panel, the front of which is inclined 80^{o} from the horizontal, is

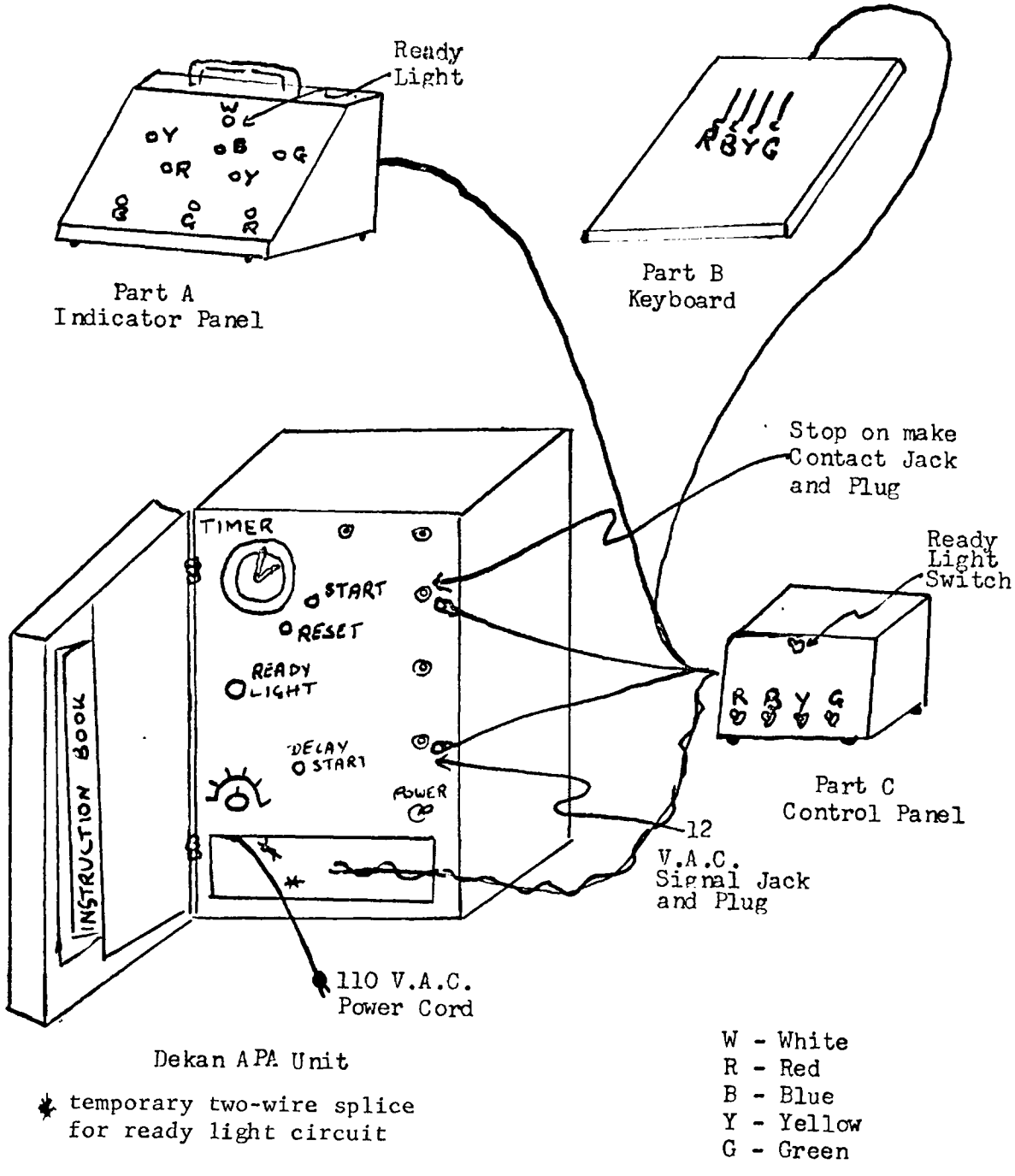


Figure 1. Stitt-Stough Choice Reaction Time Apparatus

10¼" by 7½" by 5½". The lights included a white ready-light and eight lights of four different colors. The colored lights and the ready-light were patterned after a study done by Caffrey, Jones and Hinkle (1971). The lights were arranged in three rows in the following order, left to right: row one, with three lights, was yellow, blue and green; row two, with two lights, was red and yellow; and row three, with three lights, was blue, green and red. The literature on display-control relationships (Simon and Craft 1970) emphasized that information processing was facilitated by a direct spatial correspondence between stimulus and response elements of a task. In a choice reaction time experiment, where lights are used, an example of a direct spatial correspondence would be to have the lights placed immediately over the keys. In such an experiment, there is an evident connection, or a direct spatial correspondence, because of position, between each light and its corresponding key.

In the experiment by Caffrey, Jones and Hinkle (1971) four colored lights and four response keys were used. However, since the lights were directly over the keys, the subject responded to the position of the light that flashed rather than to its color. Responding to the color of the light rather than to its position makes the task more complex. In the Stitt-Stough apparatus there were two lights of each color to give eight different stimuli to allow for a maximum choice reaction time score. The lights were arranged in three rows to avoid any direct spatial correspondence so the subject would respond to the color of the light flashed rather than its position.

In Figure 1, Part B is the keyboard, a flat board 12" by 8½". The board had four micro-switches with the two outer keys set three-sixteenths of an inch ahead of the two inner keys to better fit the subjects' finger lengths. The majority of the studies reviewed in the literature used some type of response key. Both Laming (1968) and Seibel (1963) constructed their apparatus with the keys designed to fit finger length. The spacing between the keys was five-eighths of an inch. The keys were color coded to correspond to the color of the lights in the following order from left to right: red, blue, yellow and green.

In Figure 1, Part C is the control panel, the dimensions of which are 6" by 5" by 4". The front of the panel contained a single pull-single throw toggle switch controlling the white ready light. Below this switch was a row of four three-position double pull-double throw toggle switches. These switches controlled the lights on the indicator panel. The order of the switches from left to right was red, blue, yellow and green. When any of these switches was in the top position, the corresponding color in the top position lighted. The lights in the top position were the yellow, blue and green lights in the top row of lights and the red light in the second row of lights. When any of the switches was in the middle position, the corresponding color did not light. When any of the switches was in the lower position, the corresponding color in the lower position lighted. The lights in the lower position were the blue, green and red lights in the bottom row of lights and the yellow light in the second row of lights.

A schematic diagram of the apparatus is located in Appendix A.

Located on the Performance Analyzer was the timer which recorded in hundredths of a second and a reset button to reset the timer to zero after each trial. There was a delay start button and a seven-position delay start switch so that the subject would not know when the light on the indicator panel would flash once the delay start button had been depressed. For this experiment only four of the delay positions were used. The average time from the flash of the white ready-light until the flash of the colored light was:

Delay position one = 2.5 seconds

Delay position two = 2.8 seconds

Delay position three = 3.2 seconds

Delay position four = 3.7 seconds

Pre-study

A pre-study was conducted to determine the learning curve of individuals for the SSCRTA. Four subjects were tested for eight consecutive days (two of these subjects were tested for the ninth day also) with 15 trials per day. The subjects were two men and two women ranging in age from 24 to 50 years.

Two main conclusions were reached as a result of the pre-study. With 15 trials per day, five days were found to be sufficient for the subjects to learn how to use the apparatus and for their daily scores to stabilize. After five days, the subjects showed little improvement in their time scores.

The second conclusion reached was to use the median score of the trials, rather than the mean score of the trials. Due to the positive skewness of the time scores, the mean score of the trials could not be used. Also, in the studies reviewed, the median was used more often than the mean. Goodenough (1935) stated he used the median rather than the mean because, for his data, the standard error of the median was less than the standard error of the mean. In this study there was no significant difference between the standard error of the mean and the standard error of the median.

The information shown in Appendices B and C reveal that there was a considerable difference between the median score and the mean score for most of the days for all four subjects. This can be explained more easily by observing the graphs of the frequency of the four subjects' scores for the eight consecutive days. When a subject performed poorly on a given trial, his time score was extremely slow. However, when he had a good response for a given trial, his time score did not differ greatly from his other time scores for that day. Therefore, if the mean score were used, the poor scores would receive a greater weighting than the better scores.

The pre-study also allowed the experimenter to finalize testing procedures and become consistent in the administration of the test.

Sample

The nonrandom sample consisted of 32 high school girls representing six high schools from Tucson, Arizona. The girls were enrolled

in the three school grades of sophomore, junior and senior. Table 1 indicates the school and grade distribution of the subjects.

Table 1. School and Grade Distribution of Subjects.

High Schools	Sophomores	Juniors	Seniors	Total
Canyon Del Oro	2	1	--	3
Catalina	--	5	--	5
Palo Verde	2	4	8	14
Rincon	3	--	2	5
Sahuaro	--	2	2	4
Tucson	--	--	1	1
Total:	7	12	13	32

There was a good distribution of juniors and seniors with 12 juniors and 13 seniors. There were only 7 sophomores. Palo Verde High School was the only school represented in all three grade levels with a total of 14 girls. Rincon and Catalina High Schools were second with total girls, each having 5. Sahuaro High School was represented by 4 girls, Canyon Del Oro High School by 3 girls and Tucson High by 1 girl.

Because the subjects were high school students, it was believed the intelligence range would be fairly spread. As high school attendance is required, there should be a normal distribution of intelligence from the population.

When a sample is chosen randomly and believed to be a good representation of the total population, inferences can be made about the

population. This sample was not random, however, so no inferences can be made about the population.

The SSCRTA was designed for use by both right and left-handed subjects; however, only one girl in the sample was left-handed.

Choice Reaction Time Score

It was decided to increase the number of trials from 15 (as in the pre-study) to 25 per day to give the subjects more exposure to the apparatus. In both the pre-study and the present study, all testing was done on consecutive days. In the pre-study the subjects were tested for eight consecutive days with 15 trials per day, and learned the apparatus by the fifth day. With 25 trials per day, in the present study, the subjects learned the apparatus in three to four days.

In order to achieve the one score representing the performance of each subject, the investigator calculated the average (median) of the median scores for days three and four. This was done to get a more representative picture of each subject. If the best score had been taken, it may not have been representative of each subjects' normal or average. By averaging the third and fourth days some of the fluctuation that may have occurred on consecutive days was taken into account. It was believed that four days was a good test period for the subjects to learn the apparatus and for their choice reaction time score to be taken.

Administration of Choice Reaction Time Test

The testing was done in a specially designed laboratory. Upon arriving at the laboratory, each subject completed an information sheet,

a copy of which can be found in Appendix D. A number was assigned to each subject to aid compilation of the data. The information sheet requested the subject's name, address and phone number to permit contacting the subject regarding the written text. Also, each subject's school and grade were requested as well as their age and birthdate.

The coding on the bottom of the information sheet was MEDS1, MEDS2, etc., standing for median score day one, median score day two, etc. SSCRTS stood for the Stitt-Stough Choice Reaction Time Score which was the average of the median scores for the third and fourth days of each subject. TMAS stood for the Test of Mental Ability Score which was tested by the Otis-Lennon Mental Ability Test.

After completing the information sheet, each subject entered the testing room. The subject was seated at a table with the keyboard resting on the table before the subject. The indicator panel was placed approximately at the subject's eye level and three feet from the subject's eyes. The experimenter sat behind an adjacent table to the subject's right.

On the experimenter's table rested the control panel and the Dekan Automatic Performance Analyzer and the test sheet for that specific day. The Performance Analyzer was arranged in such a way that the subject could not see exactly what the experimenter was doing.

The subject was given a very brief explanation of the test. The subject was instructed to use her preferred hand on the keyboard with one finger resting lightly on each key. The subject could move or slant the keyboard for her comfort. The subject read the written directions, which can be found in Appendix D.

After the subject read the directions, she was instructed to place cotton in her ears and then to put on the earphones provided to prevent noise distractions and to aid in concentration. From the initiation of the test until its completion conversation was not permitted unless the subject had a question.

On day one the subject was given eight practices, two on each color, to become adjusted to the equipment. Following the eight practice trials, the 25 trials for day one were started immediately. On the following three days the subject started immediately on the test with no practice trials.

The experimenter followed the choices as listed on the test sheet for each specific day. The test sheet specified the color lighted, whether the toggle switch was in the top or bottom position and the delay position. Through a random selection method, 100 colors and their positions in the upper or lower section of the indicator panel were chosen in groups of 25. Through a random means, each of four sections (each containing 25 trials) was given a number of one through four representing the day they would be used for testing. Copies of the four sheets used in conducting the test can be found in Appendix D.

Following the completion of the test on day one, the subject was instructed not to discuss the test with anyone. After the completion of the entire test on day four, each subject was shown the control panel and the Dekan Automatic Performance Analyzer and given a brief explanation of its operation.

To determine by what day the subject had learned the apparatus (when a minimum of additional learning would take place), it was noted for each subject which day it was when the subject failed to improve their score on any of the succeeding days by more than .05 seconds. The percentage of subjects who learned the apparatus by each day is listed below.

Day 1 - 18.8%

Day 2 - 37.5%

Day 3 - 28.1%

Day 4 - 15.6%

Thus, 56.3% of the subjects had learned the apparatus by the completion of day two.

An important feature built into the SSCRTA was that the correct key must be depressed before the clock would stop. The subjects were encouraged to memorize the order of the keys and were almost always aware when they depressed the wrong key and corrected their response immediately. It would be possible to stop the clock by depressing all four keys simultaneously. Because this was a possibility, the experimenter watched the subjects closely but only had to stop one subject and explain that this was not the desired response.

Otis-Lennon Mental Ability Test--Description

The investigator examined many tests before deciding to use the Otis-Lennon Mental Ability Test. The reported reliability (Otis and Lennon 1967) (using approximately 36,000 subjects) of this test was

measured three ways: by the split-half method (.95, .95 and .96 for sophomores through seniors), the Kuder-Richardson method (.94, .95 and .95 for sophomores through seniors) and the alternate forms method (.94, .94 and .92 for sophomores through seniors).

The forty-minute test was designed with 80 questions of various types measuring verbal and nonverbal skills. The test manual (Otis and Lennon 1967), however, stated that the time limits were generous and allowed ample time for students to answer those items they are capable of answering.

"Emphasis is placed upon general abstract reasoning ability rather than performance reflecting speed" (Otis and Lennon 1967, p. 6). This feature was important since the correlation was made with choice reaction time. If a significant correlation existed, the explanation for the correlation should be the intelligence of the subjects, rather than how fast they took the test, or more correctly, how fast they could make decisions.

After the subjects finished the test, the investigator asked if they felt they had had enough time for the test. The results were as follows:

65.6% felt they had enough time

25.0% wanted three more minutes

9.4% wanted six more minutes

0.0% wanted more than six minutes

The OLMAT is scored in Deviation I.Q. units (DIQ). The DIQ is a normalized standard score with a mean of 100 and a standard deviation

of 16 points. The DIQ is an index of the student's relative brightness when compared to other pupils of a similar chronological age. Table 2 shows the expected percentages of scores for the test and those achieved by the subjects in this study.

Table 2. Expected and Achieved Percentages of Deviation IQ Scores.

Expected:	
	2% of subjects will obtain DIQ above 132
	14% of subjects will obtain DIQ between 116 and 132
	68% of subjects will obtain DIQ between 84 and 116
	14% of subjects will obtain DIQ between 68 and 84
	2% of subjects will obtain DIQ below 68
Achieved:	
	12.5% of subjects obtained DIQ above 132
	28.1% of subjects obtained DIQ between 116 and 132
	56.2% of subjects obtained DIQ between 84 and 116
	3.1% of subjects obtained DIQ between 68 and 84
	0.0% of subjects obtained DIQ below 68

For a DIQ of above 132 the expected value was 2%, but the achieved percent of the subjects in this study was 12.5%. For a DIQ of 116 to 132 the expected value was 14%, but the achieved percent was 28.1%. This was a clear indication that the distribution of scores of this group was clustered toward the higher intelligence end of the

distribution. Only 3.1% of the subjects achieved a DIQ more than one standard deviation below the mean when the expected value should have been 16%.

Since the sample was fairly small, it would not be expected that the percentages would be the same as those of a much larger sample. Assuming that the distribution of scores was normal, when a sample of approximately 30 is drawn they would be expected to cover only four standard deviations (Minium 1970); the sample in this study actually covered five standard deviations. Because the sample was not drawn randomly, it cannot be assumed that it would fit the normal curve for intelligence.

Otis-Lennon Mental Ability Test--Administration

The subjects were all sent letters regarding the time and place of the written test. In addition, they were sent a map showing the location of the test and possible parking areas. Copies of these can be found in Appendix E.

The testing occurred on two different days in a classroom of the Women's Physical Education Building at the University of Arizona. The test was administered by the investigator as directed by the Manual for Administration (Otis and Lennon 1967), and no problems were incurred. The subjects answered the questions in the test booklet, and the test booklets were scored by the experimenter using the key provided in the testing packet.

Treatment of the Data

For this experiment it was necessary to study the relationship between two variables, choice reaction time and intelligence; this statistical relationship is known as a correlation.

The correlation coefficient, signified by the letter "r," is a statistical measure indicating to what extent two events are related or to what extent variations in one event go with variations in the other event (Guilford 1965, Weinberg and Schumaker 1965). Its value is such as to indicate both direction (positive or negative) and the magnitude, or strength, of the relationship between two variables (Weinberg and Schumaker 1965).

To determine the correlation coefficient, the single figure representing the relationship of two variables, the Pearson Product-Moment (PPM) correlation, was chosen. This statistical technique was selected since the data fit the two assumptions of the PPM. Both choice reaction time scores and intelligence scores are considered interval data. The relationship of the distribution of scores was rectilinear. The scatter diagram method was used to determine the curvilinearity or rectilinearity of the data (Guilford 1965). As can be seen from Appendix F, a scatter diagram indicates that a rectilinear relationship existed between the choice reaction time scores and the DIQ scores.

At the completion of the choice reaction time and intelligence testing, the data were taken to the computer center at The University of Arizona where the PPM correlation was determined.

Summary

The chapter discussed the research procedures that served as a basis for the study. The Stitt-Stough Choice Reaction Time Apparatus was described as an apparatus which tests choice reaction time in conjunction with a Dekan Automatic Performance Analyzer. The apparatus had eight choices and used colored lights as the stimulus and microswitches as the response.

A pre-study was conducted to determine the learning curve for subjects using the apparatus. The main conclusions from this study were to use the median as the choice reaction time score and to test the subjects for four consecutive days.

The nonrandom sample consisted of 32 high school girls from six Tucson high schools. These subjects were tested in a specially designed laboratory. The complete testing procedures are listed in this chapter.

The Otis-Lennon Mental Ability Test was chosen as the most appropriate test for this study. Its reliability was particularly high. Emphasis of this test was the subjects' general abstract reasoning ability, rather than performance reflecting speed.

The data were statistically treated using the Pearson Product-Moment correlation. The correlation calculations were performed by the computer center at The University of Arizona.

CHAPTER IV

ANALYSIS OF DATA AND FINDINGS

In this chapter, the data for the subjects are presented and the Pearson Product-Moment correlation of the data is given. The meaning of the correlation is discussed along with the significance of the results.

Statement of the Problem

This study sought to discover the relationship between choice reaction time, as measured by the SSCRTA, and intelligence, as measured by the OLMAT, for high school girls.

Presentation of Data

To determine a correlation coefficient there must be two scores to correlate for each subject. The two scores in this study were the choice reaction time score and the intelligence score of each individual. Table 3 presents the choice reaction time score (the average of the third and fourth day median scores) for each subject. The scores ranged from .480 seconds to .805 seconds with a mean of .6277 seconds and a standard deviation of .0841 seconds for the 32 subjects. Table 4 presents the intelligence scores obtained by the subjects in Deviation IQ units for each subject. The scores ranged from 83 units to 145 DIQ units with a mean of 112.75 DIQ units and a standard deviation of 15.368 DIQ units.

Table 3. Choice Reaction Time Scores.

Subject Identification Number	Choice Reaction Time Score in Hundredths of a Second	Subject Identification Number	Choice Reaction Time Score in Hundredths of a Second
1	.755	17	.635
2	.700	18	.585
3	.750	19	.765
4	.560	20	.660
5	.590	21	.655
6	.660	22	.555
7	.585	23	.505
8	.665	24	.665
9	.570	25	.570
10	.670	26	.660
11	.525	27	.600
12	.525	28	.560
13	.805	29	.685
14	.520	30	.790
15	.630	31	.560
16	.645	32	.480

Table 4. Otis-Lennon Mental Ability Test.

Subject Identification Number	Deviation IQ Score	Subject Identification Number	Deviation IQ Score
1	85	17	104
2	95	18	99
3	103	19	124
4	113	20	109
5	83	21	112
6	125	22	119
7	117	23	145
8	136	24	113
9	118	25	113
10	104	26	97
11	116	27	134
12	121	28	124
13	118	29	112
14	112	30	90
15	106	31	144
16	90	32	127

The expected mean for the DIQ scores is 100 with a standard deviation of 16. The DIQ distribution of scores in this study is negatively skewed toward the lower intelligence end of the scale. Guilford (1965) stated the size of "r" is very much dependent upon the variability of measured values in the correlated sample. He stated that other things being equal, the greater the variability, the higher will be the correlation. The variability of the DIQ scores in this study is restricted; therefore, the correlation coefficient which was achieved may be smaller than if the variability had not been restricted.

Results of Analysis

The correlation coefficient in this study was determined by using the Pearson Product-Moment formula. The correlation coefficient obtained between choice reaction time, as measured by the SSCRTA, and intelligence, as measured by the OLMAT, was -.42.

The null hypothesis for this study was: the correlation coefficient obtained between scores of the OMLAT and the choice reaction time scores on the SSCRTA of high school girls will differ from zero only by chance. A correlation coefficient of .349 is required for significance at the .05 level. Therefore, with the achieved correlation of -.42, the null hypothesis was rejected. The relationship between choice reaction time and intelligence was significantly different from zero, indicating that some relationship existed between the two variables. The correlation coefficient was negative, signifying that as one variable increased in its magnitude, the other variable decreased in its magnitude.

Discussion of Results

A significant negative correlation was found between the scores of the OLMAT and the choice reaction time scores on the SSCRTA for high school girls.

The coefficient of determination, r^2, is the means of interpreting the correlation coefficient. The coefficient of determination expresses numerically the amount of variance in Y (for this experiment, SSCRT scores) that is shared with, or associated with, the variance in X (for this experiment, OLMAT scores). When $r = -.42$, the percentage of the variance that is shared by choice reaction time scores and intelligence scores is 17%. Therefore, in this sample 17% of the variance in choice reaction time was explained by intelligence.

The correlation coefficient obtained was significant in that it showed there was a relationship between choice reaction time and intelligence. However, the correlation would have to be higher before it would have great implications in science and athletics. One reason why this correlation was higher than most reported in the literature may be the complexity of the apparatus with eight choices and no direct spatial relationship. Because the data was clustered to the high intelligence end, however, the variability was restricted which might cause a lower correlation than actually exists.

Summary

The data were presented and the achieved coefficient of correlation was discussed. The results were interpreted using the

coefficient of determination and it was stated that the results were significant.

On the basis of the data, the null hypothesis of the correlation coefficient obtained between scores of the OLMAT and the scores of the SSCRTA of high school girls will differ from zero only by chance at the .05 level of significance was rejected. A significant negative relationship ($r = -.42$) existed between choice reaction time and intelligence. Using the coefficient of determination, it was found that 17% of the variance in choice reaction time was explained by the variance in intelligence. This means there was a commonality of variance of 17% between choice reaction time and intelligence. The significant correlation indicated that there was a relationship between choice reaction time and intelligence.

CHAPTER V

SUMMARY, MAJOR FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter briefly reviews the literature, outlines the organization of the study, reports the major findings and conclusions and presents recommendations for further study.

Summary

The present study sought to determine the relationship between choice reaction time, as measured by the Stitt-Stough Choice Reaction Time Apparatus (SSCRTA), and intelligence, as measured by the Otis-Lennon Mental Ability Test (OLMAT), for high school girls. The null hypothesis was that the correlation coefficient obtained between scores of the OLMAT and scores of the SSCRTA of high school girls will differ from zero only by chance at the .05 level of significance. The alternative hypothesis was that a significant correlation (at the .05 level of significance) would be found between the scores of the OLMAT and the choice reaction time scores on the SSCRTA for high school girls.

The review of the literature encompassed many areas. Laming (1968) explained choice reaction time as the time necessary to perceive one of a certain set of changes in the environment and the time necessary to decide upon and initiate the desired resulting action. The controversy over exactly what intelligence is was examined. Many

definitions were stated and for the purpose of this study intelligence was considered the subject's facility in reasoning and dealing abstractly with verbal, symbolic and figural test content.

Several studies have been completed correlating simple reaction time and intelligence. In 1926, Peak and Boring, conducted such a study and obtained a correlation of .90. Philip (1934), did a study with children and found correlations of 0.0 to .25 for girls and .36 to .42 for boys when correlating simple reaction time and intelligence.

Studies have been done in the area of choice reaction time and intelligence; however, the results are inconclusive and lack consistency. Lemmon (1927) using one hundred subjects found a correlation of .25 with intelligence and choice reaction time. Scott (1940) working with children found that the above average intelligence groups were faster in a choice reaction time test than the below average groups.

Many studies have been done with mentally retarded children, and the conclusion reached by Caffrey, Jones and Hinkle (1971) and other researchers is that normal children have faster choice reaction time scores than do the retarded children.

The conflicting results found in the literature may be due, in part, to four factors. The extreme difference in choice reaction time tests used, including equipment differences may be one factor. There is a great variability in the intelligence tests administered which may contribute to the conflicting conclusions. The studies done were not consistent in the ages and sex of their subjects. The studies reviewed

used groups of inconsistent intelligence ranges, some using just high IQ, or just low IQ, or high and low IQ subjects disregarding middle IQ subjects.

Based on equipment used in previous choice reaction time experiments, the Stitt-Stough Choice Reaction Time Apparatus was designed and constructed to measure choice reaction time with eight choices. It consisted of several pieces of equipment connected to a Dekan Automatic Performance Analyzer. The apparatus included an indicator panel, a keyboard and a control panel. The indicator panel had eight lights, of four colors, and a white ready-light. The keyboard was used for the response, with four micro-switches color coded to match the lights on the indicator panel. The appropriate key was depressed by the subject after one of the colored lights was flashed. The control panel enabled the experimenter to operate the indicator panel.

The subjects consisted of a nonrandom sample of 32 high school girls. They were tested on the SSCRTA for four consecutive days. Their choice reaction time score was calculated from the median scores of the third and fourth days. All of the subjects took the OLMAT and their Deviation IQ score was calculated.

The Pearson Product-Moment method of correlation was applied to the data to determine the correlation coefficient of choice reaction time and intelligence.

Major Findings

The Pearson Product-Moment correlation coefficient calculated for choice reaction time and intelligence for the 32 subjects was -.42.

The correlation was negative, signifying that as the magnitude of one variable increased, the magnitude of the other variable decreased. A test of significance at the .05 level was applied, and it was determined that the correlation between choice reaction time and intelligence in this study is significant. Therefore, the null hypothesis that the correlation coefficient between the scores of OLMAT and the scores of SSCRTA will differ from zero only by chance at the .05 level of significance was rejected. The significant negative correlation indicated that there was some relationship between choice reaction time and intelligence in this study. The research hypothesis that a signficant correlation (at the .05 level of significance) would be found between the scores of the OLMAT and the choice reaction time scores of the SSCRTA for high school girls was accepted.

A coefficient of determination was calculated at .17, indicating that 17% of the variance in choice reaction time score was shared by the variance in intelligence.

Conclusions

Based upon the data derived, with the limitations and design of this study, two generalized conclusions appear to be justified.

A relationship does exist between choice reaction time and intelligence. Although a cause-effect relationship cannot be claimed, choice reaction time is related to intelligence.

The factor of choice reaction time should be a consideration in physical education. Teachers should be aware of the relationship between choice reaction time and intelligence, particularly in those

sports where a quick choice reaction time is crucial. The possibility of grouping students in physical education classes on the basis of their intelligence should be examined.

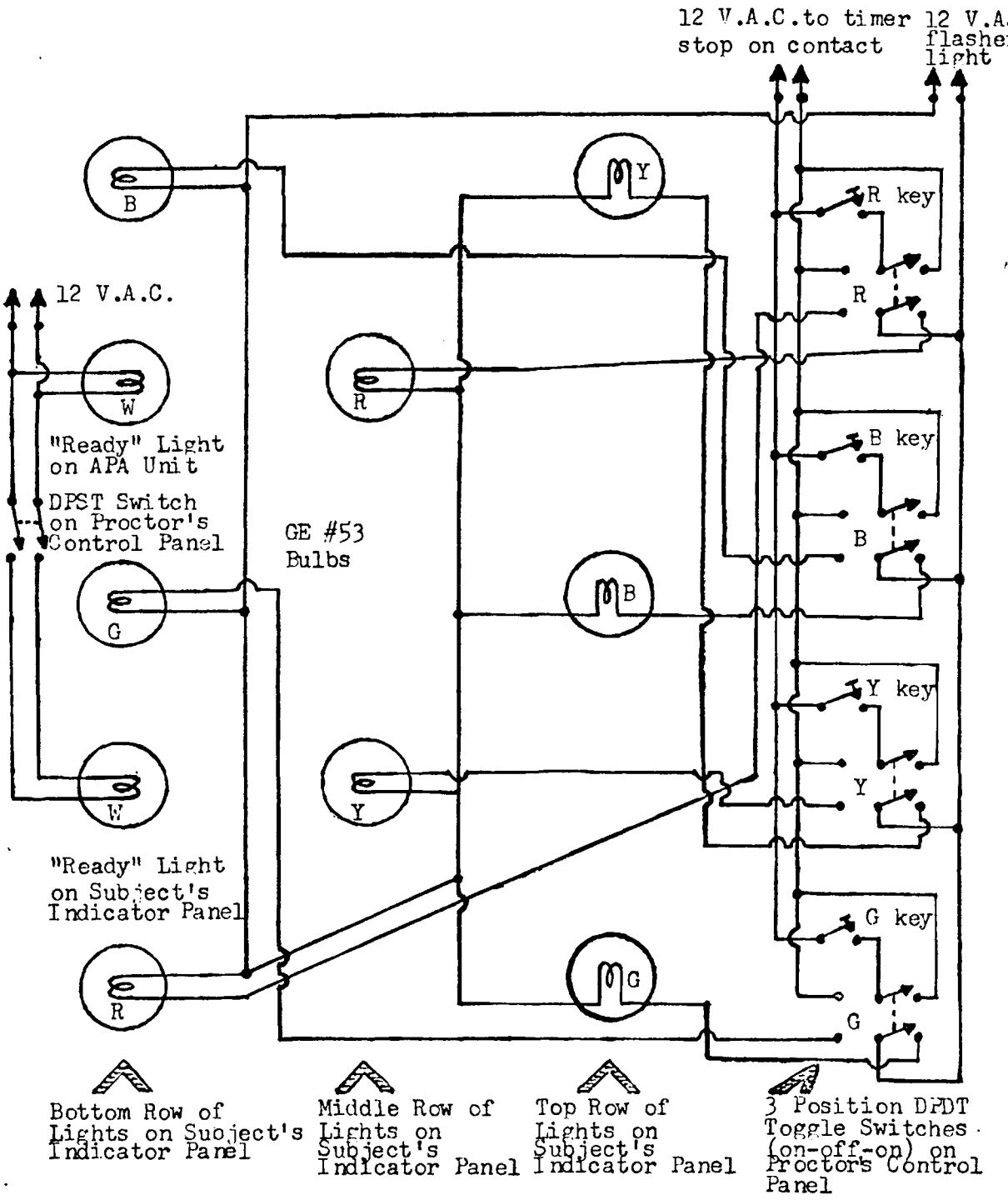
Recommendations

It is recommended that further testing be done regarding choice reaction time. First, the relationship between choice reaction time and simple reaction time should be determined. Second, the relationship between choice reaction time and the individual's ability to perceive stimuli should be examined. Third, it should be discovered what the relationship is between choice reaction time and an individual's rate of learning. Fourth, the relationship of choice reaction time between athletes and nonathletes should be determined.

The present study should be repeated using a larger random sample. Various age groups and both sexes should be tested.

APPENDIX A

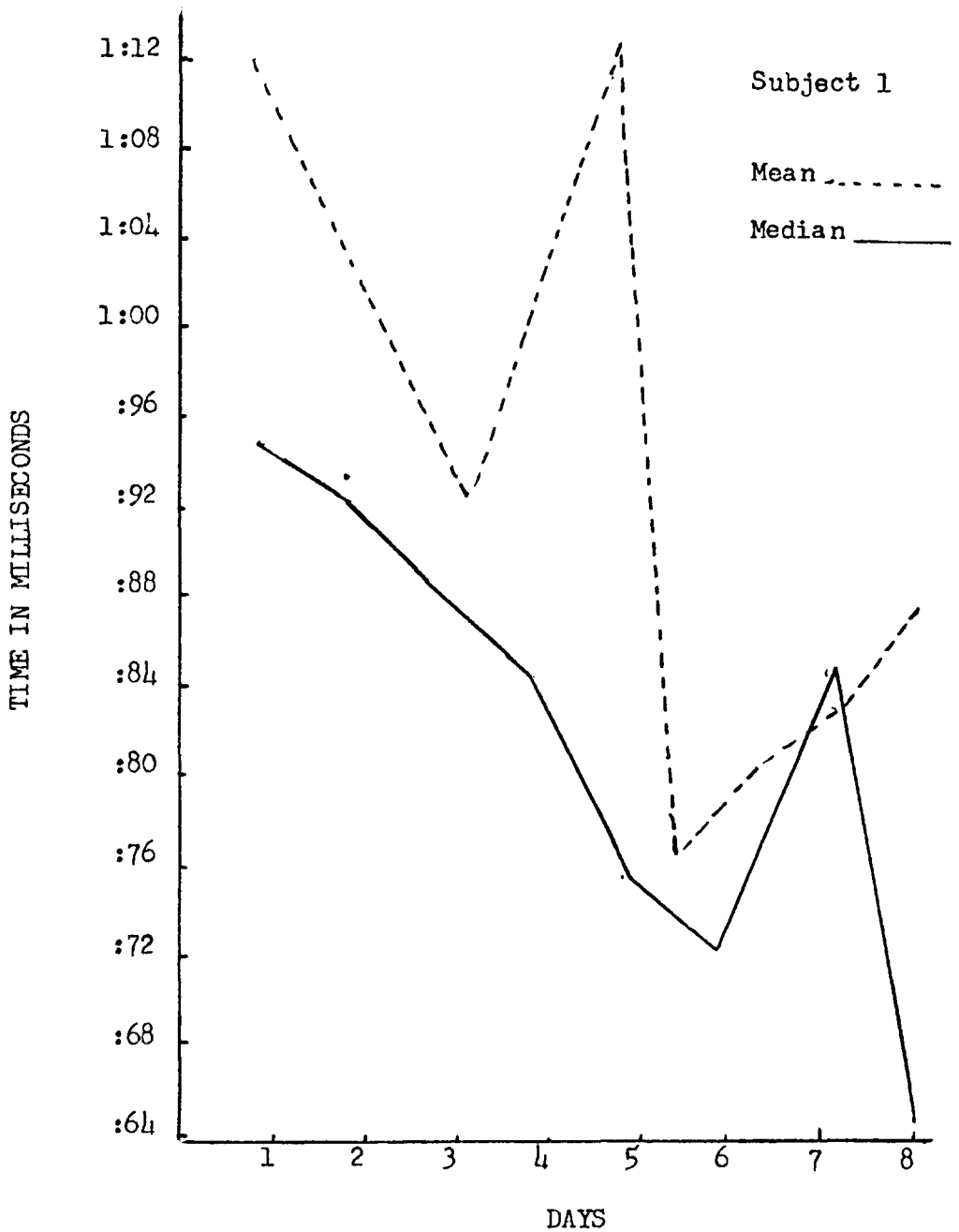
SCHEMATIC OF STITT-STOUGH CHOICE REACTION TIME APPARATUS

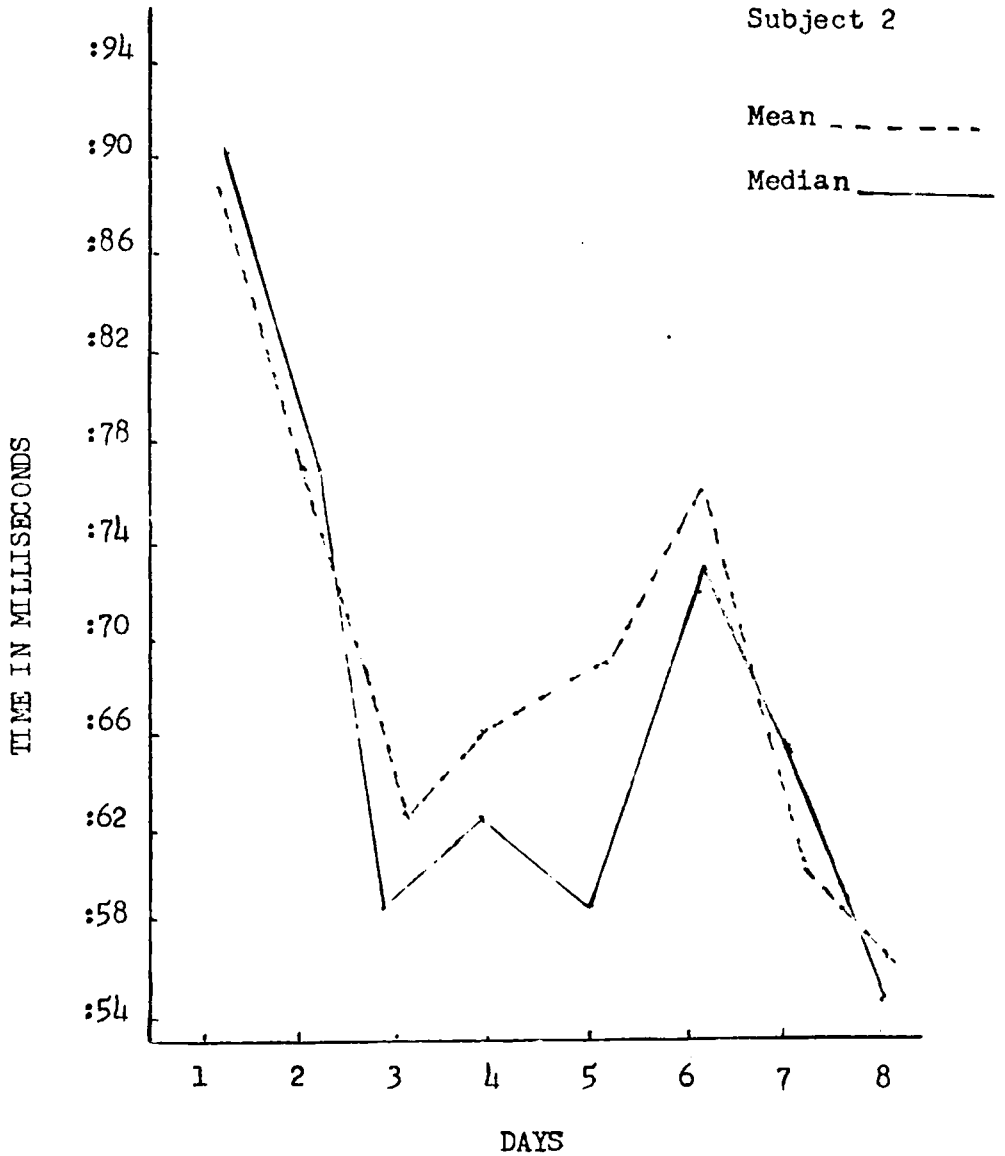

12 V.A.C.to timer stop on contact
12 V.A.C. flasher light
B
Y
R key
R
12 V.A.C.
W
R
B key
"Ready" Light on APA Unit
DPST Switch on Proctor's Control Panel
GE #53 Bulbs
B
G
Y key
W
Y
Y
"Ready" Light on Subject's Indicator Panel
G key
R
G
G
Bottom Row of Lights on Suoject's Indicator Panel
Middle Row of Lights on Subject's Indicator Panel
Top Row of Lights on Subject's Indicator Panel
3 Position DPDT Toggle Switches (on-off-on) on Proctor's Control Panel

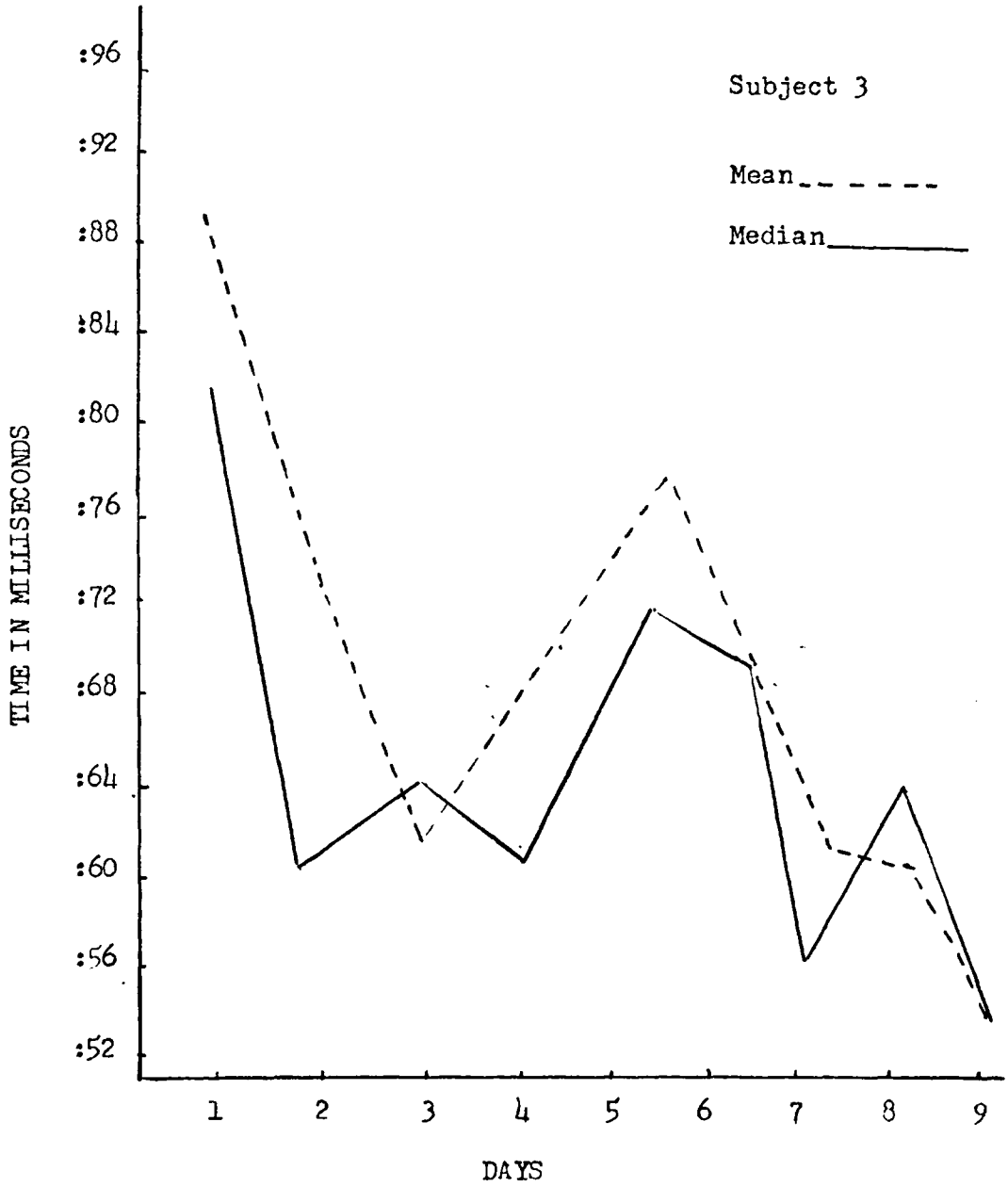
APPENDIX B

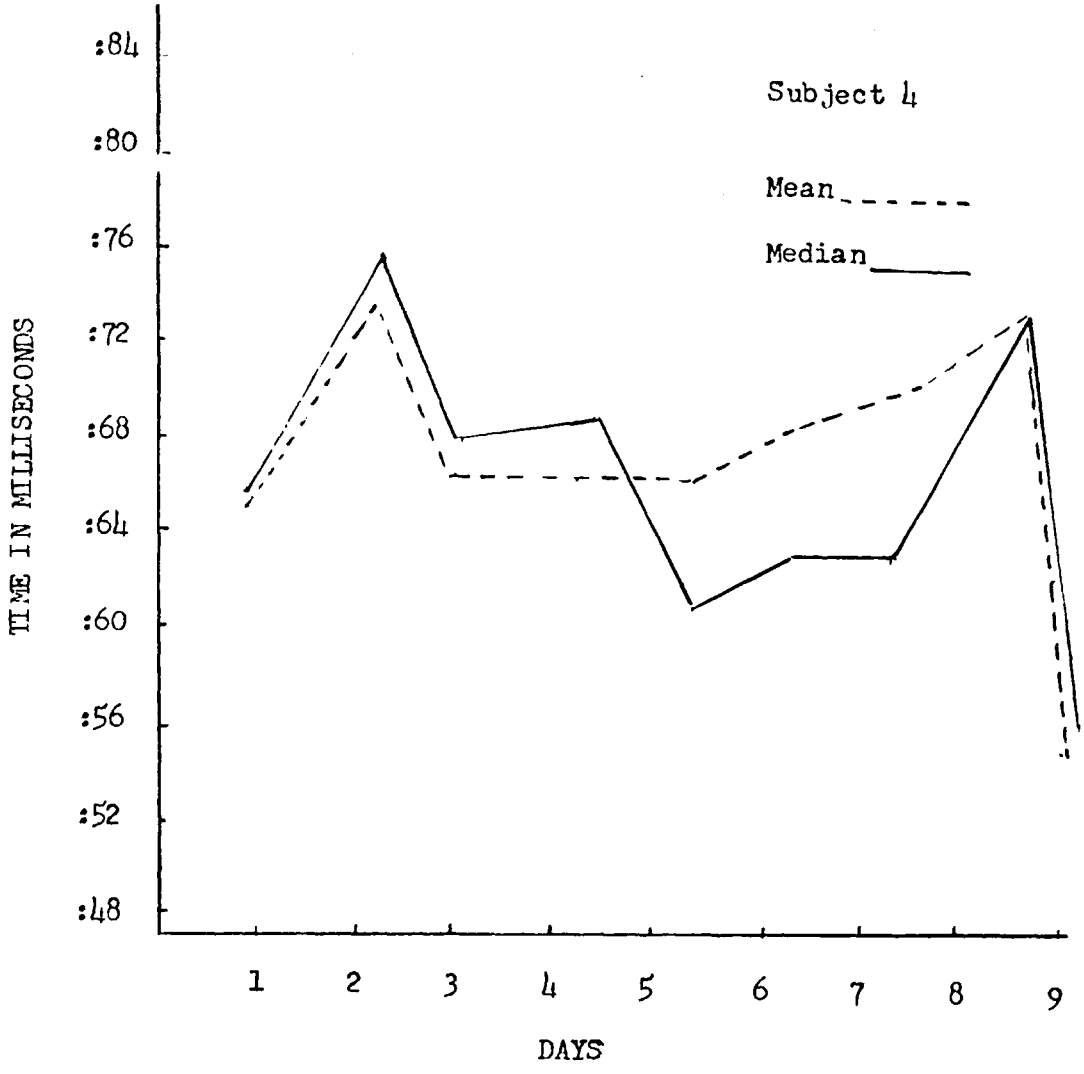
PRE-STUDY GRAPHS OF

MEDIAN AND MEAN SCORES


Subject 1
Mean
Median
TIME IN MILLISECONDS
1:12
1:08
1:04
1:00
:96
:92
:88
:84
:80
:76
:72
:68
:64
1
2
3
4
5
6
7
8
DAYS

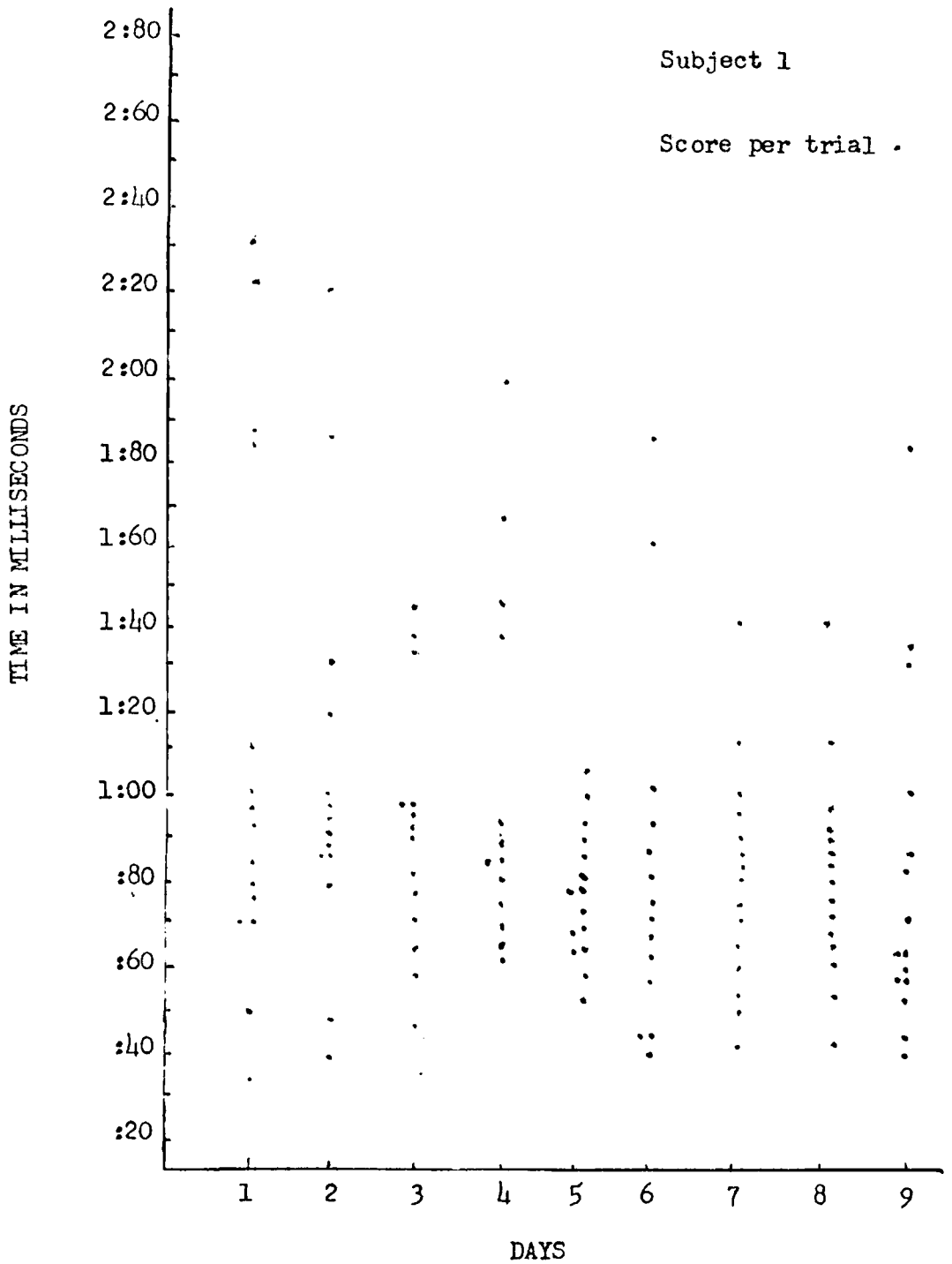

Subject 2
Mean
Median
:94
:90
:86
:82
:78
:74
:70
:66
:62
:58
:54
TIME IN MILLISECONDS
1
2
3
4
5
6
7
8
DAYS

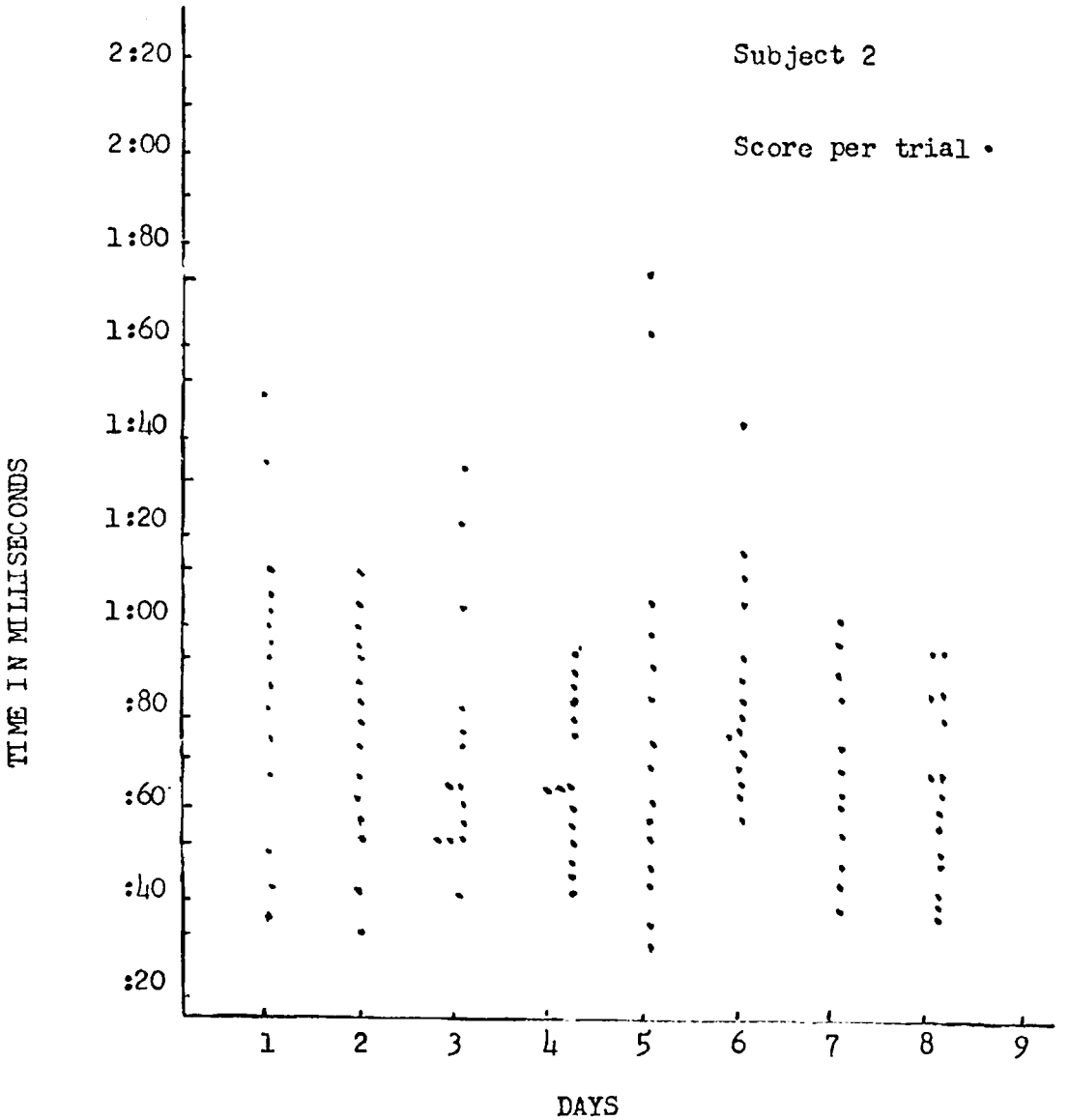

Subject 3
Mean
Median
:96
:92
:88
:84
:80
:76
:72
:68
:64
:60
:56
:52
TIME IN MILLISECONDS
1
2
3
4
5
6
7
8
9
DAYS

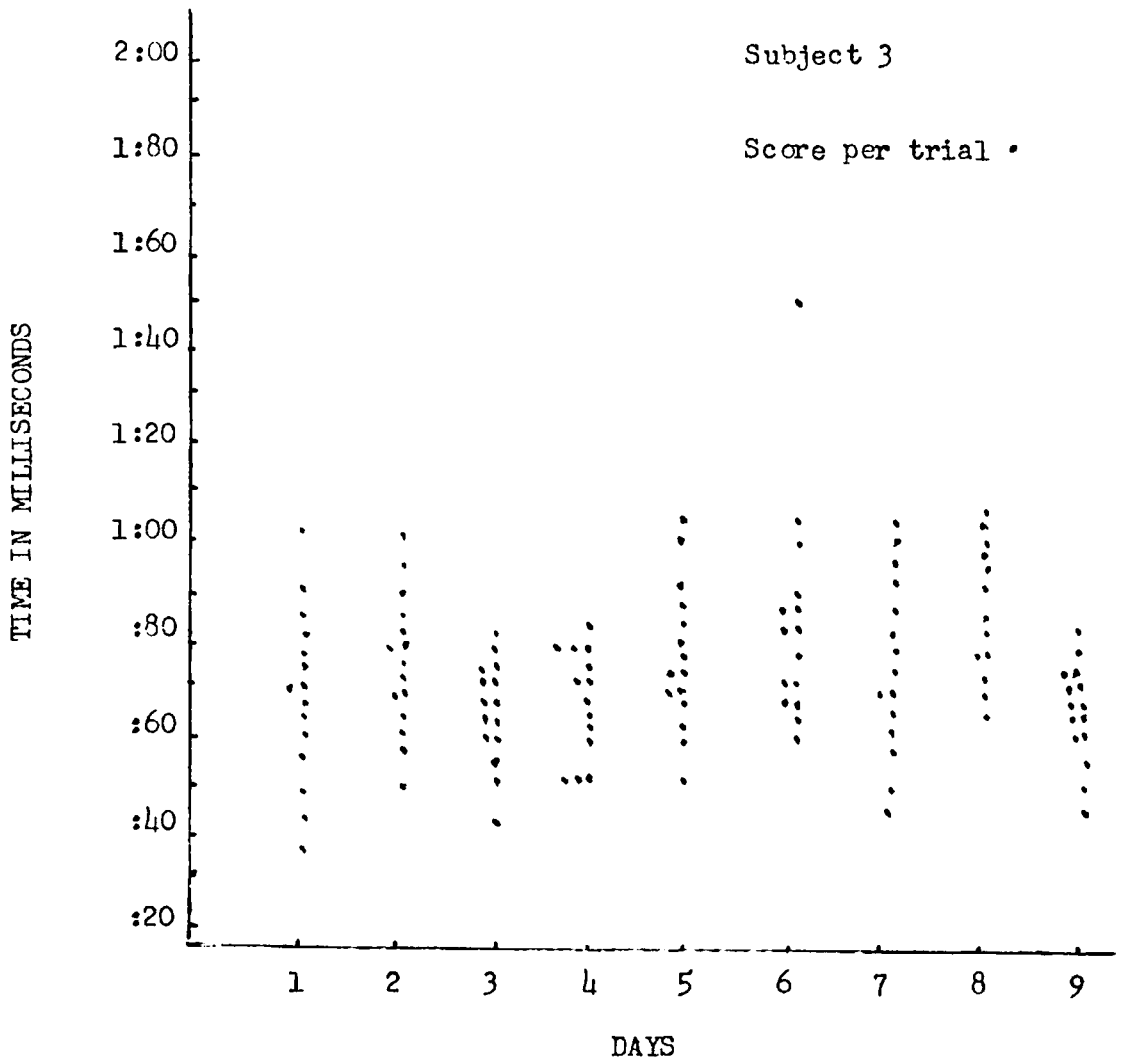

:84
:80
:76
:72
:68
:64
:60
:56
:52
:48
TIME IN MILLISECONDS
Subject 4
Mean
Median
1
2
3
4
5
6
7
8
9
DAYS

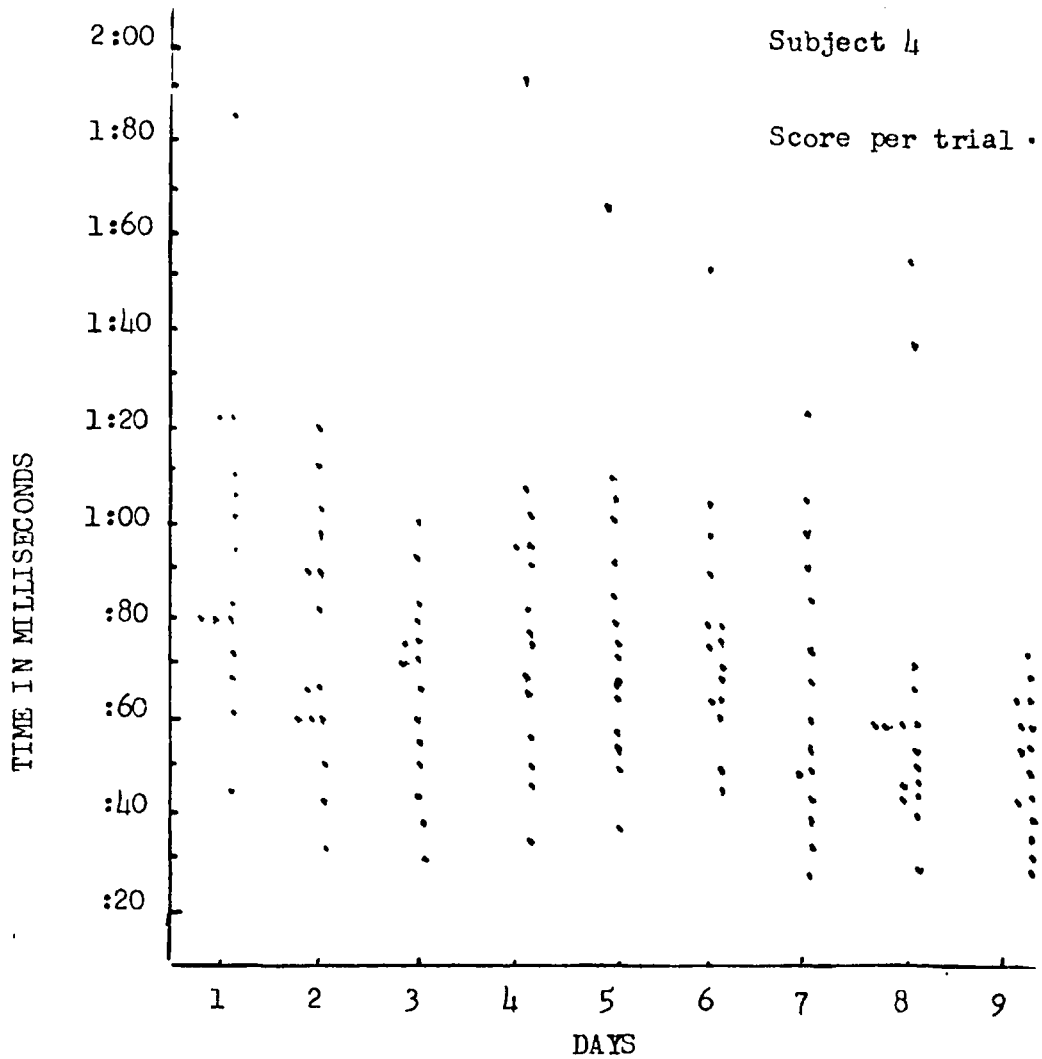
APPENDIX C

FREQUENCY OF SCORES


Subject 1
Score per trial .
TIME IN MILLISECONDS
2:80
2:60
2:40
2:20
2:00
1:80
1:60
1:40
1:20
1:00
:80
:60
:40
:20
1
2
3
4
5
6
7
8
9
DAYS


Subject 2
Score per trial •
TIME IN MILLISECONDS
2:20
2:00
1:80
1:60
1:40
1:20
1:00
:80
:60
:40
:20
1
2
3
4
5
6
7
8
9
DAYS


Subject 3
Score per trial •
TIME IN MILLISECONDS
2:00
1:80
1:60
1:40
1:20
1:00
:80
:60
:40
:20
1
2
3
4
5
6
7
8
9
DAYS


Subject 4
Score per trial
TIME IN MILLISECONDS
2:00
1:80
1:60
1:40
1:20
1:00
:80
:60
:40
:20
1
2
3
4
5
6
7
8
9
DAYS

APPENDIX D

TEST MATERIALS

Information Sheet

Number _____

(Please print clearly)

Name_____ Phone_____

Address_____

School_____ Grade_____

Birthdate_____ Age_____
(yrs.-months)

Do not write below this line

MEDS1_____ SSCRTS_____

MEDS2_____ TMAS_____

MEDS3_____

MEDS4_____ Number_____

Testing Procedure Directions

THE FOLLOWING ARE THE COMPLETE DIRECTIONS FOR THE TESTING PROCEDURE--PLEASE READ CAREFULLY. YOU ARE PARTICIPATING IN A VERY IMPORTANT EXPERIMENT WHICH NECESSITATES YOUR COMPLETE CONCENTRATION AT ALL TIMES.

On top of the light box is a white ready light; watch this instrument box carefully. After the white light flashes, one of the colored lights will flash. Depress the lever corresponding to the color of light that is flashed; only the lever corresponding to the color lighted should be depressed. The keys are color coded so be sure to use the correct finger on the proper key for the color of light flashed. If you know that you made an error, press the correct lever immediately. A soft click can be heard when the clock has stopped, signifying the correct key has been depressed.

There is a slight delay, different each time, between the ready light and the flash of the colored light. Memorize which keys go with which colors so it is not necessary to look at the keyboard before you respond. However, if you forget, you may look at the keyboard.

There will be eight practices, two on each color in the order of the keys: red, blue, yellow and green. The ready light will flash several times following the practices to start the twenty-five trials for today. There is about thirty seconds between responses.

DO YOU HAVE ANY QUESTIONS?

Daily Test Sheet

DAY 1 Number _____

Name_____

TRIAL	COLOR	POSITION	DELAY	SCORE
1	Y	B	1	
2	B	T	4	
3	Y	B	3	
4	B	B	3	
5	B	T	4	
6	B	T	4	
7	Y	B	2	
8	G	B	1	
9	B	B	4	
10	B	B	2	
11	B	T	3	
12	R	T	3	
13	B	B	3	
14	R	B	3	
15	B	T	2	
16	Y	T	1	
17	G	B	3	
18	R	B	3	
19	R	B	3	
20	G	T	2	
21	Y	B	4	
22	B	T	3	
23	Y	B	3	
24	G	B	1	
25	R	T	1	

Mean for Red_____; Blue_____; Yellow_____; Green_____

Median:_____ Mean:_____

Daily Test Sheet

DAY 2 Number_____

Name_____

TRIAL	COLOR	POSITION	DELAY	SCORE
1	R	T	3	
2	Y	T	4	
3	Y	B	3	
4	B	B	2	
5	B	B	4	
6	Y	T	3	
7	B	B	1	
8	R	B	4	
9	B	B	2	
10	R	B	4	
11	R	T	2	
12	Y	B	2	
13	G	T	3	
14	Y	B	3	
15	B	B	4	
16	B	T	3	
17	Y	B	2	
18	R	T	3	
19	B	B	3	
20	Y	B	4	
21	R	B	3	
22	R	B	3	
23	Y	B	3	
24	G	T	4	
25	R	B	3	

Mean for Red_____; Blue_____; Yellow_____: Green_____

Median:_____Mean:_____

Daily Test Sheet

DAY 3 Number_____

Name_____

TRIAL	COLOR	POSITION	DELAY	SCORE
1	R	B	3	
2	B	B	1	
3	G	B	1	
4	G	T	2	
5	B	B	3	
6	R	T	3	
7	R	T	2	
8	R	B	1	
9	G	R	1	
10	G	B	2	
11	Y	B	1	
12	Y	B	3	
13	B	B	1	
14	B	T	3	
15	R	T	2	
16	R	T	3	
17	R	T	2	
18	Y	T	1	
19	G	T	1	
20	Y	T	3	
21	R	B	2	
22	Y	T	1	
23	B	B	4	
24	R	T	4	
25	G	B	3	

Mean for Red_____; Blue_____; Yellow_____; Green_____

Median:_____Mean:_____

Daily Test Sheet

DAY 4 Number_____

Name_____

TRIAL	COLOR	POSITION	DELAY	SCORE
1	R	T	4	
2	Y	T	2	
3	G	B	4	
4	R	T	4	
5	Y	B	2	
6	Y	B	4	
7	Y	T	3	
8	G	T	2	
9	R	B	2	
10	B	B	3	
11	B	T	3	
12	G	B	1	
13	R	B	3	
14	Y	B	1	
15	B	T	1	
16	R	B	1	
17	R	T	4	
18	B	B	3	
19	Y	B	1	
20	R	B	1	
21	R	B	4	
22	Y	B	3	
23	G	B	3	
24	Y	B	2	
25	R	B	1	

Mean for Red_____; Blue_____; Yellow_____; Green_____

Median:_____Mean:_____

APPENDIX E

LETTER AND MAP REGARDING WRITTEN TEST

7051 E. Rosewood
Tucson, Arizona 85710
April 17, 1972

Dear

Your participation in the current experiment is greatly appreciated. One more task is required to complete the study--the written test I mentioned.

Two testing times have been scheduled for the test to enable you to choose one that is most convenient for you. The first test period is Saturday, April 22 at 2:00 p.m., the second, Monday, April 24 at 7:30 p.m. It will take approximately 40 minutes to complete the test. The test will be administered at the University of Arizona in the Women's Physical Education Building, Room 201. For directions to the building, see the enclosed diagram.

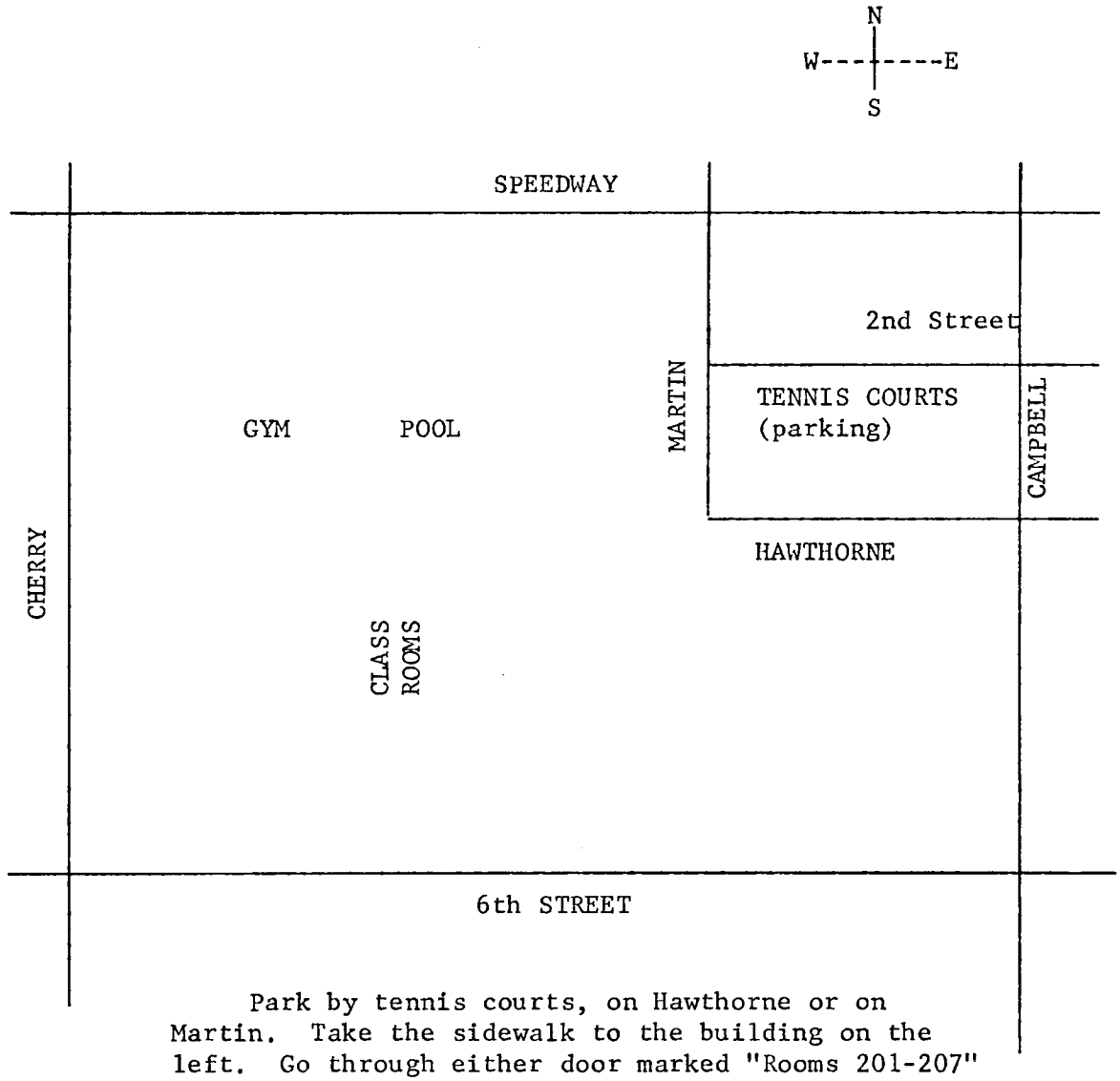
I will call you on Friday, April 21 to find which day you plan to come for the test. Since a minimum number of subjects are participating in the experiment, it is very important for everyone to complete the second task. Both tasks, the choice reaction time test and the written test, must be completed for me to include you in the study.

Which ever session you choose to attend, please try to arrive several minutes early, so the test administration can start on time. See you for the written test!

Again, thank you for your help.

Cordially yours,

Barb Stitt

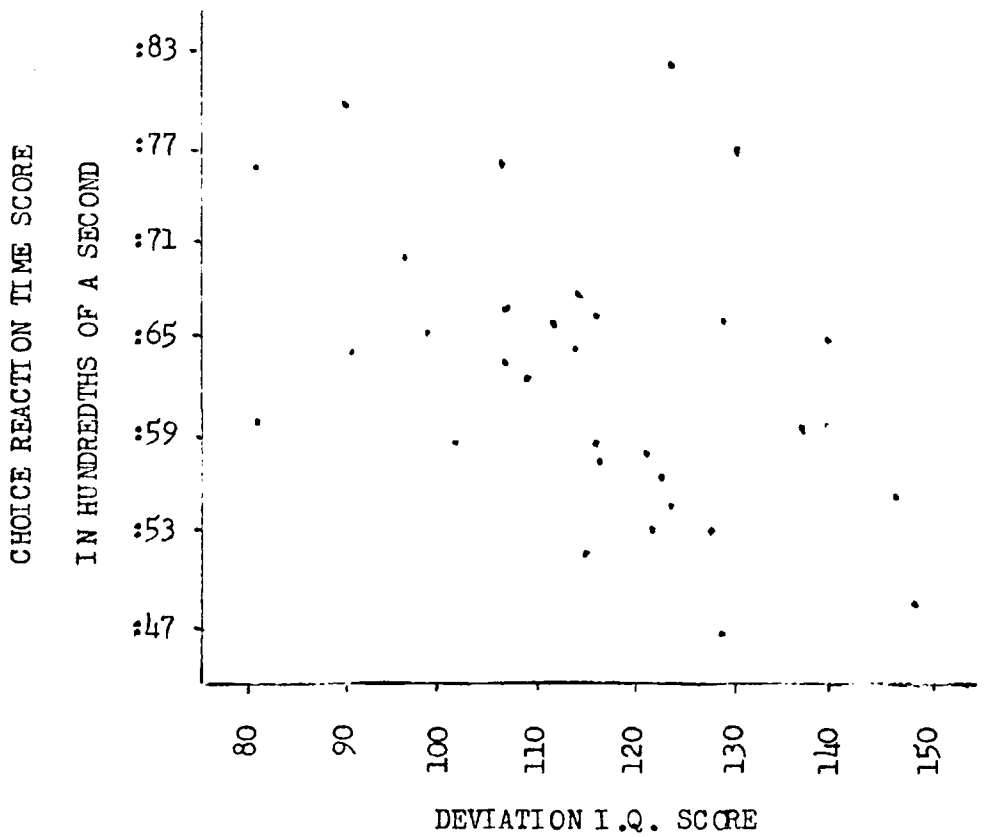


Park by tennis courts, on Hawthorne or on Martin. Take the sidewalk to the building on the left. Go through either door marked "Rooms 201-207" and go up the stairs. Walk to the south end of the building to Room 201.

APPENDIX F

SCATTER DIAGRAM OF CHOICE REACTION TIME

AND INTELLIGENCE SCORES



REFERENCES

Alegria, Jesus and Paul Bertelson. "Time Uncertainty, Number of Alternatives and Particular Signal-Response Pair as Determinants of Choice Reaction Time," Acta Psychologica, Vol. 33, III, 36-44, 1970.

Beck, L. F. "Relation of Speed of Reaction to Intelligence," American Journal of Psychology, Vol. 44, 793-795, 1932.

Bernard, Harold W. and Wesley C. Huckins. Readings in Educational Psychology. New York: The World Publishing Company, 1967.

Caffrey, Bernard, Judith D. Jones and Barbara R. Hinkle. "Variability in Reaction Times of Normal and Educable Mentally Retarded Children," Perceptual and Motor Skills, Vol. 32, 255-258, 1971.

Craft, John L. and J. Richard Simon. "Processing Symbolic Information from a Visual Display: Interference from an Irrelevant Directional Cue," Journal of Experimental Psychology, Vol. 83, No.3, 415-420, 1970.

deVries, Herbert A. Physiology of Exercise. Dubuque, Iowa: Wm. C. Brown Company Publishers, 1966.

Dingman, Harvey F. and Arthur B. Silverstein. "Intelligence, Motor Disabilities and Reaction Time in the Mentally Retarded," Perceptual and Motor Skills, Vol. 19, 791-794, 1964.

Ellis, Norman R. and William Sloan. "Relationship Between Intelligence and Simple Reaction Time in Mental Defectives," Perceptual and Motor Skills, Vol. 7, 65-67, June 1957.

Goodenough, F. L. "Development of the Reactive Processes from Early Childhood to Maturity," Journal of Experimental Psychology, Vol. 18, 431-450, 1935.

Guilford, J. P. Fundamental Statistics in Psychology and Education. New York: McGraw-Hill Book Company, 1965.

Guilford, J. P. The Nature of Human Intelligence. New York: McGraw-Hill Book Company, 1967.

Hunt, J. McVicker. Human Intelligence. Camden, N.J.: E. P. Dutton and Company, 1972.

Laming, D. R. J. Information Theory of Choice Reaction Times. London and New York: Academic Press, 1968.

Lanier, Lyle H. "Interrelations of Speed of Reaction Measurements," Journal of Experimental Psychology, Vol. 17, 371-399, 1934.

Lemmon, Vernon W. "The Relation of Reaction Time to Measures of Intelligence, Memory and Learning," Archives of Psychology, 1-35, November 1927.

Minium, Edward E. Statistical Reasoning in Psychology and Education. New York: John Wiley and Sons, Inc., 1970.

Mowbray, G. H. "Choice Reaction Times for Skilled Responses," Quarterly Journal of Experimental Psychology, Vol. 12, Part 4, 193-202, 1960.

Mulhern, Thomas and Alfred A. Baumeister. "Effects of Stimulus-Response Compatibility and Complexity upon Reaction Times of Normals and Retardates," Journal of Comparative and Physiological Psychology, Vol. 75, No. 3, 459-463, 1971.

Otis, Arthur S. and Roger T. Lennon. Manual for Administration. New York: Harcourt, Brace and World, Inc., 1967.

Peak, Helen and Edwin G. Boring. "The Factor of Speed in Intelligence," Journal of Experimental Psychology, Vol. 9, No. 2, 71-94, April 1926.

Philip, D. B. "Reaction Time of Children," American Journal of Psychology, Vol. 46, 379-396, 1934.

Reger, Roger. "Myths About Intelligence," Psychology in the Schools, Vol. 3, 39-44, January 1966.

Scott, Winifred Starbuck. "Reaction Times of Young Intellectual Deviates," Archives of Psychology, Vol. 36, No. 256, 1-64, July 1940.

Seibel, Robert. "Discrimination Reaction Time for a 1,023 Alternative Task," Journal of Experimental Psychology, Vol. 66, 215-226, 1963.

Simon, J. Richard and John L. Craft. "Effects of Altered Display-Control Relationships on Information Processing from a Visual Display," Journal of Applied Psychology, Vol. 54, No. 3, 253-257, 1970.

Smith, Edward E. "Choice Reaction Time: An Analysis of the Major Theoretical Positions," Psychological Bulletin, Vol. 69, No. 2, 77-110, February 1968.

Snodgrass, Joan Gay and R. Duncan Luce. "Some Experiments on Simple and Choice Reaction Time," Journal of Experimental Psychology, Vol. 75, No. 1, 1-4, September 1967.

Sommers, Paul A. and Lee M. Joiner. "Reaction Time, Agility, Equilibrium, and Kinesio-Perceptual Matching as Predictors of Intelligence," Perceptual and Motor Skills, Vol. 31, 460-462, October 1970.

Tyler, Leona E. Intelligence: Some Recurring Issues. New York: Van Nostrand Reinhold Company, 1969.

Weinberg, George H. and John A. Schumaker. Statistics:an Intuitive Approach. Van Nuys, California: Wadsworth Publishing Company, Inc., 1965.