A COMPARISON OF FENCERS AND NONFENCERS BY CERTAIN PSYCHOMOTOR, SPACE PERCEPTION, AND ANTHROPOMETRIC MEASURES

Thesis for the Degree of M. A.

MICHIGAN STATE COLLEGE

William Russell Pierson

1953

This is to certify that the

thesis entitled

"A Comparison of Fencers and Nonfencers by Certain Psychomotor, Space Perception and Anthropometric Measures"

presented by

William Russell Pierson

has been accepted towards fulfillment of the requirements for

MA. degree in Physical Education

Henry J. Montoye

Major professor

Date May 25, 1953

J — 2066

OCT 24 79 R

NOV 29 R

JUL 25 79 R

4 80 007

R [illegible] 72

NF 049

FEB 18 80

K 27 80 087

A COMPARISON OF FENCERS AND NONFENCERS BY CERTAIN PSYCHOMOTOR, SPACE PERCEPTION, AND ANTHROPOMETRIC MEASURES

By

William Russell Pierson

A THESIS

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

MASTER OF ARTS

Department of Physical Education, Health, and Recreation for Men

1953

ACKNOWLEDGMENTS

To the following persons, whose cooperation and guidance have made this study possible, the experimenter wishes to express his gratitude: Dr. Henry Montoye, Mr. Charles R. Schmitter, and other members of the Physical Education Staff of Michigan State College; Dr. L. L. Thurstone, of the University of North Carolina; Mr. Bela deTuscan, of the Salle deTuscan; Mr. Richard Berry, Michigan A.F.L.A. and Western Conference fencing champion; Mr. William H. Pierson, who did the photography; the subjects, who frequently inconvenienced themselves in the interests of the study; and Ann, David, and Susan, who must at times have felt themselves bereft of husband and father.

W.R.P.

TABLE OF CONTENTS

CHAPTER		Page
I.	INTRODUCTION	1
	Statement of the Problem	2
	Purpose of the Study	2
	Need for the Study	3
	Definitions of Terms Used	5
	Nonfencer	5
	Fencer	5
	Movement time	5
	Finger-press reaction time	5
	Movement-reaction	6
	Discrimination and choice movement-reaction time	6
	Discriminatory reaction	6
	Serial reaction	7
	Space perception	7
	Unknown 1	8
	Unknown 2	8
	Unknown 3	8

CHAPTER Page

Limitations of the Study 8

II. GENERAL EXPERIMENTAL PROCEDURE 10

Testing Environment 10

The Apparatus 11

The stimulus unit 11

The response unit 12

The control unit 14

Recording unit with stimulus-producing mechanism 14

The Subjects 16

Organization and Analysis 18

III. REVIEW OF THE LITERATURE 20

Literature on Fencing 22

Psychomotor Activities Literature 29

Serial action tests 38

Primary abilities in visual thinking 39

Literature on Anthropometry 41

Related Studies 42

Summary 49

IV. RESULTS 51

The Psychomotor Measures 51

CHAPTER Page

Movement 52

Movement reaction 52

Discrimination and choice movement reaction 53

Finger-press reaction 53

Discriminatory reaction 54

McCloy "Blocks Test" 54

Thurstone "S" test 57

The "Unknowns" 57

Summary 58

The Anthropometric Measures 60

Summary 66

Further Analysis of the Data 66

Discussion of Results 68

V. SUMMARY AND CONCLUSIONS 71

Summary 71

Conclusions 71

Recommendations 73

BIBLIOGRAPHY 75

APPENDIXES 84

LIST OF TABLES

TABLE		Page
I.	Significance of F and "t" for Psychomotor Scores	58
II.	Significance of F and "t" for Anthropometric Measurements	64
III.	Intercorrelations	67
IV.	Raw Scores for Fencer Group	94
V.	Raw Scores for Nonfencer Group	95
VI.	Computational Data	96
VII.	Sequence for Presentation of Stimuli	98

LIST OF FIGURES

FIGURE		Page
1.	Distribution of Apparatus	12
2.	Mean Scores of Psychomotor Measures	52
3.	Mean Scores of Anthropometric Measures	65
4.	Measures of Significance	69
5.	Circuit Diagrams of the Apparatus	86
6.	Learning Curves	87

LIST OF ILLUSTRATIONS

ILLUSTRATION		Page
1.	The Stimulus and Response Units	13
2.	Recording Unit With Stimulus-Producing Mechanism	15
3.	The McCloy "Blocks Test"	56
4.	Testing With the McCloy "Blocks Test"	57
5.	Method of Measuring Standing Height	61
6.	Method of Measuring Sitting Height	61
7.	Method of Measuring Chest Width	63
8.	Method of Measuring Arm Span	63
9.	Method of Measuring Hand Width	63

CHAPTER I

INTRODUCTION

It has long been a common belief that one must possess certain attributes in order to become a successful fencer. Furthermore, most authors of fencing texts cite certain benefits, both physiological and psychological, to be gained by participation in the sport. Although there is little agreement as to the identity of these benefits and attributes, among those most cited are fast reactions, quickness of bodily movement, and the ability to make rapid correct judgments. Certain physiques have also been named as being a definite factor in the achievement of success: tall, thin persons or those having long arms usually being the ones enjoying the supposed advantage.[1] The majority of these contentions has been based on limited observations and in no instance have experimental or statistical data been used to support a claim.

---

[1] Elmer D. Mitchell, ed., Sports for Recreation (New York: A. S. Barnes and Company, 1936), p. 135.

Statement of the Problem

The principal question to be answered in this investigation was, "Do fencers and nonfencers differ in speed of arm movement, space perception, the ability to make rapid correct judgments, and certain reaction and anthropometric measures?" Secondary problems of the study were: (1) intercorrelations of some of the tests, (2) comparison of the data with previous experimentation along similar lines, and (3) comparisons with previously established norms wherever possible.

Purpose of the Study

It was the purpose of this study to identify and investigate the differences, if any, which exist between fencers and nonfencers as a step toward placing the sport on a more scientific basis and to validate or repudiate certain popularly held concepts concerning these differences. A secondary purpose was the establishment of procedures which could be used in measuring the psychomotor effects of participation in other sports.

Need for the Study

Fencing as an intercollegiate sport has increased considerably in the past twenty years.[2,3] In 1933, the Intercollegiate Fencing Association consisted of fifteen schools; in 1952, thirty-seven schools were in the N.C.A.A. tournament and 140 schools were listed as having fencing on an intramural or interscholastic basis.

Fencing is a sport in which the basic skills of running, throwing, or jumping are not utilized;[4] therefore it is essential that much time be spent in the learning of fundamentals.[5,6,7,8,9] It is

---

[2] Julio M. Castello, The Theory and Practice of Fencing (New York: Charles Scribner's Sons, 1933), p. 10.

[3] Personal communication with Charles R. Schmitter, president of the National Collegiate Fencing Coaches Association, 1951.

[4] Scott D. Breckinridge and Scott D. Breckinridge, Jr., Sword Play (New York: A. S. Barnes and Company, 1941), p. 6.

[5] Ibid., p. 7.

[6] Luigi Barbasetti, The Art of the Sabre and the Epee (New York: E. P. Dutton and Company, 1936), p. 6.

[7] Castello, op. cit., pp. 14, 24.

[8] Clovis Deladrier, Modern Fencing (Annapolis, Maryland: United States Naval Institute, 1948), pp. xv, 58.

[9] Aldo Nadi, On Fencing (New York: G. P. Putnam's Sons, 1943), p. 231.

customary for the collegiate fencer to have at least one semester of fundamental training before engaging in varsity competition, and training continues throughout his college career.

Coaches have long felt the inadequacy of present methods for selecting team candidates with the greatest potential as well as for the determination of the candidate with little or no possibility for success. The former is necessary in producing successful teams and the latter is important in advising the candidate so that he might select a sport in which he would have less chance for failure.[10,11]

Before a predictive battery can be established it must first be determined whether or not differences do exist between fencers and nonfencers. If there are differences, it must next be determined if these are inherent or are the results of training in the sport.

---

[10] Fred D. Sheffield, "Spread of Effect Without Reward or Learning," Journal of Experimental Psychology, XXXIX (August, 1949), pp. 575-579.

[11] Carnie H. Smith, "Influence of Athletic Success and Failure on the Level of Aspiration," The Research Quarterly, XX (May, 1949), pp. 196-208.

Definitions of Terms Used

Nonfencer. For the purposes of this study, a nonfencer is one who has never fenced nor had fencing lessons.

Fencer. A fencer is one who is either a member of an organized fencing team or has been classified as a Junior by the Amateur Fencers League of America.

Movement time (M). Movement time is that measured interval of time taken to move the dominant hand forward eleven inches. No external stimulas is applied.

Finger-press reaction time (a-reaction).[12] Bills states that a simple reaction consists of a single constant response to a single constant stimulus.[13] For the purposes of this study, the time

---

[12] Cf. post. For a more detailed and explicit definition of finger-press reaction, as well as for movement-reaction, discrimination and choice movement-reaction, and discriminatory reaction, refer to the description of the recording unit of the apparatus on pp. 12 to 14.

[13] Arthur G. Bills, General Experimental Psychology (New York: Longmans, Green and Company, 1934), p. 401.

elapsing between the introduction of the stimulus and the completion of the response is defined as reaction time.[14]

Movement-reaction (M-reaction). Movement-reaction is similar to Movement, with the exception of an external stimulus. Time from the introduction of the stimulus to the completion of the response may be defined as movement–reaction time.

Discrimination and choice movement reaction time (b'-reaction). If a subject is given a choice of two responses (correct choice dependent upon the stimulus), the interval between the introduction of the stimulus and the completion of the response is the b'-reaction time.

Discriminatory reaction (c-reaction). Whereas choice reaction involves complexity on the response side, discriminatory reaction assumes a variety in the stimulus.[15,16] The interval between

---

[14] Normand L. Hoerr and others, eds., Blakiston's Pocket Medical Dictionary (New York: The Blakiston Company, 1952), p. 613.

[15] Bills, loc. cit.

[16] James Drever, A Dictionary of Psychology (Harmodsworth, England, 1952), p. 68.

the introduction of a designated stimulus and the completion of response is the c-reaction time.

Serial reaction. In serial reaction tests, the response to stimulus determines the following stimulus and so continues to the completion of the test. The attention of the individual has only one stimulus which must be acted upon before any further steps can be taken.[17]

Space perception (S). Space perception is the ability to identify objects in space or the vizualization of spatial relationships.[18,19,20,21] The ability to recognize a rigid object when seen from different angles, designated S_1 by Thurstone,[22] is the space factor with which this study was concerned.

---

[17] C. F. Hanson, "Serial Action as a Basic Measure of Motor Ability," Psychological Monograph No. 31 (1922).

[18] L. L. Thurstone, "Some Primary Abilities in Visual Thinking," University of Chicago Psychometric Laboratory Reports, No. 59 (August, 1950), pp. 1-3.

[19] C. H. McCloy, "A Preliminary Study of Factors in Motor Educability," The Research Quarterly, XI (May, 1940), p. 32.

[20] Drever, op. cit., p. 273.

[21] Harvey A. Carr, An Introduction to Space Perception (New York: Longmans, Green and Company, 1935), 413 pp.

[22] Thurstone, op. cit., p. 2.

Unknown 1 (u-1). The difference between Movement time and Movement-reaction time is a factor designated "u-1."

Unknown 2 (u-2). The difference between Movement-reaction time and discrimination and choice movement-reaction time is the factor "u-2."

Unknown 3 (u-3). The difference between discriminatory reaction time and reaction time as measured by the finger-press is designated "u-3."

Limitations of the Study

The subjects were college men between the ages of eighteen and twenty-seven, twenty-five of whom were fencers and twenty-five, nonfencers. Differences which were not significant with this number might have been, were the number of subjects greater. Further, thirteen of the nonfencer group had earned athletic awards while in high school. The differences might have been greater, were the entire group composed of those who had not earned any athletic award.

Because sixteen items were measured for each subject and a priori knowledge of these items was lacking, it is possible that one of these items may show significance due to chance alone.

Many areas in which differences might occur were not investigated, because of the lack of time and the difficulty of arranging more than one testing period for most of the subjects, especially those of the fencer group. Those areas which were not covered include movement and reaction of the legs, tests of kinesthesis, personality tests, and tests of visual thinking such as the speed of perceptual closure.

CHAPTER II

GENERAL EXPERIMENTAL PROCEDURE

Testing Environment

All subjects were tested in either the Sports Research Laboratory of Michigan State College or the Salle DeTuscan of Detroit, Michigan. The testing in both instances was conducted in windowless rooms below the ground level. Temperature and lighting were similar in both, as were the opportunities for external distractions.[1] However, it was possible to lock the room in which the subject was being tested at the college, while such was not possible at the Salle DeTuscan. The most striking difference between the two testing areas was that the sports laboratory consists of two adjacent rooms separated by an eighteen-inch concrete-block wall while the Salle is a single room in which the psychomotor stimulus and response units were placed thirty feet from the stimulus-producing, control, and recording units. At this distance the sounds of the key and control switches were

---

[1] John E. Evans, The Effect of Distraction on Reaction Time (New York: The Science Press, 1916), p. 53.

inaudible. Testing in the sports laboratory was conducted with the subject in one room and the experimenter in the other. Again the key and control sounds were inaudible to the subject.[2] Fourteen fencers were tested in Detroit, and the remainder of the subjects were tested in the Sports Research Laboratory. Testing of the fencers was not conducted on a day in which they were to participate in an interscholastic competition.

The Apparatus

For the psychomotor tests the apparatus consisted of a stimulus unit, a response unit, a control unit, and a recording unit. The stimulus production mechanism was housed with the recording unit.

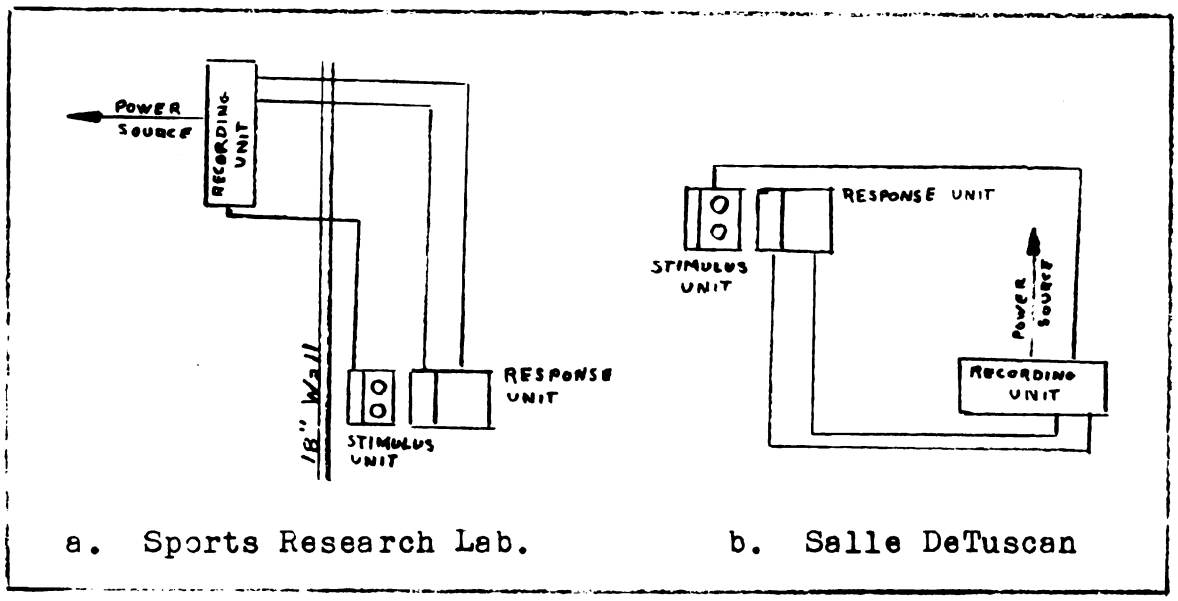
The stimulus unit.[3] Two lamps,[4] one red and one yellow, were used as visual stimuli and were centered one inch above and five inches behind the response targets. A preparatory set buzzer was incorporated in the unit.

---

[2] Figure 1.

[3] Illustration 1.

[4] General Electric NE-34.



a. Sports Research Lab. b. Salle DeTuscan

FIGURE 1.

DISTRIBUTION OF APPARATUS

The response unit.[5] Movement, M-reaction, and b'-reaction were measured by the response unit; a-reaction and c-reaction employed the standard telegraph key set to 0.05 inch. Movement times were recorded by a chronoscope which started when the subject released a microswitch[6] which required but fifty grams to hold open and 0.02 inch for contact and was stopped when he struck one of two hinged targets backed by a microswitch[7] requiring 500 grams and

---

[5] Illustration 1.

[6] Circuit normally closed.

[7] Circuit normally open.

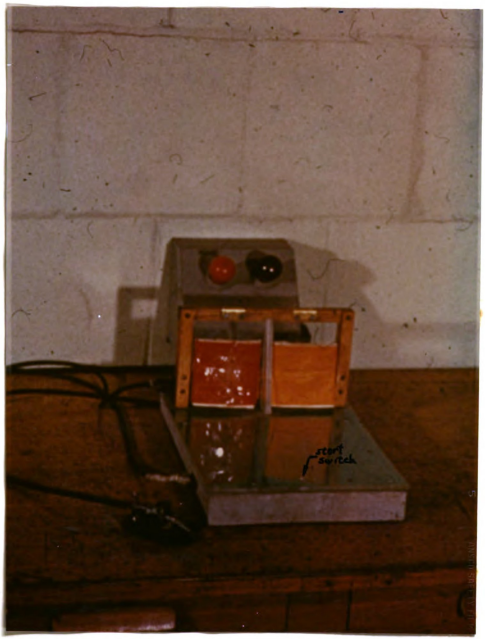


ILLUSTRATION 1.

THE STIMULUS AND RESPONSE UNITS

0.04 inch for contact. The targets were constructed of one-quarter inch lucite and were covered on the front by foam rubber one-half inch thick. The entire target assembly was mounted in an oak framework. The distance from the center of the start switch to the point where the stop switch made contact was eleven inches. In measuring M-reaction and b'-reaction the stimulus was instigated by a telegraph key which at the same time actuated the chronoscope. Release of the start switch in M-reaction and b'-reaction signalled the experimenter so that premature reactions could be noted.

The control unit. Because the experimenter was at a distance from the subject, it was necessary to construct a unit which would permit only correct responses to be recorded. This was accomplished by placing bat-handle toggle switches in the circuit between each response target and the chronoscope, permitting one or both circuits to be open or closed.

Recording unit with stimulus-producing mechanism.[8] Reaction and Movement times were recorded by means of a chronoscope

---

[8] Illustration 2.

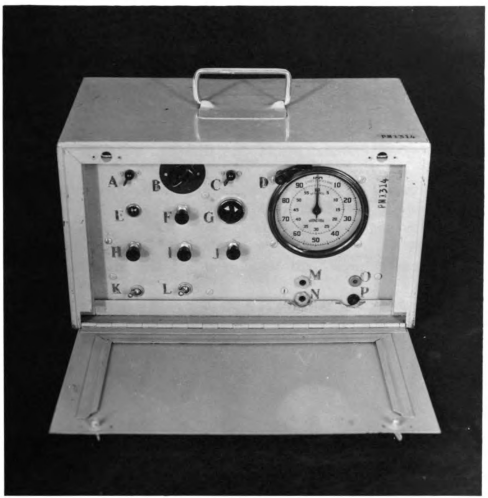


ILLUSTRATION 2.

RECORDING UNIT WITH STIMULUS-PRODUCTION MECHANISM

B, Stimulus selection knob

D, Chronoscope unit

H, Button for preparatory set buzzer

M, Chronoscope start

N, Chronoscope stop

graduated in 0.01 second units.[9] Stimuli selection and activation of the preparatory set buzzer were accomplished through mechanisms built into the unit.

The Subjects

Fifty volunteer subjects, of whom twenty-five were fencers and twenty-five were nonfencers, were tested at approximately the same time of day.[10,11,12,13] All subjects were naive as to the purpose of the tests and the nature of the items measured. Twenty-four of the nonfencers were of the freshman or sophomore classes of Michigan State College; the majority of the fencers were either

---

[9] Chronoscope model S-1-P manufactured by Standard Electric Time Company, Springfield, Massachusetts.

[10] Howard D. Marsh, The Diurnal Course of Efficiency (New York: The Science Press, 1906), p. 19.

[11] H. L. Hollingsworth, "Variations in Efficiency During the Working Day," Psychological Review, XXI (1914), p. 490.

[12] Robert A. Cowan, "A Study of Diurnal Variations, the Effect of Different Methods of Breathing and Exercise on the Accuracy of Movement of the Upper Extremities" (Unpublished Master's Thesis, State University of Iowa, 1931), 57 pp.

[13] Arthur I. Gates, Variations in Efficiency During the Day (Berkeley: University of California Press, 1916), p. 79.

juniors or seniors of Wayne University, the University of Detroit, Lawrence Institute of Technology, or Michigan State College. While the average age of the nonfencers was 231 months (19-1/4 years), that of the fencers was 287 months (23-11/12 years). The range in age of all subjects was from eighteen to twenty-seven years.

Twelve of the nonfencers neither earned an athletic award while in high school nor had ever been a candidate for a varsity sport in college. The remainder of the nonfencer group had earned major awards while in high school but were not permitted to volunteer for the tests if the award were from other than a class "C" or "D" school. These restrictions were an effort to equate the nonfencer subjects as to training. Nonfencer subjects were from the required physical education classes of Michigan State College that involved individual athletics of a running nature; testing was conducted only after the subject had had at least four weeks of class participation.

Of the fencer group, twelve were considered to be expert fencers and all but three of the entire fencer group had participated in interscholastic or A.F.L.A. competitions in 1952. Testing of the fencers was accomplished during the regular fencing season of 1953 when they were engaging in scheduled competitions.

Organization and Analysis

Arithmetic means were computed for the Movement and reaction scores, while scores for the derived measures were determined by a subtraction method involving those means. For the "Blocks Test," the score was the time, in seconds, of the faster of two trials.[14] The result of a single trial or measurement was used as the score for the "S" test and the anthropometric measures, the latter of which was recorded in centimeters. Weight was recorded in pounds to the nearest half-pound.

In order to test the homogeneity of variance in the scores of fencers and nonfencers, the F test was applied.[15] Because there were but twenty-five subjects in each group, the method selected for testing the hypothesis that differences in the means were nonexistent was the Student small sample technique.[16] The significance of "t" was determined by entering the "t" table with 48 degrees of freedom

---

[14] For description and administration of the test refer to Appendix A.

[15] $F = \frac{\text{greater } \sigma^2}{\text{lesser } \sigma^2}$.

[16] $"t" = \frac{(\bar{X}-\bar{Y})-(M_z-M_y)}{\sqrt{N_x S_x^2 + N_y S_y^2}} \sqrt{\frac{N_x N_y (N_x N_y - 2)}{N_z + N_y}}$

(n + n - 2), when the F was not significant. However, if the F was significant at the 0.05 level, the table was entered with just half that number (n - 1).[17]

Product-moment coefficients of correlation were calculated from ungrouped raw scores[18] but only of selected measures, because correlations of the data were secondary to the comparison of the means of the two groups.

---

[17] Allen Edwards, Statistical Analysis (New York: Rinehart and Company, 1950), p. 297.

[18] $$r_{xy} = \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{N}}{\sqrt{\left(\Sigma X^2 - \frac{(\Sigma X)^2}{N}\right)\left(\Sigma Y^2 - \frac{(\Sigma Y)^2}{N}\right)}}$$

CHAPTER III

REVIEW OF THE LITERATURE

Very little experimental work regarding the comparison of fencers and nonfencers in the determination of qualities essential to success in the sport has been done, although some attempts were made in 1948 at the University of Illinois to correlate body weight and speed of lunge. The results were never published.

A questionnaire study was conducted by Lance Flanagan in which thirty-six of the 221 questioned were members of beginning, intermediate, or advanced fencing classes at college level.[1] An analysis of the data collected from the following standardized tests was employed: (1) the items of factor M (masculinity-femininity) from the Guilford-Martin Inventory, (2) Allport's Ascendence-Submission Scale, (3) the Guilford Introversion-Extroversion Scale, and (4) the Emotional Stability section of Smith's Human Behaviour Inventory. On the basis of his analysis, Flanagan states that: "Fencers, as a

---

[1] Lance Flanagan, "A Study of Some Personality Traits of Different Physical Activity Groups," The Research Quarterly, XXII (October, 1951), pp. 312-323.

group, indicated by their inventory scores that they were more ascendent than any of the other groups taking a class in badminton, basketball, volleyball, boxing and swimming."[2] These differences were statistically significant when compared to basketball players, volleyball players, and boxers at the three, one, and three percent level of probability respectively. He further concluded that: "Masculinity-Femininity scores indicated the fencers to be more feminine, as a group, than any of the other groups tested. . . . Fencers indicated by their scores that they were more extroverted than any of the other groups with the exception of badminton players. . . . Fencers, again, profess to be more emotionally stable than any of the other groups. . . ."[3] In his conclusions Flanagan states:

> . In looking at the fencing and volleyball groups as a whole the writer gained the impression that fencers demonstrate the personality traits mentioned above because fencing, being an individual sport, requires more extroversion and a more dominant personality for success. Fencers cannot depend on other team members to win for them. Observation of fencing groups over a number of years has led the writer to believe that they are "exhibitionists," especially when performing before a feminine audience. This believe has been substantiated.[4]

---

[2] Ibid., p. 321.

[3] Ibid., p. 322.

[4] Loc. cit.

While these conclusions may be valid when applied to members of fencing classes, they do not necessarily portray the personality of fencers or those who continue beyond classroom work. Then, too, there are often external factors which influence the selection of activity classes in large schools which do not reflect the personality.

Literature on Fencing

Writers of works on fencing, many of them expert fencers and coaches, have generally credited the sport with certain benefits and advantages which, according to some, are to be found to such a degree in no other physical activity.[5,6,7,8,9,10,11] Aldo Nadi asserts

---

[5] M. W. Berriman, Capt., The Militiaman's Manual and Sword-play without a Master (New York: D. Van Nostrand, 1864), p. iv.

[6] Fred G. Blakeslee, Sword Play for Actors (New York: The M. W. Hazen Company, 1905), p. 9.

[7] Scott D. Bredkinridge and Scott D. Breckinridge, Jr., Sword Play (New York: A. S. Barnes and Company, 1941), p. xiii.

[8] Raoul Cléry, Lt., Traité d'Escrime de Pointe (Paris: Société Française de Presse, 1948), p. 15.

[9] Hans Kufahl, Der Fecthsport (Leipzig: Grethlein and Company, no date), p. 9.

[10] Lucien Gaudin and Gilbert Gros, L'Escrime (Paris: Librairie S. Bornemann, 1949), p. 1.

[11] Aldo Nadi, On Fencing (New York: G. P. Putnam's Sons, 1943), pp. 11-14.

". . . with profound conviction that fencing develops intelligence."[12] His profound conviction is based upon his observation of a mentally deficient boy of eight who developed into a successful businessman and upon the statement, ". . . among the athletes of all our universities, the fencers have the highest scholastic ratings."[13] Many European doctors, some of whom call fencing the Elixer of Long Life, have written concerning its physiological benefits.[14] Dr. Alexis Carrel has stated: "Fencing increases the speed and precision of motor reactions, and contributes very effectively to the harmonious development of the body."[15] Dr. Riccardo Elti de Rodeano writes that fencing reduces the curve of the stomach by automatically massaging the intestinal mass, improves organic vigor, makes greater the functions of the organs of respiration and circulation, which latter is essential in active muscular work, and that muscular contractions stimulate the motor and sensory nervous centers. He further states that fencing is also of importance in the education of the

---

[12] Ibid., p. 14.

[13] Loc. cit.

[14] Ibid., p. 7.

[15] Loc. cit.

spirit and character and it develops, in a special manner, the talents of attention, energy, perseverence, decision, and courage.[16] Cléry, discussing the physiological effects of fencing, says that it demands of different segments of the body maximum elongation; that muscles must instantaneously obey the orders of the will. He continues, "L'escrime constitue un moyen de choix pour discipliner, amplifier, juxtaposer et coordonner les impressions sensorielles (tactiles, visuelles, auditives, musculaires), et les actions psycho-motrices dans les diverses phases de l'assaut."[17] He concludes with the observation that the fencer represents the highest expression of the sensory type. Julio Castello states:

> Fencing as a sport cannot be excelled as a developer of trigger-speed movement, adaptation to the opponent, and of greater reliance upon skillful deception than upon brute strength, all of which requires a severe disciplining of the muscles to respond correctly and instantaneously to the rapid commands of the brain.
>
> All conventions of sword play are fundamentally alike in one respect: they emphasize strategy, nervous strength, mental control; and put a premium upon intelligence of conception and accuracy of execution in the various movements of the bout.
>
> . . . . . .

---

[16] Angesilao Greco, La Spada e la sua Disciplina D'Arte (Rome: G. U. Nalato and Company, 1912), p. xi.

[17] Cléry, op. cit., p. 15.

> The necessity of watching even the slightest oscillations of the opponent's blade develops and speeds up the power of observation. The need of parrying and returning the attack instantaneously quickens the decisions of the conscious will.[18]

Barbasetti believes that fencing is an incomparably useful sport because it not only promotes physical well-being but also exerts a most beneficial effect on the mental development by reason of the qualities of observation, dexterity, and initiative which it fosters.[19] E. D. Mitchell supports the right of fencing in a physical education program because of the health factor. "It gives excellent coordination of body. Furthermore, investigation shows that it is extremely beneficial as a corrective and reducing exercise . . ."[20] Characteristics developed by fencing, according to Deladrier, are grace of carriage, coordination of eye, brain, and muscle, speed of reaction, wind, and an improvement in muscle tone.[21] The effects of fencing may be summarized as follows: Muscular contractions are quickened, there is

---

[18] Julio M. Castello, The Theory and Practice of Fencing (New York: Charles Scribner's Sons, 1933), p. 15.

[19] Luigi Barbasetti, The Art of the Foil (New York: E. P. Dutton and Company, 1932), p. v.

[20] Elmer D. Mitchell, editor, Sports for Recreation (New York: A. S. Barnes and Company, 1936), p. 112.

[21] Clovis Deladrier, Modern Fencing (Annapolis, Maryland: United States Naval Institute, 1948), p. xiv.

an increase in reaction time performance, correct decisions can be made faster, and a beneficial effect is exerted on muscle tone. The development of courage, intelligence, spirit, or character may be ignored as the evidences are too isolated and uncontrolled.

There appears in the literature a distinction between qualities developed by fencing and qualities which are essential to success in the sport, although there is a frequent overlapping of the two. Cléry, in discussing the qualities essential to successful fencing, divides them into (1) physical qualities and (2) intellectual and moral qualities. Physical qualities include muscular vigor, integrity of internal organs, and speed. Speed takes two forms: natural speed and speed of execution. The first is the result of individual reactions and nervous conductability and is alone not enough. One must also have the second type of speed which is the result of the harmony and perfection with which the different actions are executed. Intellectual qualities are judgment, which is the faculty of studying and analyzing the adversary and determining the proper tactics; will, which is the essential quality of the fencer as it permits the execution of the movements already determined without hesitation; and the "á-propos," the art of profiting by the inattentions of the adversary at the precise

moment they present themselves.[22] Regarding the attack in fencing, Reynolds says: "Much depends on the à propos of the attack, which is of even greater importance than quickness."[23] Barbasetti states: "The success of the simple thrust may be due either to your superior rapidity or to your correct choice of the moment for thrusting; on the other hand, it may also be due to your having become an excellent judge of distance."[24] Castello writes:

> We may use the following subdivisions for treating the essentials involved in a bout
>
> 1. Distance
> 2. Timing
> 3. Calculation
> 4. Decision
> 5. Co-ordination.
>
> Appreciation of the above is a real requisite for successful fencing and will result from the application in the bout of what the fencer has acquired through lessons. It is true that some of these qualities depend on the natural make-up and condition of the man, physically and mentally; but others can be acquired only by perseverence and practice under able fencing masters.[25]

Deladrier states: "To become a good fencer, two qualities are essential: (1) instantaneous judgment, which in turn requires good

---

[22] Cléry, op. cit., p. 21.

[23] F. C. Reynolds, The Book of the Foil (London: Ernest Benn Limited, 1932), p. 161.

[24] Barbasetti, op. cit., p. v.

[25] Castello, op. cit., p. 54.

condition and well tempered nerves; (2) muscular strength and speed."[26] According to Aldo Nadi: "Eye, timing, speed, co-ordination, sense of distance, mechanical skill and the ability to relax completely whenever possible are the attributes a good fencer must possess."[27] The Breckinridges contend that fencing

> . . . requires the meticulous attention to technique that characterizes golf; the explosive energy of the sprint runner; the split second decisions of the tennis player and boxer; and above all and before all, it requires for its fullest achievement a power of analysis that is not equalled by any other game in the athletic group--much more nearly resembling chess in this characteristic. . . . It is a game of speed and coordination, of technical finesse and intellectual acuity, and offers full reward, both physical and mental, to those who will pursue its intracacies.[28]

Mitchell says that a good "swordsman" should possess the qualities of (1) a good eye, (2) correct judgment, (3) sensitive touch, (4) quickness, (5) precision, or exact execution of the rules of the art, (6) determination, and (7) presence of mind.[29] "Fencing is not a game for unintelligent people, or for people who are merely strong. One

---

[26] Deladrier, op. cit., p. 82.

[27] Nadi, op. cit., p. 260.

[28] Breckinridge, loc. cit.

[29] Mitchell, op. cit., p. 134.

does not fence so much with the muscles as with the nerves and brain."[30]

In summarizing fencing literature, the most cited qualities which a fencer should possess, whether inherent or the results of participation, are speed of both movement and reaction, the ability to make rapid correct decisions and judgments, a sense of "distance," and a sense of á propos or timing. It is not unreasonable to assume, from the literature, that the fencer possesses these characteristics to a greater extent than does the nonfencer. Practically no experimental work has been done to justify this assumption.

Psychomotor Activities Literature

Actions which utilize both mental and muscular processes may be said to be psychomotor in character. An action of this nature involves three general phases: reception, conduction, and response.[31] Hypothetically, a complete sensory reaction may be divided as follows: (1) the latent period in the sense organ, (2) conduction to the

---

[30] Castello, op. cit., p. 15.

[31] Perry D. Strausbaugh, Elements of Biology (New York: John Wiley and Sons, Inc., 1944), p. 160.

appropriate sensory center, (3) cortical and spinal elaboration, (4) conduction of the nerve impulse from the motor areas to the striate muscles, and (5) the latent period of the striate muscle itself. Conduction along nerves involves the speed with which the impulse can be transmitted and the time consumed in transmission through the synapses.[32,33,34,35,36,37] Lawther avers that the time elapsing from the occurrence of a stimulus to the beginning of the muscle movement includes perception time and that muscle contraction completes the response.[38] Other than nerve conduction speed, which he

---

[32] J. V. Breitweiser, "Attention and Movement in Reaction Time," Archives of Psychology, XVIII (August, 1911), pp. 1, 23.

[33] Arthur G. Bills, General Experimental Psychology (New York: Longmans, Green and Company, 1934), p. 399.

[34] Robert S. Woodworth, Psychology (fourth edition; New York: Henry Holt and Company, 1945), pp. 258-273.

[35] Charles H. Best and Norman B. Taylor, The Living Body (revised edition; New York: Henry Holt and Company, 1944), pp. 395-397.

[36] Floyd L. Ruch, Psychology and Life (third edition; Chicago: Scott, Foresman, and Company, 1948), pp. 304, 710.

[37] Clyde Marshall and Edgar L. Lazier, An Introduction to Human Anatomy (Philadelphia: W. B. Saunders Company, 1946), pp. 297-305.

[38] John D. Lawther, Psychology of Coaching (New York: Prentice-Hall, Inc., 1951), p. 223.

says is so short that it can be ignored,[39] he mentions no factors involved in reaction time. Concerning the concept of reaction as a unitary system consisting of a sense organ with its afferent, central, and efferent neural connections and the muscle, Bills states that "no psychologist would be guilty of assuming that the simple reaction, as studied in the laboratory, involves any such limited system. There is the inertia of the sense organ, the inertia of the muscle, and the central delay to be considered."[40] In human nerve fibers the average speed has been variously estimated at from thirty to one hundred meters per second.[41,42,43,44,45,46] In an exploratory study concerning

---

[39] Ibid., p. 222.

[40] Bills, op. cit., p. 400.

[41] Loc. cit.

[42] A. J. Poffenberger, "Reaction Time to Retinal Stimulation," Archives of Psychology, XXIII (July, 1912), p. 25.

[43] M. Abercrombie, C. J. Hickman, and M. L. Johnson, A Dictionary of Biology (Middlesex, England: Penguin Books, Ltd., 1951), p. 115.

[44] Best and Taylor, op. cit., p. 393.

[45] Ruch, op. cit., p. 703.

[46] Robert S. Woodworth, Experimental Psychology (New York: Henry Holt and Company, 1938), p. 299.

the factors of perception, Thurstone tentatively identified eleven factors, each of which represents one or more hypotheses concerning the basic parameters of perception.[47] Five of these seem to be concerned with the speed of different functions. Three of the five, namely C (reaction time), F (Speed of perception), and J (speed of judgment), "seem to represent speed of distinguishable perceptual functions and represent an increasing amount of central participation."[48] A typical value for reaction to light is 0.18 second.[49] Movement reaction time has been found to be from 0.18 to 0.25 second for unpracticed adults, when the response involves movement of one hand and arm[50] and the same response over a distance of eleven inches was 0.417 second when members of various required physical education classes were measured.[51] Although the latent period of an exiced and not loaded striate muscle may be measured

---

[47] L. L. Thurstone, A Factorial Study of Perception (Chicago: University of Chicago Press, 1944), 148 pp.

[48] Ibid., p. 118.

[49] Woodworth, Experimental Psychology, op. cit., p. 324.

[50] W. R. Miles, "Studies in Exertion. II. Individual and Group Reaction Time in Football Charging," The Research Quarterly, II (October, 1931), p. 8.

[51] See page 87.

as only 0.001 second, it hardly represents the true situation in the human body where muscles are attached to heavy bony levers. Therefore a latent period of 0.01 second could be considered closer to the true measure of the latent period for the muscle in moving these levers.[52,53] Time consumed in synaptic transmission has been calculated to be 12 percent of the total reaction process, 2 percent of which is consumed in transmission between the motor areas of the brain.[54]

Rarick found the mean of the muscle-thickening time of the triceps to be 0.01337 second for fifty-one varsity athletes and physical education students.[55] He found a correlation of 0.1357 between muscle-thickening (latent period) of the triceps and reaction time of the same muscle as measured by means of photographing the string of a standard Cambridge type galvonometer used in connection with

---

[52] Best and Taylor, op. cit., p. 399.

[53] Edward C. Schneider and Peter V. Karpovich, Physiology of Muscular Activity (third edition; Philadelphia: W. B. Saunders Company, 1949), p. 12.

[54] Poffenberger, op. cit., p. 72.

[55] Lawrence Rarick, "An Analysis of Speed Factors in Simple Athletic Activities," The Research Quarterly, VII (December, 1937), p. 97.

the electrocardiograph.[56] Lanier has demonstrated that there is little, if any, relationship between simple reaction time and latency of eyelid or psychogalvanic reflex.[57] He concluded that the lack of correlation between these simple types of activities would constitute a strong argument against the view that any single organic factor conditions speed in diverse motor activities somewhat uniformly.[58]

It is not illogical to assume that a great part of movement-reaction time is consumed in cortical elaboration.[59,60] although the precise nature of the conditions operating within the central nervous system to determine the speed at which a single or succession of motor acts occurs is unknown.[61,62]

---

[56] Ibid., pp. 92, 99.

[57] Lyle H. Lanier, "The Interrelations of Speed of Reaction Measurements," Journal of Experimental Psychology, XVII (April, 1934), pp. 371-399.

[58] Ibid., p. 396.

[59] Bills, loc. cit.

[60] Thurstone, op. cit., p. 118.

[61] Ibid., p. 1.

[62] Lanier, op. cit., p. 398.

Donders[63] advanced the theory that complex reaction time is simple reaction time with additional processes inserted and that the speed of these processes could be obtained by subtracting simple RT from the complex. Ach and Watt made pertinent studies discrediting this procedure and its underlying assumption.[64] They found that in preparing for simple reactions the motor readiness, which occurs before the stimulus, reached a higher pitch than when preparing for complex reactions, whether the complexity was of stimuls or of response. "The disjunctive reaction is not the simple reaction with discrimination and choice inserted; the two reactions differ from the start."[65] Disjunctive reaction times are from 0.02 to 0.20 second longer than simple reactions, and discrimination time (c-reaction) is a little faster than discrimination and choice RT (b-reaction).[66,67,68]

---

[63] F. C. Donders, "Die Schnelligkeit psychischer Processe," Archiv für Anatomie und Physiologie (1862), pp. 657-681.

[64] Cited in Woodworth, Experimental Psychology, op. cit., p. 309.

[65] Loc. cit.

[66] Ibid., p. 331.

[67] Lanier, op. cit., p. 395.

[68] Ruch, op. cit., pp. 308, 309.

Lange discovered that a subject's reaction time varies, depending on whether his attention is directed to the stimulus or the movements involved in making the response.[69] For this reason three forms of simple reaction have been distinguished: (1) the sensory, in which the attention is directed toward the stimulus, (2) the muscular, or motor, in which the attention is directed to the preparation to respond, and (3) the "natural reaction" in which the subject is left free to direct his attention to either or both.[70,71,72] Reaction time is generally faster when the attention is directed toward the movement.[73,74,75,76,77] Ruch states that the foreperiod on the interval

---

[69] Ludwig Lange, "Neue Experimente über den Vorgang der einfachen Reaction auf Sinneseindrüke," Philosophische Studien, IV (1888), pp. 479-510.

[70] Bills, op. cit., p. 401.

[71] Woodworth, Experimental Psychology, op. cit., pp. 306-308.

[72] Breitweiser, op. cit., p. 3.

[73] Ibid., p. 37.

[74] Lawther, op. cit., p. 222.

[75] Bills, loc. cit.

[76] Woodworth, Experimental Psychology, op. cit., p. 308.

[77] C. H. Judd, C. H. McAllester, and M. W. Steele, "Analysis of Reaction Movements," Psychological Monographs, VII (1905), pp. 141-184.

between the ready signal and the stimulus, should vary from one to four seconds,[78] although the majority of investigations seem to favor a period of one to three seconds. Maximum efficiency is effected at two seconds and any interval shorter than one second gives a greatly prolonged response time.[79,80,81,82,83,84] Reaction times to light stimuli are slower than those to sound,[85,86,87,88,89,90,91] necessitating

---

[78] Ruch, op. cit., p. 307.

[79] H. Woodrow, "The Measurement of Attention," Psychological Monographs, XVII (1914), 158 pp.

[80] C. W. Telford, "The Refractory Phase of Voluntary and Associative Responses," Journal of Experimental Psychology, XIV (February, 1931), p. 10.

[81] Breitweiser, op. cit., p. 22.

[82] Bills, op. cit., p. 405.

[83] Woodworth, Experimental Psychology, op. cit., pp. 314-316.

[84] Preliminary studies indicated that reaction times tend to increase if the period extends beyond 3 seconds.

[85] Ruch, op. cit., p. 306.

[86] John W. Todd, "Reaction to Multiple Stimuli," Archives of Psychology, XXV (August, 1912), p. 65.

[87] H. Nakamura, "An Experimental Study of Reaction Time of the Start in Running a Race," The Research Quarterly, V (March, 1934), pp. 33-35.

[88] Woodworth, Experimental Psychology, op. cit., p. 321.

[89] Bills, op. cit., p. 400.

[90] Breitweiser, op. cit., p. 22.

[91] Brent Baxter, "A Study of Reaction Time Using Factorial Design," Journal of Experimental Psychology, XXXI (November, 1942), pp. 430-437.

a stimulus key which is inaudible to the subject if a visual stimulus is desired.

Serial action tests. Serial reaction tests are similar to multiple reaction tests in that a certain "reaction process" is involved; they differ in that while the multiple reaction tests usually have the relevant stimulus set in the midst of an array of foreign appeals, in serial reaction testing the attention of the subject has only one stimulus which must be acted upon before any further steps can be taken.[92] Farnsworth and others conducted an experiment which disclosed that there is a very low correlation between speed in simple reaction and multiple serial reaction ($r = 0.15$), and that serial reaction has an appreciable correlation with intelligence, particularly as measured by the Army Alpha Test, although they state that the serial action test cannot be regarded as an intelligence test analogous to other forms of intelligence tests.[93] Seashore, after studying serial action tests, established the following criteria to which a serial action

---

[92] C. F. Hanson, "Serial Action as a Basic Measure of Motor Ability," Psychological Monographs, XXXI (1922), p. 380.

[93] Paul Farnesworth, Robert Seashore, and Miles Tinker, "Speed in Simple and Serial Action as Related to Performance in Certain 'Intelligence Tests,'" Pedagogical Seminary XXIV (1927), pp. 537-551.

test should conform: (1) the serial should be novel enough not to be influenced by practice in any previous activity, (2) results should be easily recorded, (3) the test should be economical to purchase and maintain and easily constructed, (4) the performance should be easily understood by the subject, (5) it should be of sufficient length for statistical reliability and to avoid easy memorization of the series, and (6) procedure should create little or no fatigue for the participator.[94]

Primary abilities in visual thinking. A primary mental ability that was isolated in early experiments using multiple factor methods, principally by L. L. Thurstone, is the ability to identify objects in space. This is called the space factor and is denoted by the letter "S."[95] Perhaps the simplest of the primary factors involved in visual thinking is the one called perceptual speed, denoted by the letter "P." In recent years several space factors have been found and three have been denoted S_1, S_2, and S_3. The first of these

---

[94] Robert Seashore, "Techniques for Measuring Serial Action," Journal of Experimental Psychology, XI (February, 1928), pp. 45-55.

[95] L. L. Thurstone, "Primary Mental Abilities," University of Chicago Psychometric Laboratory Reports, No. 50 (September, 1948), p. 4.

represents the ability to recognize the identity of an object when it is seen from different angles. "It is rather easily differentiated from the perceptual speed factor which is concerned with the identification of flat figures or surface figures which are essentially flat."[96] Concerning the second space factor, a psychological interpretation that fits the experimental findings of the University of Chicago Psychometric Laboratory is that it represents the ability to imagine the movement or internal displacement among the parts of a configuration that one is thinking about. Both the first and second factors are concerned with the imagination of movement, but differ in that the first concerns itself with rigid objects while the second is concerned with objects that show internal displacement or movement.[97] S_3 represents the ability to think about those spatial relations in which the body orientation of the observer is an essential part of the problem. In all, about twenty primary abilities have been identified, but not all have been given adequate psychological interpretation.

---

[96] L. L. Thurstone, "Some Primary Abilities in Visual Thinking," University of Chicago Psychometric Laboratory Reports, No. 59 (August, 1950), p. 1.

[97] Ibid., pp. 2, 3.

Literature on Anthropometry

Anthropometry, or the systemized measurement of man, has been a means of research since before the early Greeks. A significant step toward the standardization of techniques was taken at the Geneva convention of 1912, when it was decided to use the erect position for measuring living subjects.[98] Tildesey, after statistically analyzing various units of measure, recommended that the centimeter be used for span, arm length, chest girth, waist girth, and height measures (standing and sitting) if they are to be used directly.[99] Studies by Cureton generally indicate that men with slender build and relatively long legs excell in speed and agility events, those with massive build are very strong, and those of medium build are best at such sports as boxing, swimming, and baseball.[100,101]

---

[98] Cited in Ales Hrdlička, Practical Anthropometry (third edition; Philadelphia: The Wistar Institute of Anatomy and Biology, 1947), p. 13.

[99] M. L. Tildesey, "Choice of the Unit of Measurement in Anthropometry," Man, XLVII (May, 1947), pp. 72-77.

[100] Thomas K. Cureton, Physical Fitness Appraisal and Guidance (St. Louis: The C. V. Mosby Company, 1947), 566 pp.

[101] Thomas K. Cureton, Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), 458 pp.

Related Studies

Friedman conducted an experimental study comparing what he termed "reaction time" and the Cozens Indoor Wet Weather Test, Battery No. 12.[102] Subjects were 191 males from undergraduate physical education classes of New York University. He found the mean "reaction time" to be 1.632 seconds, which gave a correlation coefficient of 0.409 ± 0.0562 (PE) when compared to the Cozens test, indicating that there is a low positive relationship between "reaction time" and general athletic ability. He concludes that "the reaction time test, in its present form, is not a highly reliable index of general athletic ability."[103] That the tests were separated by quite a long period might be responsible for some of the low correlation was a possibility advanced. What Friedman calls "reaction time" is in reality a complex movement reaction, because the subject responds to the stimulus by arising from a back prone position and striking a telegraph key placed shoulder high on the wall.

---

[102] Edward A. Friedman, "The Relationship of Reaction Time to General Athletic Ability" (Unpublished Master's thesis, New York University, New York, 1937), 59 pp.

[103] Ibid., p. 46.

Keller[104] devised an apparatus which measured the movement time of the combined action of one arm, one foot, and the trunk to the right, left, or front of the subject. The direction of the response depended upon an illuminated stimulus "arrow" controlled by the experimenter. Thirty-six movements were recorded for each subject, in eighteen of which the direction of movement was known to the subject beforehand; a total of twelve movements were made in each of the three directions and the mean of the thirty-six was the figure representing the "quickness of bodily movement." The subjects were 515 University of Minnesota men and 240 high school men; 259 of the total were considered athletes (letter winners in baseball, basketball, football, gymnastics, swimming, track, and wrestling), and 277 nonathletes. Athletes as a group scored significantly better than the nonathletes in all phases. He concluded: "There seems little doubt that 'quickness of bodily movement' or 'total body reaction time' is definitely related to success in athletics."[105] Keller has not considered the mental factors involved in his "quickness." With

---

[104] Louis F. Keller, "The Relation of 'Quickness of Bodily Movement' to Athletic Success" (Doctor's dissertation, New York University, New York, 1940, 100 pp.), published in The Research Quarterly, XIII (May, 1942), pp. 146-155.

[105] Ibid., p. 60.

the direction of movement known to the subject, bodily response to a stimulus is actually movement-reaction time or "total body reaction time," but when the direction of response is unknown, what is measured is no longer movement-reaction, but choice movement-reaction, which involves not only the added factor of choice but may also change the response from a motor or muscular reaction to a sensorial one as well as influencing the nature of the preparatory set.[106]

Miles[107] experimented with eighty-seven football players, fifty-three of whom were on the varsity squad at Stanford University, in an attempt to determine the relationship of the "charge" of eight men at a time and found that the average charging time of the total group was 0.389 second while that of the varsity squad was 0.381 second. The coefficient for weight with charging time was 0.22 ± 0.09, which gives some slight evidence that the heavier a player, the slower he gets into action. Height with reaction time gave a correlation coefficient of 0.08 ± 0.09.

In attempting to establish a predictive battery for baseball ability, Everett tested thirty University of Iowa varsity baseball

---

[106] Woodworth, Experimental Psychology, op. cit., p. 60.

[107] Miles, op. cit., pp. 5-13.

players in baseball throw for distance, Sargent jump, shuttle run, squat thrust, McCloy "blocks test," Iowa Revision of the Brace Test, General Motor Capacity Score, and the Thurstone "S" test.[108] The criteria used were ratings by the coach of each player based on his performance the previous year. A simplified formula for predicting baseball ability was established which included the Sargent jump ($r = 0.523$ with rating), "S" test ($r = -0.521$) and the "Blocks test" ($r = -0.264$).

Rarick, in an effort to isolate and identify the various factors which influence the speed of muscular movement, statistically analyzed a group of sixteen athletic and six physiological measures taken of fifty-one varsity athletes and physical education students.[109] He identified six factors: (1) general strength, (2) velocity, or speed of movement, (3) height, (4) arm strength, (5) dead weight, or that part of weight which is not included in the active musculature of the body, and (6) muscle latency. The conclusions were that strength contributes little, if anything, to speed of performance when present in quantities greater than a certain minimum; the velocity factor appears

---

[108] Peter W. Everett, "The Prediction of Baseball Ability," The Research Quarterly, XXIII (March, 1952), pp. 15-19.

[109] Rarick, op. cit., pp. 88-105.

to be the chief limitation to man's speed; height is quite an important factor in adding distance in events which depend on rapid extension of the arm such as shot-putting; dead weight seems to act as an opposing force to speed of muscular movements; and muscle latency response seems to exert no significant influence on speed of movements. "The results of this study indicate that normal individuals with a high degree of motor ability or skill and an average amount of strength cannot increase their speed of muscular performance to any appreciable extent."[110]

Henry measured sixty college men in ball snatch coordination movement of eleven inches by means of an apparatus employing two chronoscopes which fractioned their time into reaction time and movement time.[111] Another group of forty-three men were similarly measured on a treadle press. The reaction and movement functions were found to be independent and uncorrelated ($r = -0.07$ and 0.003 for the within-sample correlation in the first experiment and $r = 0.15$ and 0.10 in the second), indicating that "there was no correlation

---

[110] Ibid., p. 104.

[111] Franklin M. Henry, "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, XXIII (March, 1952), pp. 43-53.

between reaction time and speed of movement--the two functions must therefore be considered as independent and unrelated."[112]

A serial action test designed to measure the ability to make rapid correct judgments was devised by McCloy.[113] He found that the test correlation with composite ratings of the abilities of 300 senior high school girls in basketball, volleyball, diving, and the dance was 0.510. Using the same test, Smith[114] measured the "athletic smartness" of forty football and thirty-four basketball letter winners. There was no correlation between the test and the coaches' ratings of football players, but there was a correlation of 0.65 between the test and the ratings of basketball players. Smith believes that "athletic intelligence apparently is a more essential factor in basketball than in football, generally speaking."[115] He concludes that the "blocks test" may be used to some extent in predicting basketball ability insofar as this success is based on athletic intelligence.

---

[112] Ibid., p. 51.

[113] Charles H. McCloy, "'Blocks Test' of Multiple Response," Psychometrika, VII (September, 1942), pp. 165-169.

[114] Stanley M. Smith, "The 'Blocks Test' as a Measure of Adaptive Athletic Response" (Unpublished Master's thesis, State University of Iowa, Iowa City, July, 1943), pp. 22.

[115] Ibid., p. 19.

DiGiovanna conducted a study, the purpose of which was to determine the relationship between various factors of body build, muscular strength, and explosive power to success in college athletics.[116] He found substantial differences in anthropometry of baseball players, basketball players, football linemen and backfield, gymnasts, shot-putters, and discus men. From the statistical analysis he concluded that within its limits the investigation tended to substantiate the common claim that factors of body structure, muscular strength, and explosive power are associated with athletic success. However, the study revealed no substantial differences in anthropometry of tennis players and most individual sports were not included in the study.

Jarnoff, Beck, and Child[117] experimented with fifty-one sophomore men at Yale University who had been somatotyped as freshmen. They were tested as to resistance to pain and measured as to reaction time in several modalities, particularly auditory and visual

---

[116] Vincent G. DiGiovanna, "The Relation of Selected Structural and Functional Measures to Success in College Athletics," The Research Quarterly, XIV (May, 1943), pp. 199-216.

[117] Irma Z. Janoff, Lloyd H. Beck, and Irvin L. Child, "The Relation of Somatotype to Reaction Time, Resistance to Pain, and Expressive Movement," Journal of Personality, XVIII (June, 1950), pp. 454-460.

discrimination. The conclusion was: "It may be concluded that somatotype is not a very important determinant of measures of reaction time and resistance to pain such as have been used here."[118]

Summary

Fencers should differ from nonfencers in speed of movement and of reaction, the ability to make rapid correct judgments, the ability to make the proper decision, the sense of timing, and they should be taller and thinner, if one is to believe the literature on the subject.

Henry has shown that reaction and movement times are independent and unrelated; and Rarick, that normal individuals with a high degree of motor ability cannot appreciably increase their speed of muscular performance. Although the subtractive method for determining the speed of a single factor has been generally discredited, it is not illogical to assume that fencers and nonfencers will differ in those measures, whatever they may be, that are obtained when Movement time is subtracted from Movement-reaction time because reaction is relatively unaffected by training. The same may

---

[118] Ibid., p. 459.

be said when discrimination and choice are inserted in the experiment, although what is measured may not necessarily be only those items inserted.

CHAPTER IV

RESULTS

The Psychomotor Measures

The psychomotor measures were either of a direct nature or were derived from direct measures. These latter were designated "Unknowns" because, although they could be measured, their exact identities were not known. Preliminary studies[1] indicated that trials twenty to forty occurred on a plateau so they were used in computing the mean for each subject. Movement, M-reaction, and b'-reaction were measured with the response target placed at a distance equal to the extension of the subject's arm and hand. What then was measured was the last eleven inches of the extension of his dominant arm and hand. Psychomotor testing was conducted in the following order: (1) Movement, (2) M-reaction, (3) b'-reaction, (4) a-reaction, (5) c-reaction, (6) "S" test, and (7) the "Blocks Test." The entire series of psychomotor tests was completed in forty-five minutes.

---

[1] Figure 6, Appendix A.

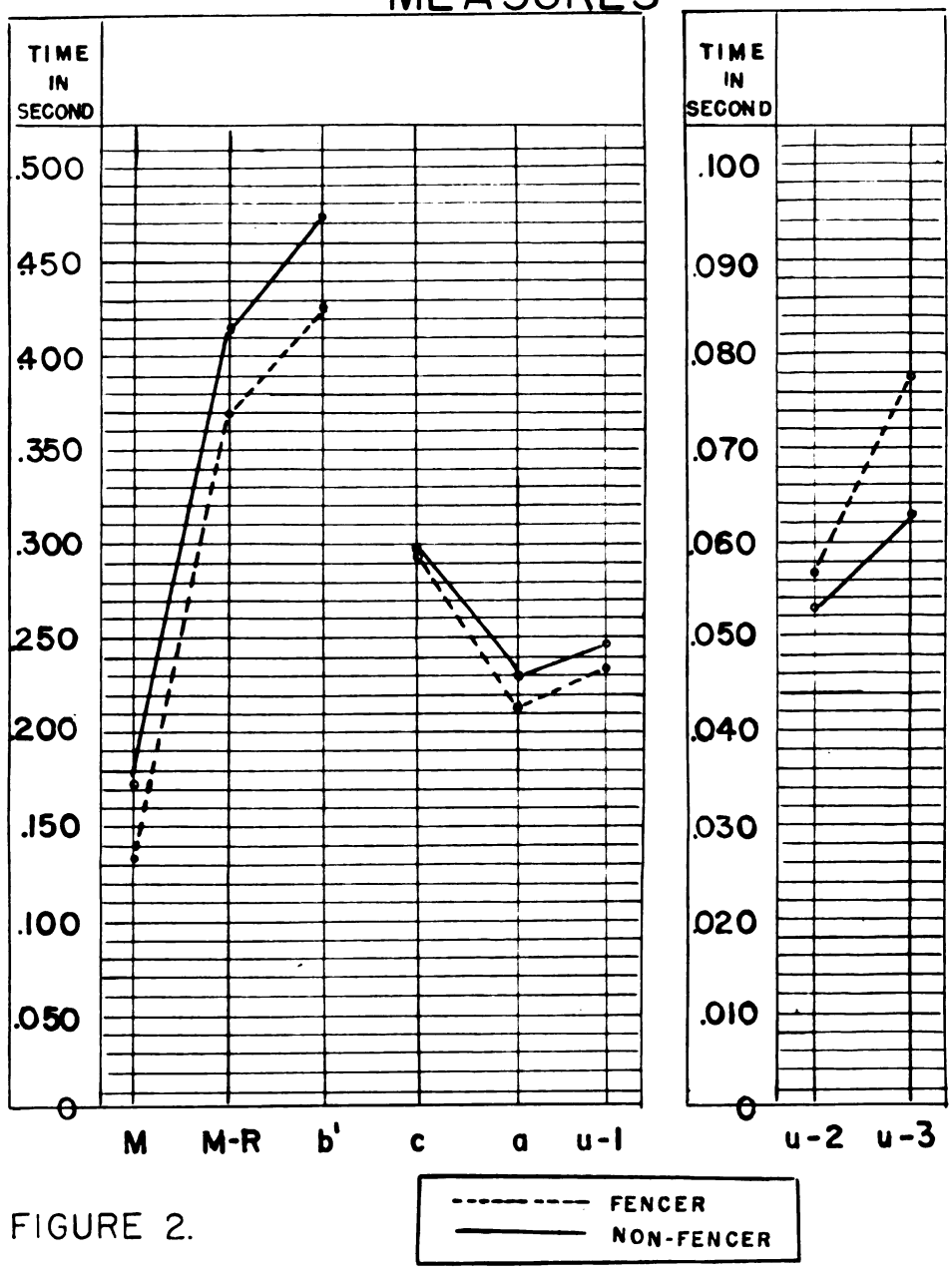

MEAN SCORES OF PSYCHOMOTER MEASURES
TIME IN SECOND
.500
450
400
.350
.300
250
200
.150
.100
.050
0
TIME IN SECOND
.100
.090
.080
.070
.060
.050
.040
.030
.020
.010
0
M
M-R
b'
c
a
u-1
u-2
u-3
FENCER
NON-FENCER

FIGURE 2.

Movement. In measuring Movement, the subject was instructed to hit either target as fast as possible any time after hearing a preparatory set buzzer which would indicate that the experimenter was ready to record. The F score indicated that the fencers and non-fencers were not of the same population with respect to variance and the differences in means was probably not due to chance, as evidenced by a "t" score which was significant at the 0.01 level.[2]

Movement-reaction. In Movement-reaction, the subject was instructed to respond to a light stimulus by striking either response target. The same stimulus lamp was used throughout the test. The instructions to the subject were so worded as not to influence him with regard to either sensory or motor responses,[3] and the stimulus occurred between one and three seconds after the introduction of the preparatory set buzzer.[4] No more than five seconds elapsed between trials. Again the two groups were probably of different population

---

[2] For significance of F and "t" see Table I.

[3] Robert S. Woodworth, Experimental Psychology (New York: Henry Holt and Company, 1938), pp. 306-308.

[4] C. W. Telford, "The Refractory Phase of Voluntary and Associative Responses," Journal of Experimental Psychology, XIV (February, 1931), p. 10.

variances and the difference in means was significant beyond the 0.01 level.

Discrimination and choice movement-reaction. b'-reaction was administered the same as was M-reaction with the exception that the subject was instructed to strike the yellow target when the yellow stimulus occurred and the red when the stimulus was red. To prevent alternation of guesses, a systematic sequence was followed in the presentation of stimuli.[5,6] The fact that the first twenty trials were not considered in the determination of the mean was convenient in demonstrating the inadvisability of "pattern" responses to the subject. As in the other two measures involving movement, both the F and "t" were significant.

Finger-press reaction. Administration of the a-reaction was similar to that of M-reaction, but the subject in this instance was instructed to respond to the stimulus by depressing a telegraph key with the index finger of the dominant hand. While the indications

---

[5] Table VII, Appendix B.

[6] Richard L. Solomon, "A Note on the Alternative of Guesses," Journal of Experimental Psychology, XXXIX (June, 1949), pp. 322-326.

were that the groups were not of the same population as regards variance, the difference in means was not significant.

Discriminatory reaction. If the subject were right-handed he was told to respond to a red stimulus by depressing a telegraph key; if the stimulus were yellow, no response was to be given. Left-handed subjects were instructed to respond to the yellow stimulus and to ignore the red. Again a systematic sequence for the presentation of stimuli was used. Because only half the trials elicited responses, the mean was computed from only ten responses of trials twenty to forty. Responses to the wrong stimuli were noted but ignored in computing the mean. Neither the F nor the "t" were significant in c-reaction.

McCloy "Blocks Test."[7,8] The "Blocks Test," a measure of adaptive athletic response or "athletic intelligence," although having rather a high correlation with success in various intercollegiate

---

[7] C. H. McCloy, "'Blocks Test' of Multiple Response," Psychometrika, VII (September, 1942), pp. 165-169.

[8] Illustrations 3, 4.

ILLUSTRATION 3

THE McCLOY "BLOCKS TEST"

ILLUSTRATION 3

THE McCLOY "BLOCKS TEST"

ILLUSTRATION 4.

TESTING WITH THE McCLOY "BLOCKS TEST"

team sports[9,10] resulted in insignificant F and "t" scores for the groups compared in this study.

Thurstone "S" test. Space perception, as measured by the Space portion of the SRA Primary Mental Abilities test, Form AH Intermediate, was found to be no greater in fencers than in nonfencers. The mean score of the fencers was 27.68; that of the nonfencers was 27.12. In the norms published for the test, raw score 27 was found to be the fiftieth percentile.[11]

The "Unknowns." While the exact nature of the unknown measures has not been established, it is not unreasonable to assume that many of the factors which operate in a-reaction also operate in u-1, those that constitute "choice" are also a part of the make-up of u-2, and that "discrimination" and u-3 are rather similar in composition. "Discrimination," as used here, may be considered to be the ability to respond to a designated stimulus when such is one of

---

[9] Stanley M. Smith, "The 'Blocks Test' as a Measure of Adaptive Athletic Response" (Unpublished Master's Thesis, State University of Iowa, Iowa City, July, 1943), 22 pp.

[10] Peter W. Everett, "The Prediction of Baseball Ability," The Research Quarterly, XXIII (March, 1952), pp. 15-19.

[11] Appendix A.

two which might be presented. The fact that the F and "t" of the fencers and nonfencers were not significant does not preclude the possibility of correlations between the "unknowns" and the direct measures.

TABLE I

SIGNIFICANCE OF F AND "t" FOR PSYCHOMOTOR SCORES

	M	M-r	b'	a	c	Blks	"S"	u-1	u-2	u-3
F	2.164	2.514	3.257	4.621	1.495	1.75	3.129	1.86	2.65	2.15
"t"	3.977	3.286	2.754	1.385	0.008	1.134	0.615	1.19	0.56	1.4

0.05 critical score: F, 1.98; $t_{(24\ df)}$, 2.10; $t_{(48\ df)}$, 2.064.

0.01 critical score: F, 2.66; $t_{(24\ df)}$, 2.79; $t_{(48\ df)}$, 2.681.

Summary. Although several of the measures tested showed a significant difference in variance, only movement and those measures involving movement gave indication that the difference in means might not be due to chance. The scores of the fencers were noticeably more closely grouped about the mean than were those of the nonfencers, as evidenced by the F scores. Unknown 1, which might be considered much akin to a-reaction, exhibited the same lack of

differentiation as did the a-reaction. The "S" test indicated that both groups were at the fiftieth percentile when compared to national norms.

The Anthropometric Measures

The results of the individual measurements, except weight, were recorded to the nearest millimeter.[12] Weight was recorded to the nearest half pound. Bar calipers were used for measurements of hand and chest width, while for arm span and height a meter stick was used. All measurements were taken in accordance with techniques established by Hrdlička.[13]

Standing height was measured with the subject in his stockinged feet and with his heels, buttocks, back, and head in contact with the meter stick which had been placed against the wall.[14] Fencers had a mean height of 176.544 centimeters, while that of the nonfencers was 178.4. Neither the F nor the "t" indicated that the

---

[12] M. L. Tildesey, "Choice of the Unit of Measurement in Anthropometry," Man, XLVII (May, 1947), pp. 72-77.

[13] Ales Hrdlička, Practical Anthropometry (third edition; Philadelphia: The Wistar Institute of Anatomy and Biology, 1947), pp. 82-99.

[14] Illustration 5.

ILLUSTRATION 5.

METHOD OF MEASURING STANDING HEIGHT

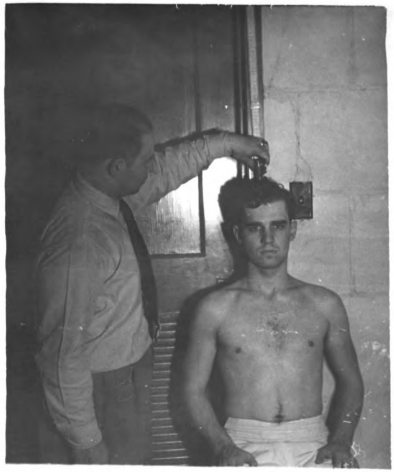


ILLUSTRATION 6.

METHOD OF MEASURING SITTING HEIGHT

variances in mean scores of the fencers were significantly different from those of the nonfencers.

Sitting height was measured with the subject sitting on a bench with his buttocks, back, and head in contact with a meter stick placed against the wall.[15] Again the F and "t" were not significant.

Weight was recorded to the nearest half pound and the fencers averaged 161.24 to the nonfencers' 159.46. As in the previous measures, neither the F nor the "t" was significant.

To enable one to form a crude idea of the body build of the two groups, chest width was added to the other measures. This measurement was taken with the bar calipers at the fourth rib, pressed rather firmly against them.[16] The measurement was taken in the period between exhalation and inhalation. The means were very nearly the same for the two groups: 30.652 for the fencers, and 29.032 for the nonfencers. Although the F was significant at the 0.01 level, the "t" indicated that the difference in means might be due to chance.

---

[15] Illustration 6.

[16] Illustration 7.

ILLUSTRATION 8.

METHOD OF MEASURING ARM SPAN

ILLUSTRATION 7.

MEASURING CHEST WIDTH

ILLUSTRATION 9.

MEASURING HAND WIDTH

Arm span was measured with the subject's arms and hands extended and, with his chest, in contact with a meter stick placed against the wall.[17] The measurement was taken from the tip of one middle finger to the tip of the other. As in height, the nonfencers recorded about two centimeters more than the fencers, although the difference was not significant.

It was thought by some expert fencers that the width of hand[18] may be some indication of the success to be enjoyed in the sport. However, neither the F nor the "t" would indicate that fencers and nonfencers differ in this measure. The range for the fifty subjects was but 2.1 centimeters.

TABLE II

SIGNIFICANCE OF F AND "t" FOR ANTHROPOMETRIC MEASUREMENTS

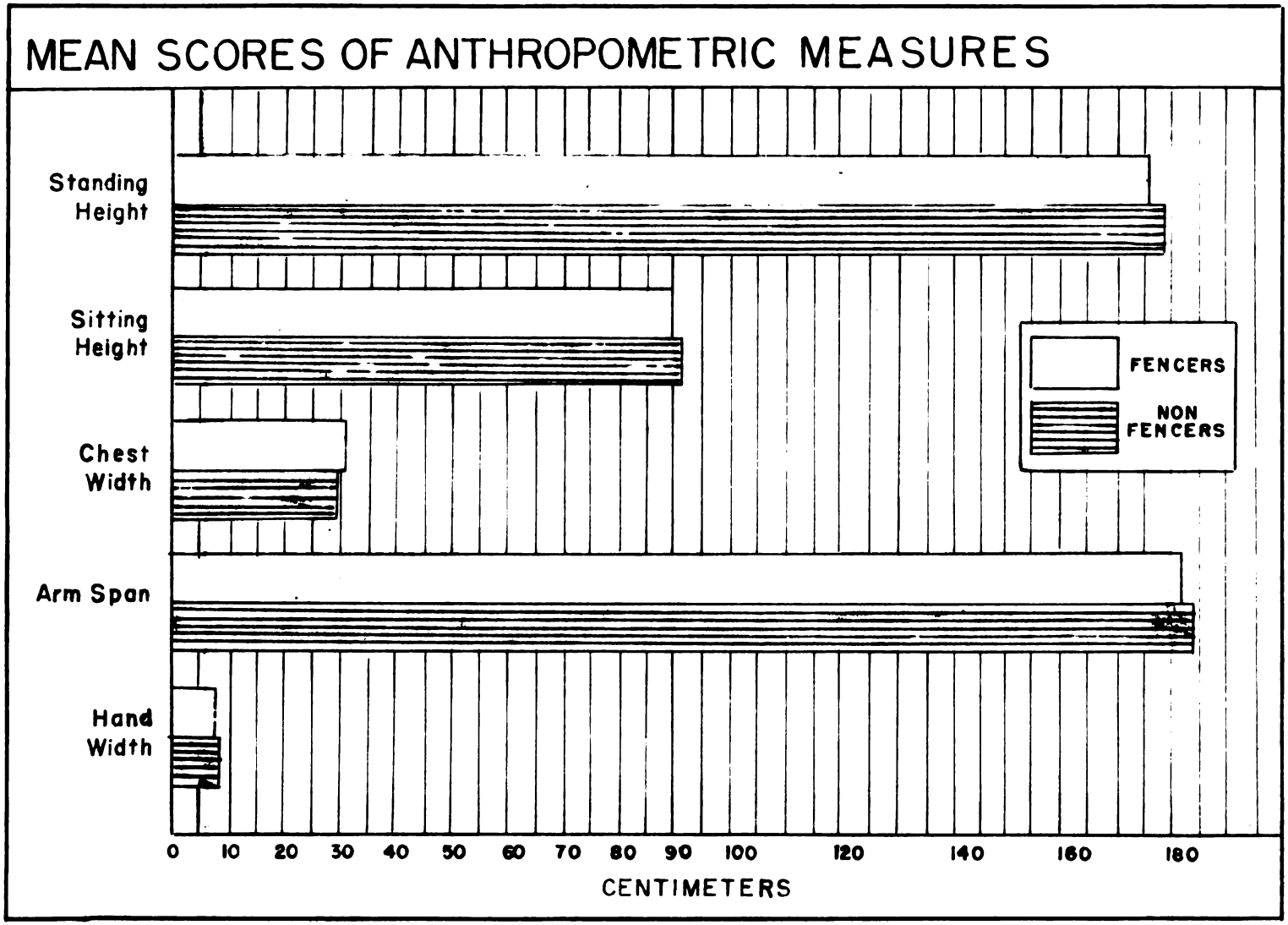
	Standing Height	Sitting Height	Weight	Chest	Span	Hand
F	1.233	1.928	1.321	3.358	1.531	1.16*
"t"	0.347	1.399	0.316	0.666	1.002	1.93

* For critical scores see Table I.

[17] Illustration 8.

[18] Illustration 9.

FIGURE 3.


MEAN SCORES OF ANTHROPOMETRIC MEASURES
Standing Height
Sitting Height
Chest Width
Arm Span
Hand Width
FENCERS
NON FENCERS
0 10 20 30 40 50 60 70 80 90 100 120 140 160 180
CENTIMETERS

Summary. Although the mean scores would indicate that the nonfencer is slightly taller and weighs a little less than the fencer, none of the items measured indicated that there is any difference that could not be due to chance.

Further Analysis of the Data

Information of secondary importance was the intercorrelation of various measures. Although these measures might not differentiate between fencers and nonfencers, certain conclusions which may be pertinent to the study might be drawn from their correlation. In addition, the correlation might be a check on some of the other results. Because the fencers and nonfencers in most instances were significantly different in variance or mean scores, it was decided to compute coefficient correlations for each group.

The lack of correlation between movement and a-reaction[19] would tend to substantiate the findings of Henry, who used a fractioning technique in determining the two speeds and concluded that they may be considered as independent of each other.[20]

---

[19] Table III.

[20] Franklin M. Henry, "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, XXIII (March, 1952), p. 51.

Although M-reaction and a-reaction had but a moderate correlation, it is interesting to note that the addition of Unknown 1 to movement has produced a higher correlation with a-reaction.

Unknown 1 and a-reaction had a correlation that was significant for both fencers and nonfencers. The difference between this coefficient and that of Movement and a-reaction may be due to chance or it might be due to the fact that the two groups differ most significantly in Movement and the subtraction of it from Movement-reaction leaves something very similar to a-reaction.

TABLE III

INTERCORRELATIONS

	M; a	M-r; a	u-1; a	Span; a	Span; M	b'; Blocks
Fencer	0.00	0.62*	0.51*	0.06	0.00	0.04
Nonfencer	0.02	0.50*	0.72*	-0.05	-0.11	-0.01

* Significant at the 0.01 level.

That length of arm has little to do with speed of movement or reaction is indicated by the lack of correlation in these measures. This does not imply that a person with long arms can fully extend as fast as can one with short arms.

The lack of correlation between the "Blocks Test" b'-reaction might indicate that different, at least in extent, physical and mental qualities are involved in discriminatory choice reactions and serial reactions.

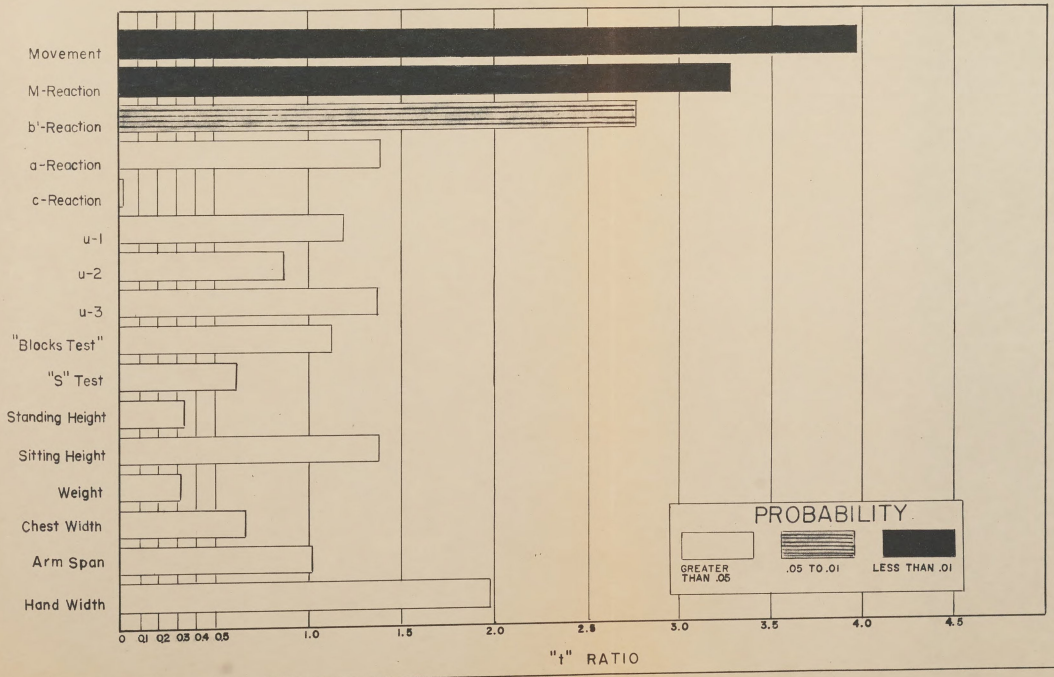
Discussion of Results

Of all the measures noted--psychological, physiological, and anthropometric--it was only in those measures involving speed of arm movement where differences between fencers and nonfencers was probably not due to chance. Further, when Movement time was subtracted from the M-reaction and b'reaction, the remainder showed no differentiation. It appears then that the only factor in which the two groups differ is speed of arm movement. This would tend to discredit the theories that fencing quickens the reactions. The lack of a significant difference in results of the McCloy "Blocks Test" would indicate that fencing does not make possible more rapid correct judgments, at least not as measured by this test.

Choosing tall men for épée and short men for foil, a custom followed by many coaches, appears to be detrimental to their best interests as evidenced by the fact that there is no correlation between speed of arm movement and length of arm. Tall men, being nearer

FIGURE 4.

MEASURES OF SIGNIFICANCE



to the target than their opponent in foil, have a natural advantage which they lose when placed in épée, where each is the same distance from the target.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Twenty-five fencers and twenty-five nonfencers were measured under laboratory conditions and a statistical comparison of the data was made. The two groups were compared as to psychomotor qualities, which included (1) Movement, (2) Movement-reaction, (3) discrimination and choice movement reaction, (4) finger-press reaction, (5) discriminatory reaction, (6) three unknown factors derived from the foregoing measures, (7) the McCloy "Blocks Test," (8) the Thurstone "S" test and as to anthropometric measures of (1) standing height, (2) sitting height, (3) weight, (4) arm span, (5) chest width, and (6) hand width. Correlations of certain measures which seemed pertinent were made.

Conclusions

On the basis of the statistical analysis of the data it is possible to draw the following conclusions:

1. Fencers are significantly faster than nonfencers in those measures which involve movement of the arm. These would include Movement, M-reaction, and b'-reaction.

2. Fencers and nonfencers do not differ in reaction or discriminatory reaction time when it is measured by the finger-press.

3. There is no psychomotor measure which might be determined by the subtractive method, which would indicate an unknown quality in which fencers are superior to nonfencers. This discredits the theory of an increase in the speed of perception.

4. Fencers are not any more endowed with "athletic intelligence," as measured by the McCloy "Blocks Test," than are nonfencers.

5. Fencers do not differ from the general population in the primary mental ability S_1 as measured by the "S" portion of the SRA Primary Mental Abilities test.

6. There are no significant differences in the height, weight, arm span, chest width, or hand width of fencers and nonfencers.

7. There is no correlation in either fencers or nonfencers for speed of arm movement and reaction time, speed of arm movement and arm length, or reaction time and arm length.

8. The same psychological factors, or different factors having the same speed, operate in both u-l and a-reaction to about the same degree.

9. Identical psychological factors do not operate, at least not to the same extent, in the b'-reaction and the McCloy "Blocks Test."

Recommendations

Although the differences between fencers and nonfencers were discussed, it was not the purpose of this study to determine if these differences were inherent, the outcome of training, or the result of fencing. A study to determine the cause could be done by following the progress of a required physical education class in fencing. Such a study would also be a check of the results obtained in this one.

During the course of the study, other measures were noted where differences between fencers and nonfencers might exist. Tests of those measures would be (1) a test of leg movement and reaction such as described by Cureton,[1] (2) a test of body agility, (3) a test

---

[1] Thomas K. Cureton, Physical Fitness of Champion Athletes (Urbana: The University of Illinois Press, 1951), p. 94.

of perceptual speed such as the Navy's tachistoscope or the Thurstone "P" test,[2] and (4) a test of kinesthesis.

[2] L. L. Thurstone, "Some Primary Abilities in Visual Thinking," University of Chicago Psychometric Laboratory Reports, No. 59 (August, 1950), p. 1.

BIBLIOGRAPHY

Books

Arkin, Herbert, and Raymond R. Colton. Statistical Methods. New York: Barnes and Noble, Inc., 1950. 47 pp.

_____. Tables for Statisticians. New York: Barnes and Noble, Inc., 1950. 152 pp.

Barbasetti, Luigi. The Art of the Foil. New York: E. P. Dutton and Company, Inc., 1932. 276 pp.

_____. The Art of the Sabre and the Epee. New York: E. P. Dutton and Company, Inc., 1936. 170 pp.

Berriman, M. W., Capt. The Militiaman's Manual and Swordplay Without a Master. New York: D. Van Nostrand, 1864. 107 pp.

Best, Charles H., and Norman B. Taylor. The Living Body. New York: Henry Holt and Company, 1944. 571 pp.

Bills, Arthur G. General Experimental Psychology. New York: Longmans, Green and Company, 1934. 620 pp.

Blakeslee, Fred G. Sword Play for Actors. New York: The M. W. Hazen Company, 1905. 188 pp.

Bovard, John F., Fredrick W. Cozens, and E. Patricia Hagman. Tests and Measurements in Physical Education. 3d ed.; Philadelphia: W. B. Saunders Company, 1949. 410 pp.

Breckinridge, Scott D., and Scott D. Breckinridge, Jr. Sword Play. New York: A. S. Barnes and Company, 1941. 100 pp.

Butsch, R. L. C. How to Read Statistics. Milwaukee: The Bruce Publishing Company, 1946. 184 pp.

Carr, Harvey A. An Introduction to Space Perception. New York: Longmans, Green and Company, 1935. 413 pp.

Castello, Julio M. The Theory and Practice of Fencing. New York: Charles Scribner's Sons, 1933. 272 pp.

Cléry, Raoul, Lt. Traité d'Escrime de Pointe. Paris: Société Française de Presse, 1948. 80 pp.

Cureton, Thomas K. Masters Theses in Health, Physical Education, and Recreation. Washington: American Association for Health, Physical Education and Recreation, 1952. 292 pp.

_____. Physical Fitness Appraisal and Guidance. St. Louis: The C. V. Mosby Company, 1947. 558 pp.

_____. Physical Fitness of Champion Athletes. Urbana: The University of Illinois Press, 1951. 458 pp.

Deladrier, Clovis, Modern Fencing. Annapolis, Maryland: United States Naval Institute, 1948. 289 pp.

Drever, James. A Dictionary of Psychology. Harmondsworth, England: Penguin Books, Ltd., 1952. 315 pp.

Edwards, Allen L. Experimental Design in Psychological Research. New York: Rinehart and Company, Inc., 1950. 446 pp.

_____. Statistical Analysis. New York: Rinehart and Company, Inc., 1946. 360 pp.

Gates, Arthur I. Variations in Efficiency During the Day. Berkeley: University of California Press, 1916. 156 pp.

Gaudin, Lucien, and Gilbert Gros. L'Escrime. Paris: Librairie S. Bornemann, 1949. 32 pp.

Greco, Agesilao. La Spada e la sua Disciplina d'Arte. Rome: G. U. Nalato, 1912. 148 pp.

_____. La Spada nella sua Realtá. Rome: Casa Editrice Pinciana, 1930. 210 pp.

Hoerr, Normand L., and others, editors. Blakiston's Pocket Medical Dictionary. New York: The Blakiston Company, 1952. 1005 pp.

Hrdlička, Ales, Practical Anthropometry. 3d. ed.; Philadelphia: The Wistar Institute of Anatomy and Biology, 1947. 230 pp.

Kufahl, Hans. Der Fechtsport. Leipzig: Grethlein and Company, n.d. 150 pp.

Larson, Leonard A., and Rachael D. Yocum. Measurement and Evaluation in Physical, Health, and Recreation Education. St. Louis: The C. V. Mosby Company, 1951. 507 pp.

Lawther, John D. Psychology of Coaching. New York: Prentice-Hall, Inc., 1951. 333 pp.

Lipovetz, Ferd J. Medical Physical Education. Minneapolis: Burgess Publishing Company, 1946. 417 pp.

Mitchell, Elmer D., ed. Sports for Recreation. New York: A. S. Barnes and Company, 1936.

Marshall, Clyde, and Edgar L. Lazier. An Introduction to Anatomy. Philadelphia: W. B. Saunders Company, 1946. 418 pp.

Nadi, Aldo. On Fencing. New York: G. P. Putnam's Sons, 1943. 300 pp.

Parise, Masaniello. Das Fechten mit Degen und Säbel. Leipzig: F. W. Gloeckner and Company, n.d. 160 pp.

Reynolds, F. C. The Book of the Foil. London: Ernest Benn Ltd., 1932. 219 pp.

Ruch, Floyd L., Psychology and Life. 3d ed.; Chicago: Scott, Foresman and Company, 1948. 782 pp.

Schneider, Edward C., and Peter V. Karpovich. Physiology of Muscular Activity. Philadelphia: W. B. Saunders Company, 1949. 346 pp.

Stevens, S. S., ed. Handbook of Experimental Psychology. New York: John Wiley and Sons, Inc., 1951. 1436 pp.

Strausbaugh, Perry D. Elements of Biology. New York: John Wiley and Sons, Inc., 1944.

Thurstone, L. L. A Factorial Study of Perception. Chicago: The University of Chicago Press, 1944. 148 pp.

Thurstone, L. L., and Thelma G. Thurstone. Factorial Studies of Intelligence. Chicago: The University of Chicago Press, 1941. 94 pp.

Woodworth, Robert S., Psychology. New York: Henry Holt and Company, 1945. 639 pp.

_____. Experimental Psychology. New York: Henry Holt and Company, 1938. 889 pp.

Parts of Series

Breitweiser, J. V. Attention and Movement in Reaction Time. Archives of Psychology, No. 18. New York: The Science Press, August, 1911. 49 pp.

Evans, John E. The Effect of Distraction on Reaction Time. Archives of Psychology, No. 37. New York: The Science Press, November, 1916. 106 pp.

Hollingsworth, H. L. The Inaccuracy of Movement. Archives of Psychology, No. 13. New York: The Science Press, June, 1909. 87 pp.

Marsh, Howard D. The Diurnal Course of Efficiency. Archives of Philosophy, Psychology, and Scientific Method, No. 7. New York: The Science Press, July, 1906. 50 pp.

Poffenberger, A. T. Reaction Time to Retinal Stimulation. Archives of Psychology, No. 23. New York: The Science Press, July, 1912. 73 pp.

Thurstone, L. L. Primary Mental Abilities. Psychometric Monographs, No. 1. Chicago: The University of Chicago Press, 1938. 121 pp.

_____. Primary Mental Abilities. University of Chicago Psychometric Laboratory Reports, No. 50. Chicago: University of Chicago Press, September, 1948. 10 pp.

_____. Some Primary Abilities in Visual Thinking. University of Chicago Psychometric Laboratory Reports, No. 59. Chicago: The University of Chicago Press, August, 1950. 9 pp.

Todd, John W. Reaction to Multiple Stimuli. Archives of Psychology, No. 25. New York: The Science Press, August, 1912. 65 pp.

Periodicals

Baxter, Brent. "A Study of Reaction Time Using Factorial Design," Journal of Experimental Psychology, XXXI (November, 1942), 430-437.

Burpee, Royal H., and Wellington Stroll. "Measuring Reaction Time of Athletes," The Research Quarterly, VII (March, 1936), 110-118.

Davis, R. C. "The Pattern of Muscular Action in Simple Voluntary Movement," Journal of Experimental Psychology, XXXI (November, 1942), 347-366.

DiGiovanna, Vincent. "The Relation of Selected Structural and Functional Measures to Success in College Athletics," The Research Quarterly, XIV (May, 1943), 199-216.

Donders, F. C. "Die Schnelligkeit psychisher Processe," Archiv für Anatomie und Physiologie (1892), 657-681.

Elbel, E. R. "A Study of Response Time Before and After Strenuous Exercise," The Research Quarterly, X (March, 1939), 35-50.

Everett, Peter W. "The Prediction of Baseball Ability," The Research Quarterly, XXIII (May, 1947), 15-19.

Farnesworth, Paul, Robert Seashore, and Miles Tinker. "Speed in Simple and Serial Action as Related to Performance in Certain 'Intelligence Tests,'" Pedagogical Seminary, XXIV (1927), 537-551.

Flanagan, Lance. "A Study of Some Personality Traits of Different Physical Activity Groups," The Research Quarterly, XXII (October, 1951), 312-323.

Freeman, G. L., and W. E. Kendall. "The Effect Upon Reaction Time of Muscular Tension Induced at Various Preparatory Intervals," Journal of Experimental Psychology, XXVII (August, 1940), 136-148.

Garrett, Henry E. "Variability in Learning Under Massed and Spaced Practice," Journal of Experimental Psychology, XXVII (June, 1940), 547-567.

Hanson, C. F. "Serial Action as a Basic Measure of Motor Ability," Psychological Monographs, XXXI (1922), 320-382.

Henry, Franklin M. "Independence of Reaction and Movement Times and Equivalence of Sensory Motivators of Faster Response," The Research Quarterly, XXIII (March, 1952), 43-53.

_____. "The Loss of Precision from Discarding Discrepant Data," The Research Quarterly, XXI (May, 1950), 145-152.

Jarnoff, Irma Z., Lloyd H. Beck, and Irvin L. Child. "The Relation of Somatotype to Reaction Time, Resistance to Pain, and Expressive Movement," Journal of Personality, VIII (June, 1950), 454-460.

Judd, C. H., C. H. McAllester, and M. W. Steele. "Analysis of Reaction Movements," Psychological Monographs, VII (1905), 141-184.

Keller, Louis F. "The Relation of 'Quickness of Bodily Movement' to Athletic Success," The Research Quarterly, XIII (May, 1942), 146-155.

Lange, Ludwig. "Neue Experimente über den vorgang der einfachen Reaction auf Sinneseindrüke," Philopische Studien, IV (1888), 479-510.

Lanier, Lyle H. "The Interrelations of Speed of Reaction Measurements," Journal of Experimental Psychology, XVII (April, 1934), 371-399.

Loveless, James C. "Relationship of the War-Time Navy Physical Fitness Test to Age, Height, and Weight," The Research Quarterly, XXIII (October, 1952), 347-355.

McCloy, Charles H. "A Preliminary Study of Factors in Motor Educability," The Research Quarterly, XI (May, 1940), 28-39.

_____. "'Blocks Test' of Multiple Response," Psychometrika, VII (September, 1942), 165-169.

_____. "The Measurement of Speed in Motor Performance," Psychometrika, V (September, 1940), 173-179.

Miles, W. R. "Studies in Exertion II. Individual and Group Reaction Time in Football Charging," The Research Quarterly, II (October, 1931), 5-14.

Nakamura, H. "An Experimental Study of Reaction Time of the Start in Running a Race," The Research Quarterly, V (March, 1934), 33-35.

Rarick, Lawrence. "An Analysis of the Speed Factor in Simple Athletic Activities," The Research Quarterly, VIII (December, 1937), 89-105.

Riopelle, Arthur J. "Psychomotor Performance and Distribution of Practice," Journal of Experimental Psychology, XL (June, 1950), 390-395.

Seashore, Robert. "Techniques for Measuring Serial Action," Journal of Experimental Psychology, XI (February, 1928), 45-55.

Sheffield, Fred D. "Spread of Effect Without Reward or Learning," Journal of Experimental Psychology, XXXIX (August, 1949), 575-579.

Smith, Carnie H. "Influence of Athletic Success and Failure on the Level of Aspiration," The Research Quarterly, XX (May, 1949), 196-208.

Solomon, Richard. "A Note on the Alternation of Guesses," Journal of Experimental Psychology, XXXIX (June, 1949), 322-326.

Telford, C. W. "The Refractory Phase of Voluntary and Associative Responses," Journal of Experimental Psychology, XIV (February, 1931), 10-17.

Tildesey, M. L. "Choice of the Unit of Measurement in Anthropometry," Man, XLVII (May, 1947), 72-77.

Twining, W. E. "Mental Practice and Physical Practice in Learning a Motor Skill," The Research Quarterly, XX (December, 1949), 432-435.

Weaver, Herbert B. "A Study of Discriminative Serial Action," Journal of Experimental Psychology, XXXI (September, 1942), 195-201.

Woodrow, H. "The Measurement of Attention," Psychological Monographs, XVII (1914), 1-158.

Unpublished Materials

Cowan, Robert A. "A Study of Diurnal Variations, the Effect of Different Methods of Breathing and Exercise on the Accuracy of Movement of the Upper Extremities." Unpublished Master's Thesis, State University of Iowa, Iowa City, 1931. 45 printed pages.

Friedman, Edward D. "The Relationship of Reaction Time to General Athletic Ability." Unpublished Master's Thesis, New York University, New York, 1937. 70 printed pages.

Peterson, Arthur A. "The Accuracy of the Arms in Fast and Slow Movements." Unpublished Master's Thesis, State University of Iowa, Iowa City, 1931.

Smith, Stanley M., "The 'Blocks Test' as a Measure of Adaptive Athletic Response." Unpublished Master's Thesis, State University of Iowa, Iowa City, 1943. 22 printed pages.

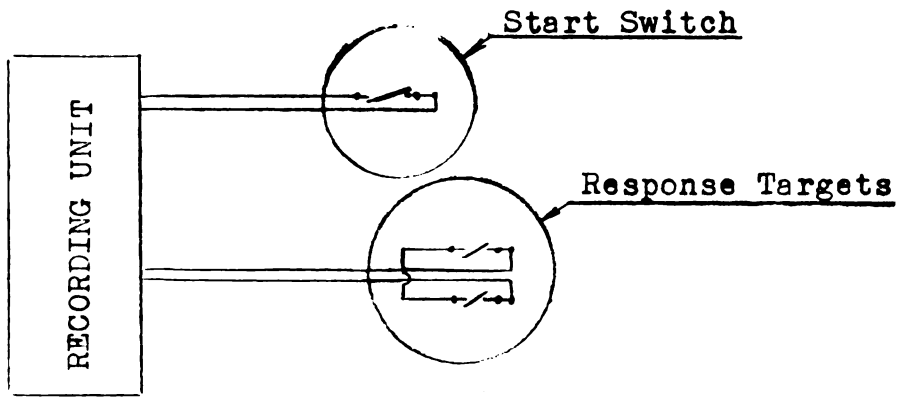
Wiebe, Vernon R. "A Study of Tests of Kinesthesis." Unpublished Master's Thesis, State University of Iowa, Iowa City, 1951.

APPENDIXES

APPENDIX A

1. Circuit Diagrams.
2. Learning Curves.
3. The McCloy "Blocks Test."
4. The Thurstone "S" Test.
5. Self-Interpreting Profile for the "S" Test.

a. Circuit Diagram for Movement Timing



b. Circuit Diagram for Movement-reaction and Discrimination and choice movement-reaction

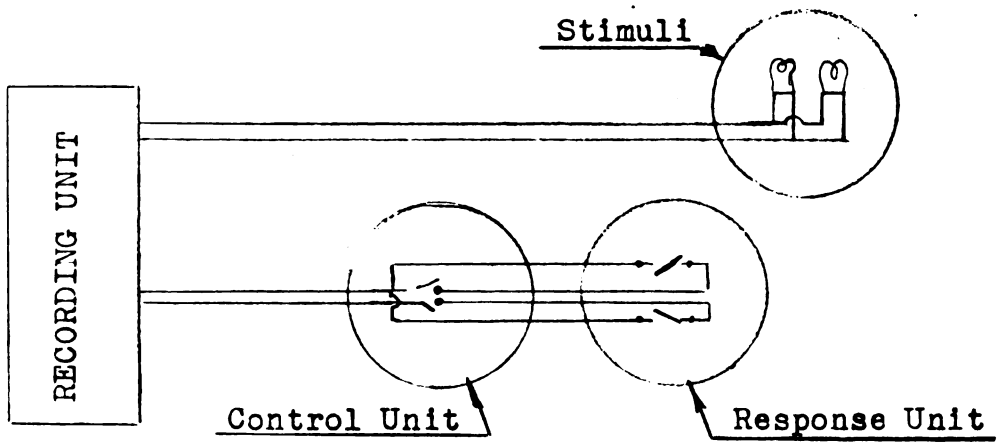


FIGURE 5.

CIRCUIT DIAGRAMS

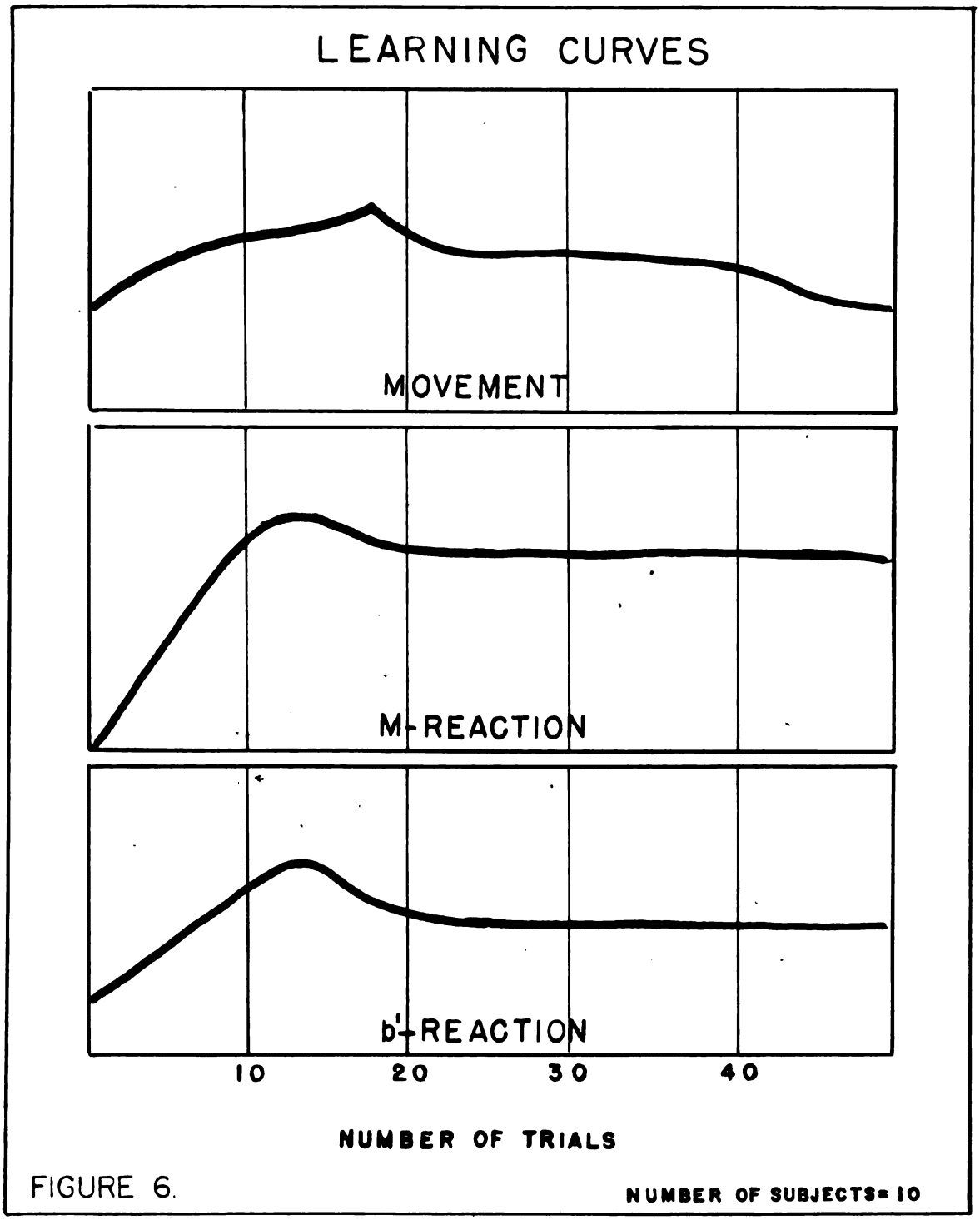

LEARNING CURVES
MOVEMENT
M-REACTION
b'-REACTION
10
20
30
40
NUMBER OF TRIALS
NUMBER OF SUBJECTS= 10

FIGURE 6.

"BLOCKS TEST" OF MULTIPLE RESPONSE[1]

Construction Prepare 24 blocks of wood, about 3 inches square and 1 inch thick. Paint the tops of 6 of these blocks red; 6, white; 6, blue; and 6, green. The bottoms of these blocks are painted in the same four colors according to the pattern given in Table 1. In this table the asterisk preceding the color placed on the bottom of the block means that a black ring is painted around the color on the bottom. This black color should not be on the edge of the block and should not be visible when the block is on the table. Serial numbers about 1/2 inch high should be painted in black on the tops of the blocks in order to facilitate the arrangement of the blocks in their proper order.

Administration This test is designed to measure speed in the making of correct choices, complicated partly by motor actions and partly by memory of the color-sequence. It can be administered rather rapidly, though it is primarily a research tool and will probably be used mainly as such. The blocks are placed about 3 inches apart in two rows across the table in front of the subject. The arrangement is as follows:

1 3 5 7 9 11 13 15 17 19 21 23
2 4 6 8 10 12 14 16 18 20 22 24

To take the test, the subject first memorizes the order of the colors: red, white, blue, green; red, white, blue..... The subject, being timed in seconds, should be allowed one practice and two test trials. If he makes an error, he must correct it before going on.

Standardized Directions (While giving directions, perform the indicated actions) "This is a test of how rapidly you can make decisions that involve intelligent choice, and act on them. You will note that these blocks are arranged in two rows, and that going in this order (point), the colors on the top are red, white, blue, green, red white, etc. The bottom of each block is painted one of these four colors, also, but it may be any one of the four colors, regardless of the color on top. On some of the blocks, in addition to the color on the bottom, there is a black circle.

"In taking this test, pick up this first (red) block (pick it up), raise it, and look at the bottom. Then put it back again, and pick up the block beyond, that is, one color <u>beyond</u> the color on the bottom of the block in the red, white, blue, green, red sequence: e.g., the bottom of the first block is blue, so you pick up the next block with a green top; if the bottom of the block is green, pick up the next block whose top is red in color. <u>If</u>, however, the bottom of the block has a black ring on it, pick up the next color in the sequence, but <u>before</u> the block you have picked up; e.g., if I pick up this block (pick up No. 9), you note that the bottom is blue with a black ring. You would then pick up this one (No. 8), whose top is green--the next color in the sequence.

[1] C. H. McCloy, "'Blocks Test' of Multiple Response", <u>Psychometriks</u>, VII (September, 1942), 165-169.

"Now let us try one or two. If I pick up this one (pick up No. 11), turn it over and show that the bottom is red), which one should I pick up next? That is correct, I should pick up this one (No. 14). If I pick up this one (pick up No. 19, which has a red bottom with a black ring), which would I pick up next? That is correct, it would be this one (No. 18).

"Is the method clear now? All right, begin with this one (No. 1) and continue to the end on the right."

(Note: Continue with the demonstration until the subject gives evidence that he understands the procedure.)

Table 1

Block Number	Top	Bottom	Number on Bottom
1	red	blue	1
2	white	any color	
3	blue	green	4
4	green	red	2
5	red	white	5
6	white	*white	3
7	blue	green	6
8	green	red	8
9	red	*blue	7
10	white	white	9
11	blue	red	10
12	green	green	12
13	red	white	13
14	white	*blue	11
15	blue	green	14
16	green	any color	
17	red	white	15
18	white	blue	17
19	blue	*red	16
20	green	green	18
21	red	white	19
22	white	blue	21
23	blue	*red	20
24	green	any color	22

Table 2

Correct Order of Responses

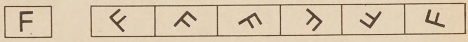
Block Number	Color on Top	Color on Bottom	Block Number	Color on Top
Pick up 1	red	blue	go to 4	green
Pick up 4	green	red	go to 6	white
6	white	*white	3	blue
3	blue	green	5	red
5	red	white	7	blue
7	blue	green	9	red
9	red	*blue	8	green
8	green	red	10	white
10	white	white	11	blue
11	blue	red	14	white
14	white	*blue	12	green
12	green	green	13	red
13	red	white	15	blue
15	blue	green	17	red
17	red	white	19	blue
19	blue	*red	18	white
18	white	blue	20	green
20	green	green	21	red
21	red	white	23	blue
23	blue	*red	22	white
22	white	blue	24	green

SPACE

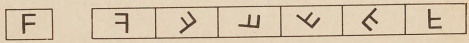
3

PRACTICE EXERCISES

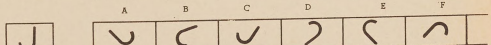
Look at the row of figures below. The first figure is like the letter F. All the other figures are like the first one, but they have been turned in different directions.



Now look at the next row of figures. The first figure is like the letter F. But none of the other figures looks like an F, even if they were turned right side up. They are all made backward.

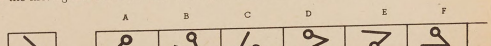


Some of the figures in the next row are like the first figure. Some are made backward.



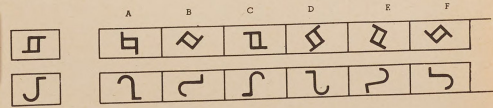
Figures C, E, and F are LIKE the first figure. X's have been marked in [C], [E], and [F] on the Answer Pad. Notice that ALL the figures which are LIKE the first figure have been marked.

In the row of figures below, mark an X in the box of EVERY figure which is LIKE the first figure. Do NOT mark the figures which are made backward.



You should have marked an X in [A] and in [E].

In the two rows below, mark an X in the box of EVERY figure which is LIKE the first figure in that row. If you wish to change an answer, draw a circle around this box like ⊗. Then mark the new answer in the usual way.



In the first row, you should have marked [A], [D], and [F]. In the second row, you should have marked [C] and [F].

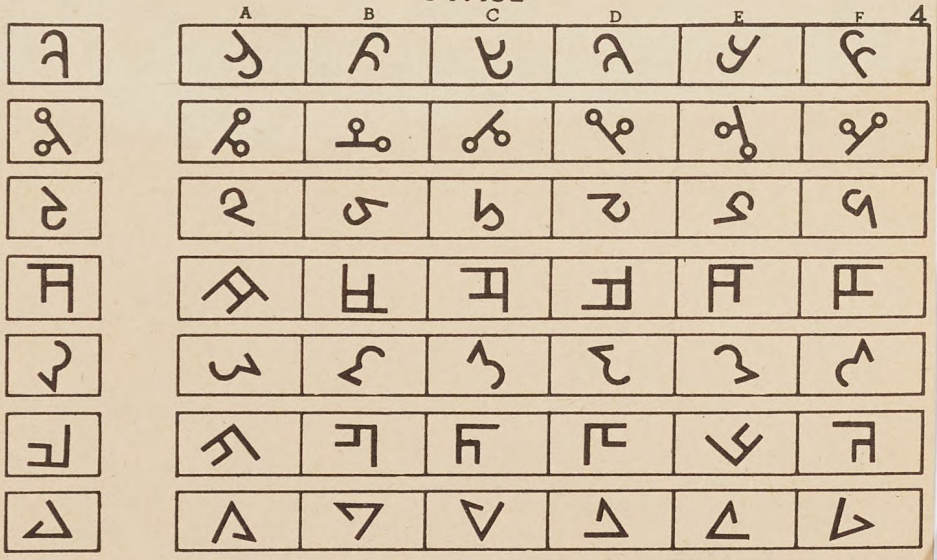
Remember that in each row, there may be any number of figures LIKE the first one.

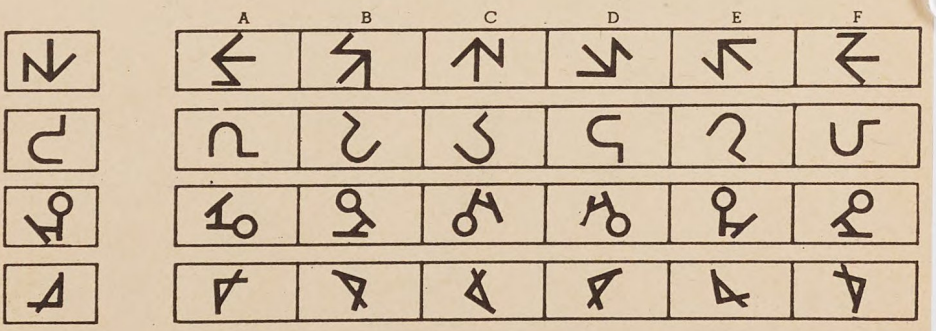
Be sure you understand how to work this kind of problem. When the examiner gives the signal, you are to work more problems like those above.

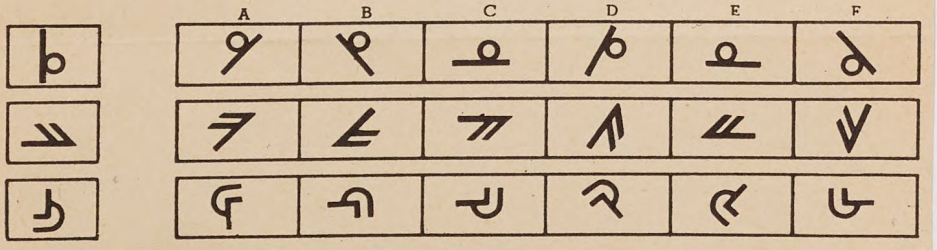
Work quickly, but try not to make mistakes. You will have 5 minutes for the test. You are not expected to finish in the time allowed.

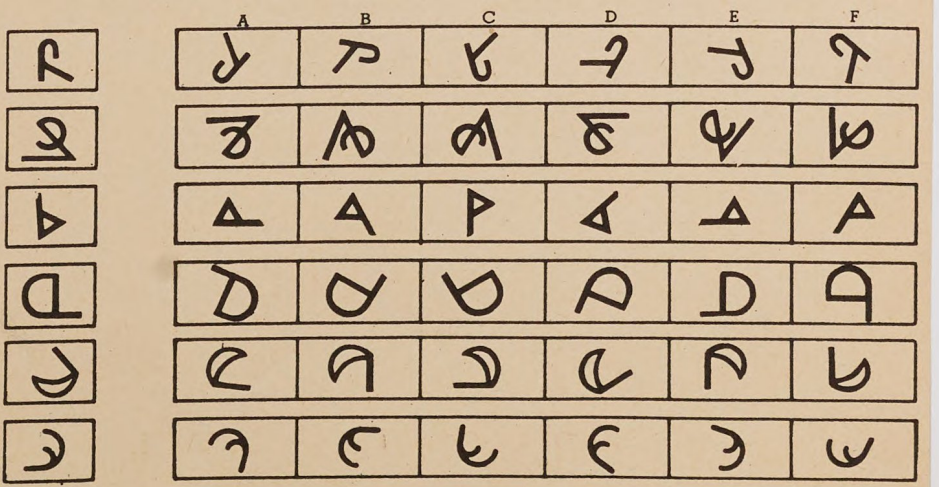
STOP HERE—DO NOT TURN THE PAGE UNTIL THE EXAMINER TELLS YOU

SPACE









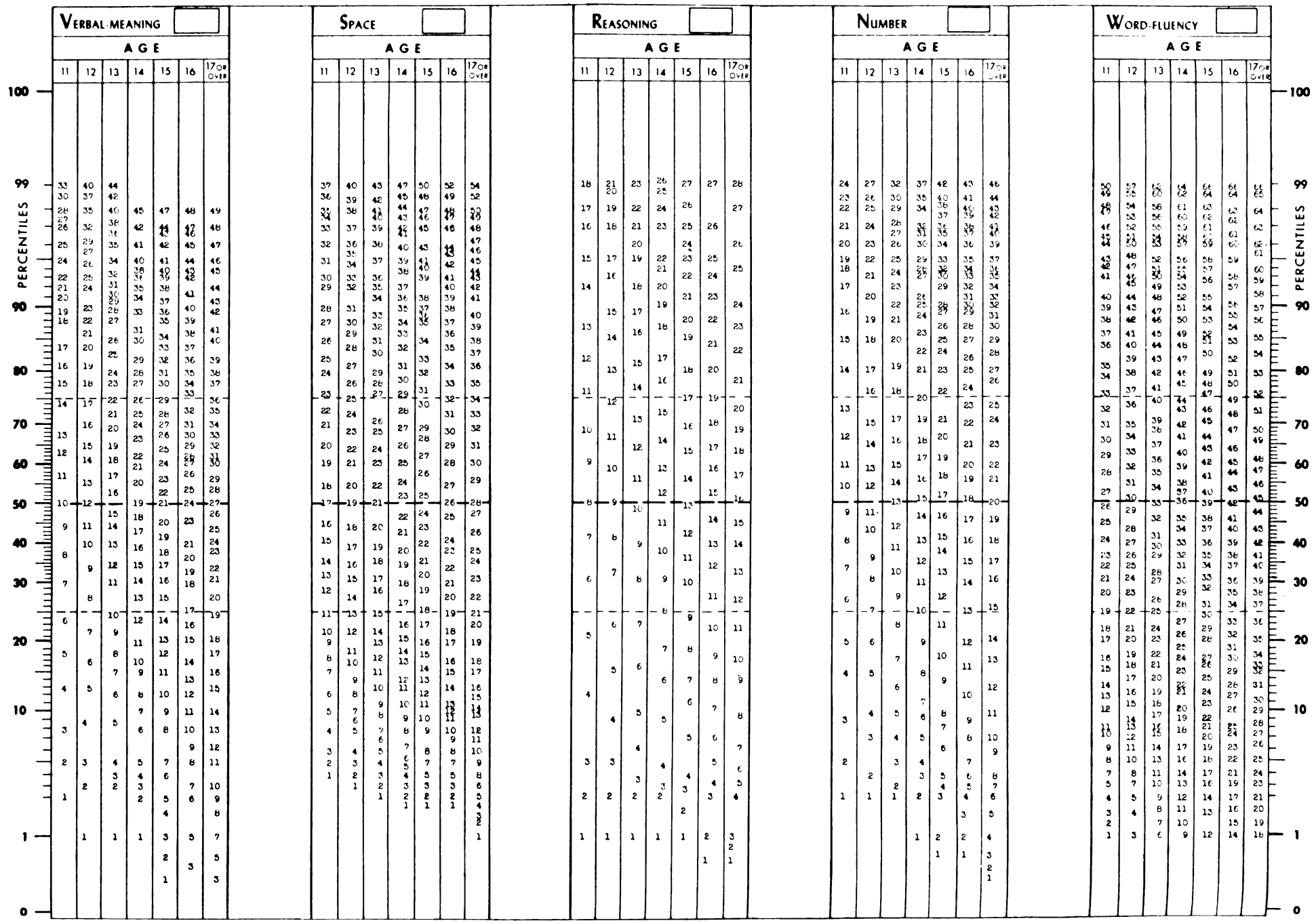
STOP HERE—DO NOT TURN THE PAGE UNTIL THE EXAMINER TELLS YOU

SELF-INTERPRETING PROFILE for the SRA PRIMARY MENTAL ABILITIES—Intermediate—For Ages 11-17

Revised August, 1949

NAME _____ _____ _____ GROUP _____ AGE _____ DATE _____

PRINT Last First Initial (At *last* birthday)



T-100-Q

Your PMA PROFILE

The *SRA Primary Mental Abilities* (PMA's) tell you about your **"intellectual self."** Your PMA Profile shows your present ability to solve **five important types of mental tasks.**

Here is what the *ups* and *downs* on your profile mean:

On each PMA where your score is *above the top dotted line*, you are **high** in that Primary Mental Ability.

If your score is *between the two dotted lines*, you are **about average** in that ability.

If your score is *below the bottom dotted line*, you are **low** in that PMA.

People used to think that intelligence was just one ability, and that every person was born with a certain amount of it that remained about the same throughout life. Now we know that intelligence is made up of many different abilities, and that under certain conditions these abilities can be improved.

Like most people, you are undoubtedly higher in some PMA's than in others. You should concentrate on activities related to your high PMA's, because you probably have the greatest chance for success in these. *The higher you already are in a PMA, the more you probably can increase your ability to solve problems and do good work of that type through further training and practice.* But you should not neglect the PMA's in which you are low. While you may have more trouble with activities in these areas, you can probably improve yourself through training. Through training your Primary Mental Abilities, you are really *learning how to think better*, which is most important for your success in later life.

The paragraphs below tell you what each PMA score means. For easy reference you may enter your percentile ranks in the boxes located at the right of the paragraphs.

V ☐

VERBAL-MEANING is your ability to **understand ideas** expressed in words. It is needed in activities where you get information by reading or listening. High ability in V is especially useful in such school courses as English, foreign languages, shorthand, history, and science. V is needed for success in such careers as secretary, teacher, editor, scientist, librarian, and executive.

S ☐

SPACE is the ability to think about objects **in two or three dimensions.** Blueprint reading, for example, requires this ability. The designer, electrician, machinist, pilot, engineer, and carpenter are typical workers who need ability to visualize objects in space. S is helpful in geometry, mechanical drawing, art, manual training, radar, physics, and geography classes.

R ☐

REASONING is the ability to **solve logical problems**—*to foresee and plan*. It is the ability that helps to make inventors, doctors, teachers, executives, statesmen, scientists, and supervisors outstanding. The higher you go in school, the more R you need for success. Understanding science and mathematics takes a lot of R.

N ☐

NUMBER is the ability to **work with figures**—*to handle simple quantitative problems rapidly and accurately*. Accountants, cashiers, comptometer operators, bookkeepers, bank tellers, salesclerks, and inventory clerks should be high in N. NUMBER ability is useful for success in business arithmetic, accounting, bookkeeping, and statistics.

W ☐

WORD-FLUENCY is the ability to **write and talk easily**. People to whom words come rapidly and fluently are high in W. Careers requiring W include actor, stewardess, reporter, comedian, salesman, writer, and publicity man. Being high in W should help you in drama classes, public speaking, radio acting, debate, speech, and journalism.

The scores in these five areas give you a **general picture** of your present ability to deal with intellectual problems. While the results of your work on this test are important, these PMA scores should not be considered the *only* index of your likely success in school or in later life. There are other areas of intelligence which were not measured here. Tests for them would take too long to administer. Other factors, such as your personality, vocational interests, and how hard you work also have an important bearing upon your chances of success.

The *SRA Primary Mental Abilities* are merely a **shortcut** for finding out about your **"intellectual self."** They help you *to understand yourself better*—and thus to recognize your strengths and weaknesses. They can assist you in planning your school courses, career choices, and leisure activities wisely. **The better you know yourself, the more successful and satisfied you can become.**

APPENDIX B

1. Raw Scores of Fencer Group.
2. Raw Scores of Nonfencer Group.
3. Computational Data.
4. Sequence for Presentation of Stimuli.

TABLE IV

RAW SCORES FOR FENCER GROUP

S No.	M	MR	b'	a	c	u-1	u-2	u-3	BT*	S	I	II	III	IV	V	VI
26	.1670	.3600	.3915	.2240	.2330	.1930	.0315	.0090	117.0	16	170.7	90.8	169.5	30.7	180.6	9.0
27	1520	4110	4545	2405	2480	2590	0435	0075	115.6	24	186.3	95.5	160.0	29.8	188.0	8.6
28	1345	4595	5035	2630	4400	3250	0440	1770	126.0	28	178.3	89.8	140.0	28.7	185.5	9.2
29	1640	3835	4355	2360	3180	2195	0520	0820	87.0	21	175.4	91.0	187.0	31.0	188.4	9.2
30	1560	3585	4450	1865	3020	2025	0865	1155	45.9	29	178.1	92.1	155.0	32.1	175.3	8.8
31	1200	3790	4285	2415	2820	2590	0495	0405	72.7	42	176.6	89.5	158.0	35.9	187.0	8.5
32	1290	3760	4285	2085	2420	2470	0525	0335	90.4	17	160.5	83.6	127.0	27.2	170.1	6.4
33	1735	3605	3900	1920	2430	1870	0295	0510	46.5	29	180.6	92.7	160.0	31.7	182.3	8.7
34	0880	2890	3390	1885	2280	2010	0500	0395	103.6	38	177.1	88.8	150.0	28.2	180.3	8.1
35	1335	3445	4435	2030	3300	2110	0990	1270	59.7	26	180.5	90.5	215.0	32.7	177.4	8.9
36	1360	3705	4250	1995	2350	2345	0500	0355	76.4	37	169.4	86.6	122.5	28.9	176.1	8.0
37	1545	3550	4365	2050	2450	2005	0815	0400	64.1	28	176.9	89.7	165.0	32.0	181.0	8.4
38	1345	3695	4285	2215	3220	2350	0590	1005	72.0	17	180.0	92.7	159.0	30.5	183.1	8.5
39	1520	4170	4895	2390	3790	2650	0725	1400	88.5	34	168.4	89.5	210.0	33.7	169.3	8.2
40	1150	3930	4355	2405	2820	2780	0425	0415	40.0	26	175.1	88.1	146.0	30.5	178.0	8.3
41	1455	3765	4195	2245	3210	2310	0430	0965	98.3	34	172.0	89.4	162.0	29.2	176.4	8.3
42	1755	4245	4585	2100	3290	2490	0340	1190	79.0	34	180.5	92.1	185.0	28.0	197.7	9.4
43	0980	3600	4485	2320	3490	2620	0885	1170	86.9	30	177.7	92.5	163.0	31.4	189.3	8.5
44	1125	3280	3935	2265	3490	2155	0655	1225	89.2	12	163.1	83.7	150.0	35.0	171.2	8.6
45	1490	3965	4555	2250	3220	2475	0590	0970	56.8	20	181.1	92.0	158.0	31.4	186.8	9.2
46	1255	3430	3985	1955	2580	2175	0555	0625	22.0	29	183.5	96.2	160.0	28.5	190.0	8.5
47	1165	3820	4725	2045	2960	2655	0905	0915	41.5	34	178.1	90.2	175.0	31.0	187.7	8.9
48	1075	3265	3730	2200	2760	2190	0465	0560	97.5	30	184.1	77.2	155.0	29.8	185.1	9.0
49	1600	4025	4440	2105	3000	2425	0415	0895	70.3	28	176.5	91.6	145.0	27.1	170.0	8.0
50	1135	2990	3715	1985	2550	1855	0725	0565	51.9	25	184.1	93.5	154.0	31.3	187.7	8.1

* BT is Blocks Test; S is "S"; I is Standing Height; II, Sitting Height; III, Weight; IV, Chest Width; V, Arm Span; VI, Hand Width

TABLE V

RAW SCORES FOR NON-FENCER GROUP

S No.	M	MR	b'	a	c	u-1	u-2	u-3	BT*	S	I	II	III	IV	V	VI
1	1930	.5295	.6005	.3200	.3580	.3365	.0710	.0380	58.6	29	187.4	95.1	179.5	31.2	191.4	10.6
2	1835	3830	5080	2175	2790	1995	1250	0115	62.0	27	180.6	89.3	154.0	30.2	182.8	9.1
3	1710	4765	5895	3880	4170	3055	1130	0290	137.8	-7	166.0	89.4	153.0	29.0	174.1	8.8
4	1820	4910	5205	2175	3280	3090	0295	1105	57.2	42	177.7	91.6	140.0	28.0	183.1	8.5
5	1855	4265	5040	2060	2670	2410	0775	0470	71.0	13	173.9	89.9	150.0	27.2	175.5	8.1
6	1480	4435	4465	2455	2770	2955	0030	0315	118.0	35	182.2	96.2	212.0	33.2	190.6	9.6
7	1705	4030	4510	1955	2290	2325	0480	0335	59.9	3	178.3	92.4	167.5	33.2	183.7	9.9
8	1740	4105	4485	2310	3150	2365	0380	0840	62.2	33	177.3	91.4	142.5	27.8	188.5	9.0
9	2470	4785	5260	2025	2840	2315	0475	0815	62.0	28	177.3	91.1	197.0	32.6	177.3	8.5
10	1680	5170	5465	2260	3130	3490	0295	0870	120.1	29	187.4	91.1	168.0	28.6	193.4	8.9
11	1675	3920	4195	2365	2990	2245	0275	0625	150.0	16	180.0	88.7	147.0	27.8	187.8	8.8
12	1750	4405	4915	2395	2800	2655	0510	0405	109.5	30	175.5	93.5	170.0	29.6	181.2	8.0
13	2420	4785	5945	2615	3640	2365	1160	1025	60.6	22	173.4	88.4	150.0	27.8	180.5	8.9
14	1905	3670	4130	2180	2250	1765	0370	0070	76.8	44	174.8	87.6	135.0	26.8	181.4	8.3
15	1425	3360	4055	1915	2810	1935	0695	0895	110.5	34	178.0	90.5	160.0	33.5	185.6	8.6
16	1420	3815	2955	2125	3050	2395	0140	0925	90.5	46	187.8	95.4	179.0	32.0	193.3	9.1
17	2315	5110	5290	2175	2910	2795	0180	0735	57.2	42	177.7	91.6	140.0	28.0	183.1	8.5
18	1600	3590	3925	2290	2790	1990	0335	0500	73.0	38	182.2	92.3	175.5	32.2	183.3	9.2
19	1055	3160	3625	1870	2470	2105	0475	0600	83.5	29	176.3	93.2	155.0	29.5	176.4	8.4
20	1455	4090	4795	2090	2720	2635	0705	0630	55.6	26	178.0	93.4	160.0	29.7	182.2	8.6
21	1505	3550	4365	2200	3080	2045	0815	0880	63.8	35	180.4	94.0	150.0	29.1	182.6	8.7
22	1660	4315	4835	2365	2910	2655	0520	0545	65.1	42	185.4	95.6	159.5	31.2	180.4	8.9
23	1805	3915	4420	2355	3050	2110	0505	0695	85.4	14	171.1	84.7	138.5	28.1	181.8	8.7
24	1065	3430	4050	2000	2490	2365	0620	0490	57.2	24	173.9	90.8	140.0	28.7	174.1	8.4
25	1290	3695	3925	2125	3290	2405	0230	1165	192.0	27	185.5	91.5	152.5	30.1	194.4	8.7

* For explanation of symbols see Table IV

TABLE VI

COMPUTATIONAL DATA

	ΣX	ΣX^2	M_x	ΣM_x^2	σ
Movement					
Fencers	3.413	.479603	.13652	.0186377104	.02338
Non-fencers	4.257	.754448	.17028	.0289952784	.03438
M-reaction					
Fencers	9.265	3.468529	.3706	.13734436	.03738
Non-fencers	10.440	4.447559	.4176	.17438976	.05927
b'-reaction					
Fencers	10.7095	4.62203075	.42838	.1835094244	.03704
Non-fencers	11.7835	5.66574025	.47134	.2221613956	.06684
a-reaction					
Fencers	5.436	1.1913165	.21744	.0472801536	.01936
Non-fencers	5.756	1.3682995	.23024	.0530104576	.03150
c-reaction					
Fencers	7.384	2.9536	.29536	.0872375296	.04093
Non-fencers	7.392	2.9568	.29568	.0874266624	.03164
Standing Ht.					
Fencers	4413,6	780143.30	176.544	31167.78393	6.16036
Non-fencers	4460,0	796433.06	178.400	31826.56000	5.54707
Sitting Ht.					
Fencers	2249.3	202755.17	89.972	8094.96078	3.90512
Non-fencers	2284.1	208882.11	91.364	8347.38050	2.81140
Weight					
Fencers	4031.0	660763.50	161.24	25998.3376	6.57419
Non-fencers	3986.5	643864.75	159.46	25427.4916	5.71839
Arm Span					
Fencers	4544.3	827319.73	181.772	33041.05998	7.19236
Non-fencers	4591.6	844155.82	183.664	33732.46490	5.81120
Chest Width					
Fencers	766.3	23608.05	30.652	939.54510	2.18563
Non-fencers	750.8	22949.12	30.032	901.92102	4.005
Hand Width					
Fencers	213.3	1828.51	8.532	72.79502	.58770
Non-fencers	221.2	1964.62	8.848	78.28710	.54561

TABLE VI (continued)

COMPUTATIONAL DATA

	ΣX	ΣX^2	M_x	ΣM_x^2	σ
u-1					
Fencers	5.852	1.3957235	.23408	.0547934464	.03217
Non-fencers	6.183	1.5774720	.24732	.0611671824	.04395
u-2					
Fencers	1.440	.9200850	.05760	.0033177600	.01904
Non-fencers	1.336	.9534575	.05342	.0028536964	.03098
u-3					
Fencers	1.948	1.970605	.07792	.0060715264	.03256
Non-fencers	1.572	1.198750	.06288	.0039538944	.02900
"Blocks Test"					
Fencers	1898.8	161069.52	75.952	5768.706304	25.96344
Non-fencers	2148.3	214175.91	85.932	7384.308624	34.3948
"S" Test					
Fencers	692	2036	27.68	766.1824	6.94406
Non-fencers	678	2216	27.12	735.4944	12.28414

TABLE VIII

SEQUENCE FOR PRESENTATION OF STIMULI*

Trial	Stimulus	Trial	Stimulus
1.	Red	21.	Red
2.	Red	22.	Red
3.	Yellow	23.	Yellow
4.	Yellow	24.	Yellow
5.	Red	25.	Red
6.	Yellow	26.	Yellow
7.	Red	27.	Red
8.	Red	28.	Red
9.	Red	29.	Red
10.	Yellow	30.	Yellow
11.	Red	31.	Red
12.	Yellow	32.	Yellow
13.	Yellow	33.	Yellow
14.	Yellow	34.	Yellow
15.	Red	35.	Red
16.	Yellow	36.	Yellow
17.	Yellow	37.	Yellow
18.	Red	38.	Red
19.	Yellow	39.	Yellow
20.	Yellow	40.	Yellow

* For right-handed subjects

APPENDIX C

1. General Recording Form.

2. Recording Form for the Chronoscope.

DATE _____

SUBJECT NUMBER _____ CLASSIFICATION _____

NAME _____

HOME ADDRESS _____ CITY _____ STATE _____

BIRTHDATE _____ MONTH _____ YEAR _____

Years of Fencing experience _____

Percentage of wins in dual meets last year: 10 20 30 40 50 60 70 80

Championships, wins, or placings in last five years:

Conference _____

_____

_____

N.C.A.A. _____

_____

_____

A.F.L.A. _____

_____

_____

A.F.L.A. rating: _____ FOIL _____ EPEE _____ SABRE _____

Prep _____

Novice _____

Junior _____

Intermediate _____

Senior _____

I. Anthropometric measurements

1. Standing height _____ cms.
2. Sitting height _____ cms.
3. Weight _____ lbs. _____ ozs.
4. Chest width _____ cms.
5. Reach _____ cms.
6. Hand width _____ cms.

II. Motor Speed _____

III. "S" Test _____ Percentile c/t norms _____

IV. Reaction Time (apparatus) _____

Perception time (IV minus II) _____

Reaction Time (key) _____

Perception time (IV minus II) _____

V. "Blocks" Test

first _____ errors _____

second _____ errors _____

third _____ errors _____

VI. Choice Reaction Time (apparatus) _____

Decision time (VIa minus IVa) _____ errors _____

Choice Reaction Time (key) _____

Decision time (VIk minus IVk) _____ errors _____

TABULATION SHEET

MT		RT		CRT		RT^1		CRT^1		
										Total
										Arith Mean

S number ________

Date ________

Time ________

U1 ________

U2 ________

$(U2)^1$ ________