REACTION TIME AND MOVEMENT TIME IN ELEMENTARY SCHOOL CHILDREN

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

In the majority of studies and experiments conducted to determine reaction time and movement time, subjects have represented segments of an adult population. Groups of college students have been the most popular, or at least the most accessible subjects for testing purposes. A limited number of studies have concerned themselves with children, resulting in a similarly limited number of statistics in this area.

There have been experiments using sizeable groups of six year olds, or twelve year olds, but no research was uncovered where the subjects ranged in age along a continuum and included all ages of the elementary grades within one study. There seemed some possibility that when age groups were limited or separated by several years, results might be quite different than those which might be obtained from a group composed of all age groups within the elementary grades. An instrumental factor in making this study was to gather data on this group.

Purpose of the Study. The purpose of this study was to measure the reaction time and movement time of children in the elementary grades. Sub-problems were to 1) determine the relationship of (a) age to reaction time, (b) age to movement time, (c) height to reaction time, (d) height to movement time, (e) weight to reaction time, (f) weight to movement time; 2) to compare mean reaction times and movement times of the children divided into six twelve-month age groups; 3) to compare

reaction time and movement time of boys with that of girls, and 4) to establish reaction time and movement time norms for elementary school boys and girls.

Definitions. The term "elementary grades" was used to designate grades one, two, three, four, five and six of the public elementary schools of Stillwater, Oklahoma. Stillwater schools have a six-three-three system, so elementary schools were attended by children only of the grades and ages tested.

The abbreviation "RT" used throughout the report designates reaction time as measured in the study. "RT" and "reaction time" are used interchangeably. The reaction time as measured consisted of the subject listening for an auditory stimulus, a buz-z-z sound, and upon hearing the sound, using the thumb to depress the button at the end of the control cord. The timer began with the auditory stimulus and stopped when the button was depressed.

The abbreviation "MT" designated body movement time as measured. "MT" and "movement time" were used interchangeably. Movement time consisted of an eighteen inch jump by the subject from a starting position on to a floor mat upon hearing an auditory stimulus. Movement time included the reaction time involved in initiating the jump. The clock began with the auditory stimulus and ceased as both feet landed on the mat and broke the circuit.

The age figure denoted age to the nearest month, an age of ninety-six implying a child of ninety-six months or eight years. Weight was measured to the nearest pound and designated as "Wt." Height measurements were recorded to the nearest half-inch and designated "Ht." The capitals "F" and "M" denoted sex of subject, female and male respectively.

Limitations. The children in this study represented three elementary schools in Stillwater. The children were white, with the possibility of a few subjects of Oriental descent. Approximately eighty per cent of the children tested attended the same school. This school was located in an area embracing families from all socio-economic groups. Children from a university housing project were transported to this school. Families of the children were professionals, business people and laborers. Many of the children were from homes in a lower income and minimal education bracket. The remaining twenty per cent of the children attended schools generally considered to be in "better neighborhoods" with parents probably having a higher degree of education and socio-economic status. The children as a total group included extremes of age, height, weight, and intelligence.

Throughout the city, physical education is taught within the elementary schools to fourth, fifth and sixth graders. The children in grades one, two and three had not participated in a physical education program, while those in grades four, five and six participated in a regularly scheduled physical education program including gymnastics, calisthenics, games, sports and rhythms.

Summary. This study, as most, had its periods of discouragement and frustration along with many enlightening moments. It could be stated, unequivocally, that children, because of the novelty of the experiment and their own innate and unconcealed curiosity, did not prove to be simple subjects. There were no relaxation periods for the examiner, and the difficulty of one person managing both children and equipment was occasionally an almost insurmountable handicap. The examiner felt, however, that to have an objective and reliable experiment, it was essential to have one person do all measurements and recording of results.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction The "eye and ear" method used by astronomers in their early attempts to measure the personal equation in transit observations marked a beginning in the study of reaction time. Gatewood, in tracing the history of reaction studies, stated that perhaps the first published results of simple reaction experiments were those by Helmholz in 1850. In 1865, some of the first experimental work was done with a psychological interest. In this early twentieth century report, Gatewood placed reaction time studies in three history periods: (1) 1865-1888, when the interest center was time relations of simple and complex mental processes and their variation with the quality intensity and complexity of stimuli, (2) 1888-1905, when studies centered around the effect of direction on reactions, and (3) since 1905, when involvement had been concerned with the introspective analysis of the reaction. She suggested that prior to 1865, physiologists were the leaders in reaction studies, but this position had since been taken by psychologists.[1] Subsequent history and research would substantiate that physiologists have re-entered the area of study in reactions times. The field of physical education has been actively engaged in studies and research experiments concerned with reaction time and movement time.

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[1] Esther L. Gatewood, Individual Differences in Finger Reactions, Psychological Monographs 28, No. 4 (N. J. and Pa., 1920) pp. 3 and 4.

Related studies. Buford Johnson, in 1917, investigated the effect on the learning process of practice in motor coordination of children 4 to 10.[2] She stated that results prior to this time showed a marked increase of motor control with age.[3] Several problems were encountered in her study such as competitive attitude of children, false reaction responses and other factors influencing procedures.[4] Results of this experiment were (1) a marked improvement due to practice in quickness of response, (2) premature responses were more frequent in simple reactions and (3) an increasingly shortened RT appeared with increasing age for the subjects studied, but the average of all children more closely approximated that for adults than results of other tests. Superiority of boys and girls in this age group varied.[5]

Pierson, in 1959, measured the relationship of MT and RT from childhood to senility and, in his statistical analysis of data concerning 400 subjects from eight to eighty-three years of age, reported that there was a significant correlation coefficient ($r_o = .56$). His estimate of the correlation for the total population was 0.54. He questioned past research which suggested no significant correlation, by suggesting that most studies had been made using college students and this would not be a representative group. He suggested that when conclusions concerning an adult male population are drawn from college students there is considerable chance for error. He concluded "There is a statistically

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[2]Buford J. Johnson. Experimental Study of Motor Abilities of Children in the Primary Grades. The Johns Hopkins Press (Baltimore, 1917) p. 9.

[3]Ibid., p. 15.

[4]Ibid., p. 39.

[5]Ibid., p. 57.

significant correlation between reaction time and movement time as measured in this study."[6]

Mendryk questioned the findings of Pierson and an exchange of articles took place, each defending his own position, and verifying results of his studies.[7, 8]

Mendryk, in 1960, studied reaction times and movement times in three general age groups, twelve, twenty-two and forty-eight in which he found an average correlation of only .127 for a short arm movement and .138 for a longer movement.[9] He also found college groups to be faster in both reaction time and movement time than younger or older groups with the average RT of a twenty-two year old subject as .192. Twelve year old subjects were fifteen per cent slower than twenty-two year olds, and forty-eight year olds were thirteen per cent slower than twenty-two year olds with no significant difference between twelve year olds and forty-eight year olds. He concluded that junior high school boys as well as middle aged men are slower than college men in both RT and MT. Mendryk felt that for the age range studied, reaction time and speed of movement were not correlated; and there was no influence of age on this relationship.[10]

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[6]William R. Pierson, "The Relationship of Movement Time and Reaction Time from Childhood to Senility." Research Quarterly, May 1959, pp. 229-230.

[7]Stephen Mendryk. "Reply to W. R. Pierson's Comments by Stephen Mendryk." Research Quarterly, May 1961, pp. 267-268.

[8]William R. Pierson. "Comment on Investigation of RT/MT Relationship." Research Quarterly, May 1961, pp. 266-267.

[9]Stephen Mendryk. Reaction Time, Movement Time, and Task Specificity Relationships at Ages 12, 22 and 48 years." Research Quarterly, p. 156.

[10]Ibid., pp. 161-162.

Emotional tension was mentioned as having an effect on speed of both reaction and movement time according to an experiment by Howell. There was also a relationship between personal evaluation and emotional conditions and the degree of emotional tension as exhibited. A relationship also existed between the subjects evaluation of emotion and that of the experimenter.[11] Factors depicting emotional tension were false starts, perspiration, undue worry, and an apprehensive appearance.[12]

In 1962, Tweit, Gollnick and Hearn conducted experiments testing total body reaction time before a training period, and a retest after six weeks of participation in a vigorous training program. It was their purpose to verify previous studies on reaction times which had displayed that athletes possess shorter reaction times than non-athletes among both men and women. In an attempt to more easily produce and detect changes, individuals of low fitness were used.[13]

They found that total body reaction time scores in sub-fit individuals were significantly improved by participation in a strenuous physical training program. This study indicated that though correlation was relatively low, between individual fitness tests and total body reaction time, in a composite score of the fitness tests there was some correlation with total body reaction. The experimenters concluded that total body reaction time could be improved by training. This study added

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[11] Maxwell Howell. "Influence of Emotional Tension on Speed or Reaction and Movement." Research Quarterly, March 1962, p. 23.

[12] Ibid., p. 27.

[13] A. H. Tweit, P. D. Gollnick, and G. R. Hearn. "Effect of Training Progress on Total Body Reaction Time of Individuals of Low Fitness." Research Quarterly, December 1963, p. 508.

evidence to former studies indicating that athletes had shorter reaction times than non-athletes.[14]

In one of the more extensive and more recent studies of reaction time and speed of movement, Hodgkins tested nine hundred and thirty men, women and children ranging in age from six to eighty-four years. The study was to determine differences between males and females of various ages in the speed of reaction and movement and to discover whether a relationship existed between reaction time and movement time.[15]

Using specially designed apparatus consisting of a telegrapher key type piece of equipment, reaction time was measured as the subject saw a light and released a key, moving the arm as quickly as possible to a rod -- a simple arm movement. One clock measured the reaction time which was the period of time between seeing the light and release of the key. This clock would stop at which time a second clock or timer began to measure the time taken for the subject to move his arm to the rod. Reaction time and movement time were timed separately but consecutively, thus the movement time did not involve a reaction period. After three practice trials, ten trials were used to compute the mean score.[16]

Subjects were groups representing first, seventh and tenth grades, college students, young, middle and older adult group and a group of elder subjects between seventy and eighty-four years of age.[17]

Unconverted scores were used throughout the study with mean reaction

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[14]Ibid., p. 512.

[15]Hodgkins, Jean. "Reaction Time and Speed of Movement in Males and Females of Various Ages." Research Quarterly, October 1963, p. 335.

[16]Ibid., pp. 336-337.

[17]Ibid., p. 337.

time and movement time scores taken from ten trials. Among the female groups there appeared little relationship between RT and MT except at the twenty-two to thirty-eight age level where there was a correlation of .453. Among the male groups, coefficients of correlation of .35 or above were found in two of the eight groups, young men (.450) and elderly men (.713). When all female groups were combined, the coefficient of correlation of RT and MT was .540, and for the combined male groups, .680. Combined subjects of both sexes had a resultant correlation of .824. While these correlations appeared statistically significant, Hodgkins did not consider them such because of the relatively low coefficient correlation when the groups were taken individually.[18]

The results of this study strongly indicated that males reacted more quickly than females, with no clear explanation as to why. This difference was most apparent at the college level although it existed at all levels. Males were also considerably quicker at speed of movement than females with the exception of the youngest group tested. Hodgkins suggested that this clearcut difference in shorter movement time for males might be directly attributed to greater strength. This compared with former studies which had suggested a correlation of strength with movement time. Hodgkins study also gave evidence that the greatest increase in reaction time occurred between the ages of six and twelve in both males and females, the males showing an increase of eighty two per cent and females eighty six per cent. The greatest increase in movement time was also between age six and twelve.[19]

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[18]Ibid., p. 338.

[19]Ibid., pp. 341-342.

Hodgkins concluded that males from age twelve to forty-three react faster and have a shorter movement time with the peak speed of reaction between eighteen and twenty-one, and the peak speed of movement between ages fifteen and seventeen. The conclusion also was that no relationship existed between speed of reaction and speed of movement in the majority of age groups tested.[20]

Another factor considered in reaction and movement time was the relationship of muscle to reaction. Smith in a study of forty college men tested the relationship of muscle tension to reaction and movement time. He concluded that relaxation, tension and stretch of muscle had little influence on the reaction time or movement time.[21]

Summary. A survey of the literature suggested that in most cases, males have both a shorter reaction time and movement time than females. Further, reaction time and movement times decrease with age, and reach the period of shortest time during the late teens and early twenties. The correlation between reaction time and movement time remains an area of controversy with some studies concluding an insignificant correlation and other studies suggesting a significant correlation.

Factors such as strength and practice have an effect on both reaction time and movement time. The majority of subjects in experiments of reaction time and movement time have been male college age.

A minimum of experiments have been undertaken utilizing children as subjects, with most of these centered upon specific age groups. In those few studies dealing primarily with children, factors such as excitement, emotion, competition and false reactions were in evidence.

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[20] Ibid., pp. 342-343.

[21] Leon Smith. "Effect of Muscular Stretch, Tension and Relaxation upon the Reaction Time and Speed of Movement of a Supported Limb." Research Quarterly, December 1964, p. 552.

CHAPTER III

METHODOLOGY

Equipment. An Athletic Performance Analyzer was used to measure all reaction and movement times. This timing device called the "APA" was an electrical piece of equipment manufactured by the Dekan Timing Devices, P. O. Box 712, Glen Ellyn, Illinois. The APA weighed less than twenty pounds, was contained in a carrying case and was completely portable. Though it contained sensitive electrical components, with ordinary handling it was not easily harmed. A diagram of the analyzer can be found in Figure 1.

The basic unit measured practically any physical reaction or movement, maintained any accuracy within 1/100th of a second and had a delay start circuit adjustable from one to six seconds. Included as part of the APA and used to measure reaction time was a six foot control cord with a button on one end and a jack plug on the other. Separate equipment but operated by the basic unit and used for measuring movement time was an oblong floor mat containing an electrical circuit and attached by a cord with jack to the basic unit.

Starts were activated by the examiner by a button on the control panel and the timer was stopped by thumb pressure on a button at the end of the control cord for reaction time, and foot pressure on the floor switch mat for movement time. An auditory stimulus was provided by a buzzing sound set to go off with the delay start circuit button.

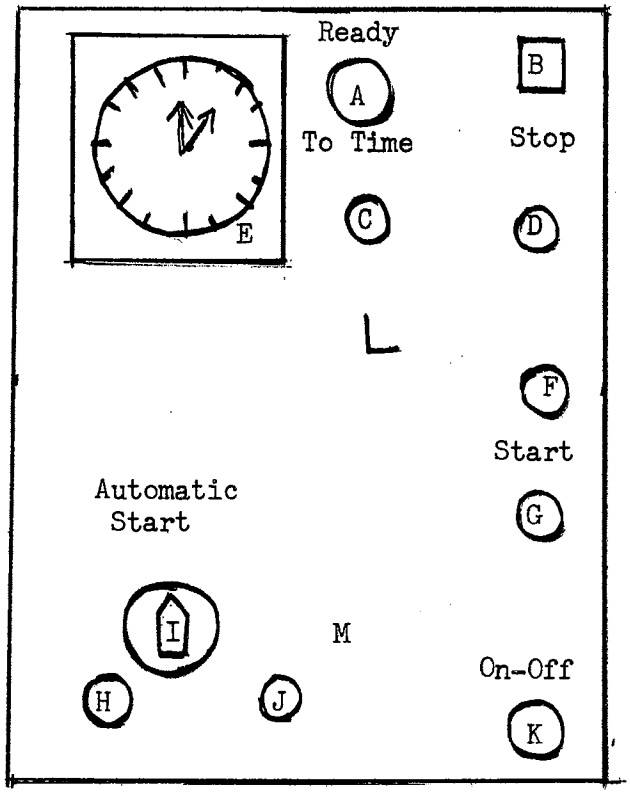


Figure 1. Control Panel of the APA

*A. Ready to time indicator.
B. Line Stop Slip Switch.
*C. Jack for Mat Stop.
*D. Jack for Switch Stops.
*E. Timer Reset.
F. Jack for Start (no sound).
G. Button for Manual Start with Sound.
*H. Get Set Button.
*I. Delay Adjust.
J. Control Cord Jack for Get-Set Switch.
*K. Master Switch for "ON" and "OFF" and to reset the APA.

* Controls used in experiment.

Height, weight, age. Height was measured by a tape measure affixed to a straight wall or door facing. Weight was measured on a bathroom scale, and ages were verbally requested or obtained from class cards.

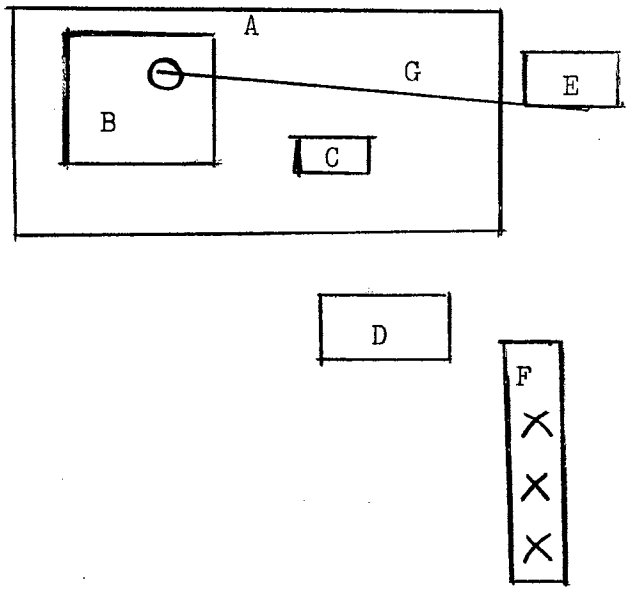
Record Cards. A card was prepared for each subject with blanks in which were recorded subjects name, age, height, weight, school, grade. Ten spaces each were provided to record reaction time and movement time trials, and a space was provided for remarks.

Subjects. One hundred and fifty-six boys and girls between the ages of seventy-two months and one hundred forty-three months were tested for reaction and movement time. The scores of one hundred and forty-five subjects were retained for the study, and of this number, seventy-four were girls and seventy-one boys. The children were white students in the elementary grades of Stillwater, Oklahoma schools. One hundred twenty of the children attended the same elementary school, the remainder represented two additional schools. All schools had the same educational program, all of the schools had a physical education program in the fourth, fifth and sixth grades. Children from grades four, five and six were obtained for the study by arrangements with the school principal and the physical education instructor who allowed the use of both subjects and space during the regularly scheduled physical education period. The children from grade one were tested in their class room during the noon hour period through permission of the teacher and the principal. Second and third grade girls were tested at a Girl Scout Brownie troop meeting, and third and fourth grade boys were tested at a Cub Scout Den meeting. Additional subjects in Grades one, two and three were neighborhood children.

Testing Procedures. Each child was weighed on a bathroom scale in

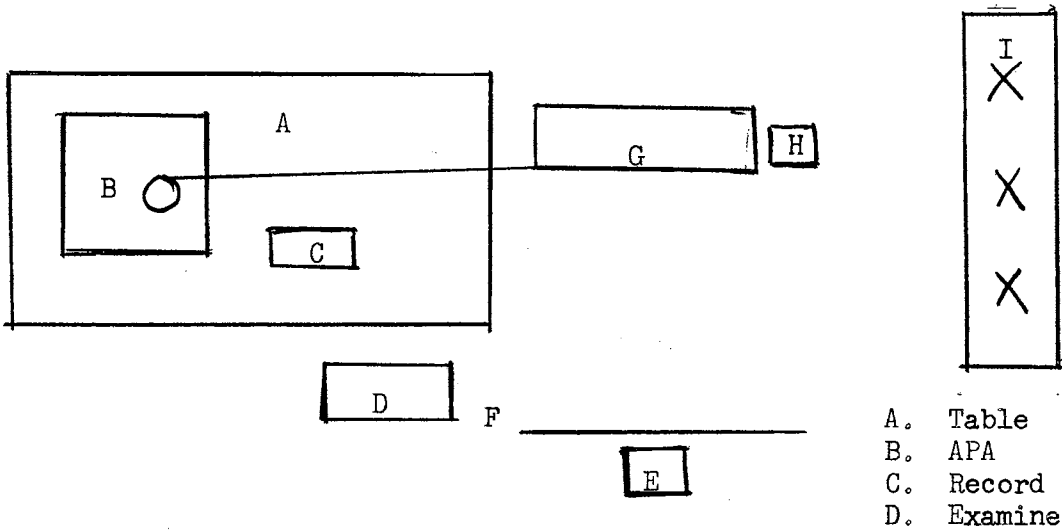
his school attire and weights were recorded to the nearest pound. The height of each child was measured by placing the subject with his back against the wall on which was fastened a tape measure. The flat side of a ruler was leveled on the head, and heights were recorded to the nearest half-inch. Children in grades two through six were asked age, and month, day and year of birth. This information was recorded on the record card. In cases where discrepancies appeared between stated age and birthdate, the school secretary was contacted for verification of birth dates. Class cards were borrowed from the teacher of the first grade children and birth dates were obtained from these. Age was recorded to the nearest month.

Reaction time. The APA was placed on a table accessible to an electrical outlet and in an area with sufficient room for measurements. Record cards were placed on the table to the right of the APA and the examiner stood behind and facing the table. Before beginning the trials on a child or group of children, introduction to the machine and experiment and an explanation of the subjects part in the experiment was made. The subject was then placed with his back to the machine and his right side generally in the direction of the examiner. (See Figure 2). The cord with button was placed in the hand of the subject who was instructed to use the hand which he used most. If necessary, a demonstration was given by the examiner in correct thumb placement. The first child in each group needed the most explicit information and with a rotating testing program, or with older children, the instructions did not need frequent repeating. The child was told to hold the thumb as close as possible to the button and to push the button when "he heard the loud buzz." Before each trial, the subject was given a ready signal. Each



A. Table
B. APA
C. Record Card
D. Examiner
E. Subject
F. Waiting Subjects
G. Control Cord with button

Figure 2. Subject and Equipment Arrangement for RT



A. Table
B. APA
C. Record Card
D. Examiner
E. Subject
F. Starting Line
G. Floor Mat
H. Subject 2
I. Waiting Subjects

Figure 3. Subject and Equipment Arrangement for MT

child was given ten reaction time trials with the automatic timer adjusted from one to six seconds for a delayed interval auditory stimulus throughout the ten trials. All ten trials were recorded; however the first five were considered practice.

There were innumerable false reactions when no auditory stimulus had been given or when it occurred simultaneously with the stimulus. The noise of the timer, the resetting of the clock and the slight sound made when the starter button was depressed all proved distracting to some of the subjects causing many false thumb reactions. It was essential for several of the children to initiate practice by keeping the thumb well above the button until they overcame a "trigger happy" impulse. In most cases, after several practice trials, these children were able to rest the thumb on the button which eliminated a limb reaction not desired in the experiment. Several children displayed an anxiety or tension sufficient enough to cause more false reactions than true reactions. In the case of a few subjects, confusion caused by lack of comprehension of the task was a factor. In most cases, however, the false reactions and tenseness seemed to be the result of wishing to do well rather than fear of the task. Ten reaction trials were recorded, the last five were used to compute each child's mean reaction time.

Movement time. Movement time consisted of an eighteen inch jump on to a mat after an auditory stimulus. The mat, attached to the APA by an electrical cord, was placed flat on the floor with masking tape or a chalk mark made on the floor to designate its correct position. Eighteen inches in front of the leading edge of the mat, a starting line was marked with either masking or plastic tape affixed to the floor. (See Figure 3). Each child was instructed to stand on both feet with toes behind the

starting line. Upon hearing the buzzer, the child was to jump from both feet on to the mat, landing with both feet. The timer, activated when the buzzer sounded would be stopped by the foot pressure on the mat. Due to a fatigue factor, trials were limited to eight with trials three through seven used to compute the mean.

The children needed constant reminding to begin and end with both feet. There were many false or incorrect starts, frequently numbering as many as correct trials. Fatigue played a major role in this part of the testing, and there were many varieties of jumps. Some children jumped mostly vertical, others almost cleared the mat; many in attempting to be ready, were overready and lost their balance before the auditory stimulus was either activated or heard. It was important to position mat, subject and machine within a line of vision of the examiner.

Special testing conditions. To facilitate testing, whenever possible, a rotation pattern of subjects was established. Approximately five children composed a unit, one subject was in the process of being tested, a second child was assigned the task of floor mat alignment after trial jumps, a third child stood ready to move into the position of two as this child became subject. Child four distributed record cards which already had names recorded, to subject five who in each case was the replacement for the most recently completed subject. This procedure minimized both the number of subjects in the room and allowed the children to rotate between the play yard and the testing room with very little confusion. Another advantage was that the child was familiar with the procedure by the time he became subject which saved much time.

The majority of testing had to be done in a location where there were other children around and thus distractions. To standardize all

measurements, those children tested in the home and in less noisy surroundings were never tested without the presence of at least one other child and frequently several children were present. Though this may not have been the ideal situation, it was a constant situation throughout the experiment.

All reaction time and movement time trials on all subjects were done by the examiner. The judgment of the examiner was the only judgment as to validity of trials. There were, occasionally other people involved in measurements of age, height, and weight.

Special problems. Some of the children were intensely competitive. This was not peculiar to any specific age or grade but manifested itself at all grade levels. It was also essential to keep a constant watch on handling of the control cord as the children had a tendency to either shift it from hand to hand or brace one hand with the other. Many of the children wished to observe the machine as they were tested which had to be discouraged. Crowding the waiting subjects during actual testing was an occasional problem. The first graders who were tested in their classroom during noon hour, needed special attention, they needed constant reminders and discouragement to remove themselves from the testing area and the examiner.

Measurement and Records. Information consisting of age, height, weight, reaction time and movement time trials were recorded on the record cards. Each subject and card was assigned a key number and information was transferred to charts. The subjects were divided into six groups by age in months. Group I consisted of children between 72 and 83 months; Group II were 84 to 95 months; Group III were 96 to 107 months; Group IV were 108 to 119 months; Group V were 120 to 131 months and Group VI children were 132 to 143 months. For additional statistics, the subjects

were divided into two groups, A and B. Group A consisted of children 72 to 107 months, and Group B from 108 to 143 months.

Mean reaction time and movement time scores were computed for each child, for each of Groups I through VI, for each sex within these six groups and for Groups A and B. Correlations were made between reaction time and age, height and weight and between movement time and age, height and weight. A correlation was made between reaction time and movement time.

The basis for division of the six groups into Groups A and B was an examination of raw data which seemed to depict a substantial difference in RT and MT between Groups III and IV, so this became the dividing line. A t-ratio was computed between means of Groups III and IV. Mean scores and standard deviations were computed for Groups A and B. For future use a standard score and T-score Table was established for children of the ages in Groups A and B.

CHAPTER IV

RESULTS

Relationship between MT and RT. The mean reaction time for each subject was the mean score of trials six through ten. The mean movement time for each subject was the mean score of trials three through seven. From this data, the mean score for each age group of children was determined. The mean scores for Groups I through III (or Group A) and Groups IV through VI (or Group B) were also computed from this data. Mean scores for female and male subjects were determined. Unconverted scores were used throughout the computations to calculate coefficient of correlation and standard deviations.

The mean RT for all subjects was .308. The mean MT for all subjects was .939. There was a positive correlation of .883 between RT and MT which was significant at the .01 level of confidence. The mean RT for all female subjects was .323 and for all male subjects was .293. The mean reaction time for Group A (72 to 107 months) was .390 and the mean reaction time for Group B (108 to 143 months) was .269. The mean movement time for Group A was 1.068 and for Group B .878. There was a positive correlation of .65 between RT and MT in Group A and a positive correlation of .60 between RT and MT in Group B. These correlations were significant at the .01 level of confidence.

Table 1 includes mean RT and MT scores for each of the six age groups in the study, mean RT and MT scores for females and males, and the

mean RT and MT scores for all subjects in the study. Table II includes correlations between RT and MT.

TABLE I

MEAN RT AND MT SCORES

		Reaction Time			Movement Time		
Group	(Age)	F	M	Combined	F	M	Combined
I.	(72-83)	.389	.421	.403	1.072	1.048	1.061
II.	(84-95)	.445	.39	.419	1.122	1.103	1.116
III.	(96-107)	.361	.354	.358	1.022	1.060	1.033
IV.	(108-119)	.303	.263	.287	.968	.888	.938
V.	(120-131)	.273	.246	.256	.908	.835	.861
VI.	(132-143)	.275	.255	.265	.862	.806	.833
All females		.323			.971		
All males			.293			.906	
All subjects				.308			.939

Age and RT, Age and MT. Reaction time decreased at most levels as age increased. Movement time decreased at most age levels as age increased. There was a negative correlation of .575 between age and reaction time, this was significant at the .01 level of confidence. There was a negative correlation of .74 between age and movement time which was significant at the .01 level of confidence. Upon observation of data, the greatest decrease in reaction time and movement time appeared to occur between Groups III and IV. Computations were made on data from

Groups III and IV to determine if any statistical significant difference existed. A t-ratio of .401 for reaction time was not significant. A t-ratio of 11.3 for movement time was significant at the .01 level of confidence.

Additional Correlations. Correlations were computed between reaction time and height and reaction time and weight. Correlations were also computed between movement time and height and movement time and weight. There was not a significant correlation between height and RT. A negative correlation of .423 between weight and RT was significant at the .01 level of confidence. Negative correlations of .492 between height and MT and .505 between weight and MT were significant at the .01 level of confidence. Table II lists correlations.

TABLE II

CORRELATIONS

Variables	Correlation
Age-Reaction Time	- .575
Age-Movement Time	- .740
Height-Reaction Time	- .028
Height-Movement Time	- .492
Weight-Reaction Time	- .423
Weight-Movement Time	- .505
Reaction Time-Movement Time	+ .883
Group A: Reaction Time-Movement Time	+ .65
Group B: Reaction Time-Movement Time	+ .60

Comparisons of females and males. Reaction time and movement time of males was compared with that of females. In the group of subjects studied, boys were faster than girls in reaction time at every age level except the youngest group. Boys were faster in movement time at all levels except Group III. The mean reaction score for boys was .293 and the mean reaction score for girls was .323. The mean movement time score for boys was .906 and girls had a mean movement time score of .971. A t-ratio was computed for the difference between mean RT and MT of boys and girls. The t-ratio of 1.87 for RT was not significant. A t-ratio of 2.82 for MT was significant at the .05 level of confidence.

Mean scores for boys and girls RT and MT are found in Table I. Figure 4 shows by means of a line graph the pattern of RT and MT mean scores for all six groups.

Standard Scores. A Standard Score table of reaction time and movement time for Groups A and B was constructed. Included in the table are the sigma scores, T-scores for RT and MT of Groups A and B. For purposes of establishing the standard score table, the groups were divided on the basis of observed difference in movement time between Groups III and IV. The computation of a t-ratio between means of these groups indicated a significant difference for movement time.

Group A included children from 72 to 107 months of age and Group B included children from 108 to 143 months of age. Table III is a Standard Score Table of RT and MT for boys and girls of the ages studied. The table also includes mean scores and standard deviations for Groups A and B. A bar graph, Figure 5 portrays the mean reaction times and movement times for Group A, Group B and total subjects.

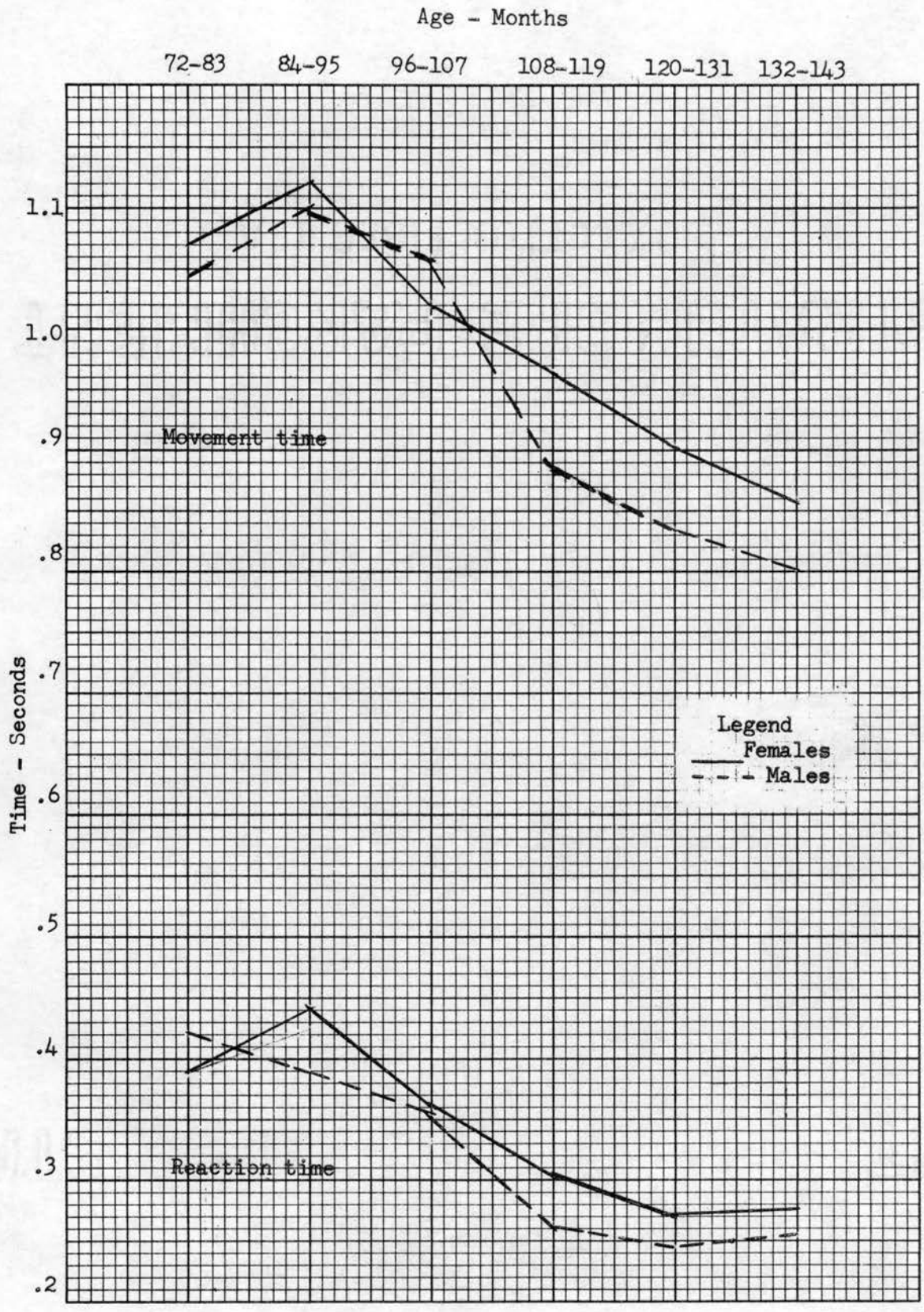


Figure 4. A Comparison of males with females in Speed of RT - MT

TABLE III

STANDARD SCORE TABLE OF RT AND MT FOR BOYS AND GIRLS

		RT		MT	
Sigma	T Score	72-107 mo.	108-143 mo.	72-107 mo.	108-143 mo.
	98	.00	.00	.60	.20
	92	.00	.00	.66	.26
	86	.03	.00	.71	.32
100	80	.09	.02	.77	.38
90	74	.15	.07	.83	.44
80	68	.21	.12	.89	.50
70	62	.27	.17	.95	.56
60	56	.33	.22	1.01	.82
50	50	.39	.27	1.07	.88
40	44	.45	.32	1.13	.94
30	38	.51	.37	1.19	1.00
20	32	.57	.42	1.25	1.06
10	26	.63	.47	1.31	1.12
0	20	.69	.52	1.37	1.18
	14	.75	.57	1.43	1.24
	8	.81	.62	1.49	1.30
	2	.87	.67	1.55	1.36
Mean		.390	.269	1.068	.878
SD		.104	.077	.104	.095
Number of Subjects		47	98	47	98

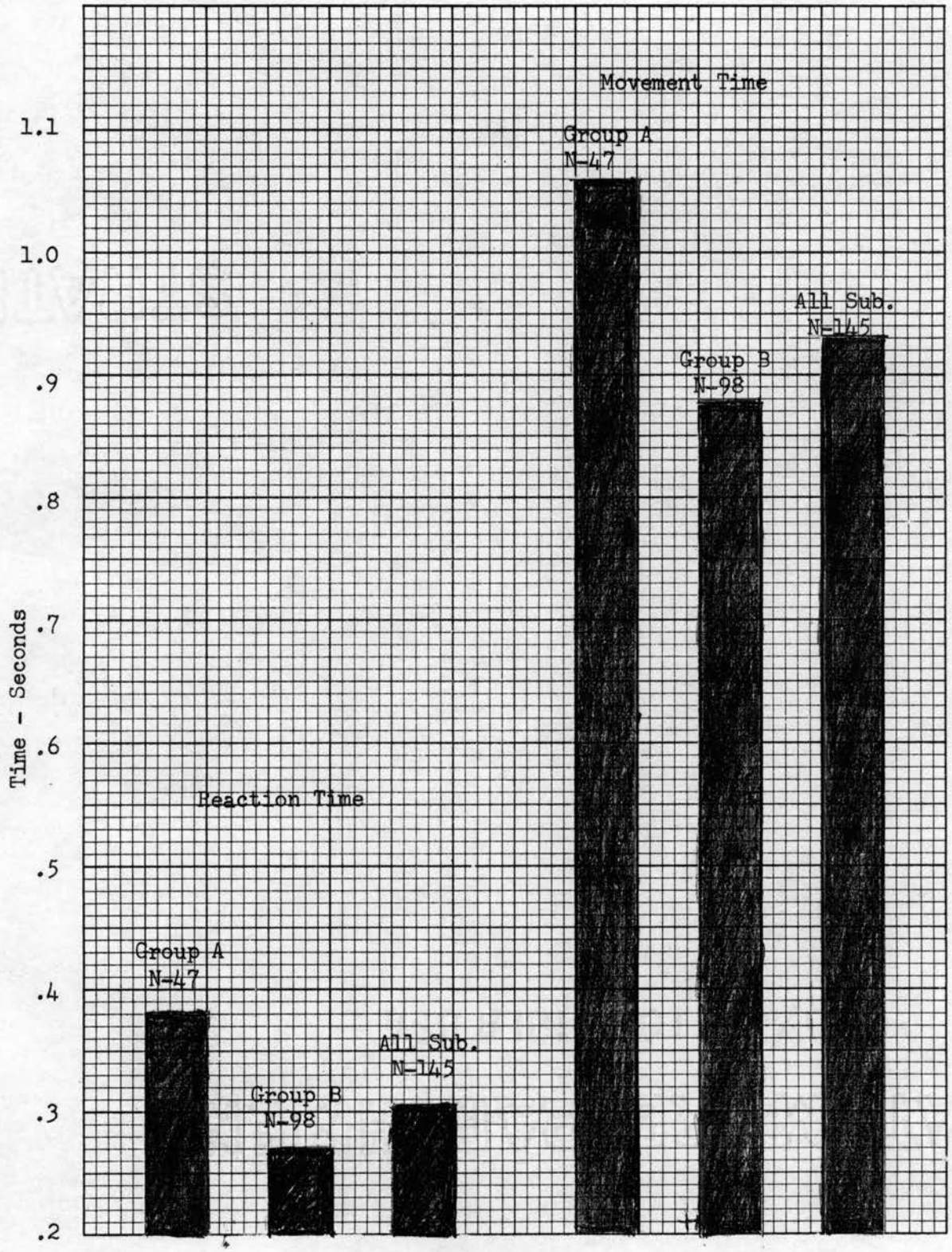


Figure 5. Mean RT and MT - Groups A, B and All Subjects

CHAPTER V

DISCUSSION OF RESULTS

Results of this study indicated a positive correlation between reaction time and movement time. This was similar to findings made by Pierson in his study of 400 subjects aged 8 to 83. He reported a significant correlation of .56 for reaction time to movement time in his specific study and .54 for total population.[1] His MT measurement excluded RT and for this reason would be lower than in this study.

A negative correlation was found between age and reaction time. A negative correlation was also found between age and movement time. Height and weight seemed to be of little significance in reaction time, but were more closely related to movement time, as height and weight increased, movement time decreased in the children of the study.

The relationship between RT and MT was comparable with Hodgkins study in which she found a correlation of .824 between RT and MT which compared with .882 in this study. The MT in Hodgkins study did not include RT. She did not, however consider the correlation significant on the basis of lower correlations between RT and MT in several of the groups. Ages tested in her study were divided into eight age groups between ages 6 and 80.[2]

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[1]William T. Pierson. "The Relationship of Movement Time and Reaction Time from Childhood to Senility." Research Quarterly. May, 1959, p. 229.

[2]Jean Hodgkins. "Reaction Time and Speed of Movement in Males and Females of Various Ages." Research Quarterly. October 1963, p. 338.

The examiner feels that in this study there was high relationship of RT to MT.

Statistical data would indicate that males are faster than females. The t-ratio computations did not indicate a significant difference in RT, but a difference of significance was indicated between males and females in MT. Hodgkins found a statistically significant difference between males and females in both RT and MT.[3]

Data from all groups indicated that reaction time and movement time decrease with age; however, statistical evidence was only significant for the negative correlation between movement time and age. Hodgkins stated that the greatest increase in speed occurred somewhere between the ages of 6 and 12 after which time the increase leveled off reaching its peak at college age.[4] As she had no subjects in her group between the ages of 6 and 12, she had no data on where this increase might take place. From the data gathered for this study, there were indications that a definite increase in speed of movement time occurred sometime between 100 months and 120 months. This would equate with an increase between the ages of 8 and 10 years of age, or most normally when children were in grades 3 and 4.

It is of interest to note at this point, that the children in the schools tested have a physical education program beginning with 4th grade. If practice has a significant effect on movement time, this might have some bearing on the difference occurring between groups III and IV. Yet, the children in the study when measured had participated

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[3]Ibid., p. 341.

[4]Ibid., p. 342.

less than two months in the physical education program which hardly seems justification for the significant decrease in movement time.

There was some indication in this study that after 132 months, some leveling off in both reaction time and movement time occurred. As the oldest children measured were 143 months it was not feasible to project this trend further or to conclude it as significant. Further studies would be needed.

CHAPTER VI

CONCLUSIONS

The purpose of this study was to measure reaction time and movement time in elementary school children. Sub-problems were to determine the correlations between reaction time and age, reaction time and height, reaction time and weight, movement time and age, movement time and height, movement time and weight, and reaction time and movement time. An additional problem was to compare males and females in reaction time and movement time.

From the study made and the data computed, the following conclusions seem warranted.

1. The mean RT of boys and girls of elementary school age is .308 seconds.

2. The mean MT of boys and girls of elementary school age is .939 seconds.

3. The following correlations were found, all of which were statistically significant:

a. RT with MT +.882

b. RT with Age -.575

c. MT with Age -.740

d. RT with Wt. -.423

e. MT with Ht. -.492

f. MT with Wt. -.505

4. There is a general decrease in both RT and MT with an increase in age between the ages of 72 and 143 months.

5. Between the ages of 72 and 143 months, males have a shorter RT than females but not significantly so.

6. Males have a statistically significant shorter MT than females between the ages of 72 and 143 months.

7. False responses in both measurements of RT and MT are prevalent when testing children ages 72 to 143 months.

Recommendations. It is recommended that further studies include additional numbers of children, particularly in grades 1 through 3. It is further recommended that similar reaction time and movement time measurements be made in schools where either all grades participate in a physical education program or schools where none of the subjects participate in a physical education program in order to determine if participation has any effect on RT and MT.

Further study is indicated in the controversial area of male or female superiority with specific investigation of reasons for this superiority is any exists.

If there is a significant decrease in RT or MT at the ages of 9 or 10 years as indicated in this study, further statistical evidence might be of value to both classroom teachers and physical educators in the type of activity planned. There may be reason to believe that children under a certain age are not physically prepared for some of the motor skill activities requiring rapid reaction and movement for success. This might well be the area of research most indicated for additional research on reaction time and movement time in children.

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A P P E N D I X

APPENDIX A

RAW DATA

APPENDIX B

APPENDIX A

RAW DATA

Case	Sex	Age	Ht.	Wt.	MRT	MMT
1-1	M	75	46	46	.336	1.128
2-1	F	76	46.5	46	.521	1.194
3-1	F	76	48	49	.452	1.148
4-1	F	78	49	46	.414	1.106
5-1	M	78	49	50	.380	1.108
6-1	M	79	51	65	.340	1.166
8-1	M	80	49.5	55	.566	1.006
9-1	F	80	44	39	.344	1.100
10-1	M	81	51	60	.652	1.116
11-1	F	81	46	46	.372	.982
12-1	F	81	47	45	.332	.970
13-1	M	82	45	45	.412	.950
14-1	M	82	51.5	60	.264	.862
15-1	F	81	46.5	50	.438	1.252
16-1	F	82	46	39	.356	.952
17-1	F	83	49	51	.268	.940
18-1	F	84	50.5	60	.400	1.058
19-1	M	84	51.5	70	.320	1.058
20-1	F	85	52	75	.320	1.078
21-1	M	86	52.5	73	.530	1.046
22-1	M	86	49	48	.268	1.026
23-1	F	87	46	40	.556	1.144
24-2	F	88	47	42	.648	1.318
25-1	M	89	48.5	53	.314	1.278
26-1	M	90	49	53	.452	1.182
27-2	F	90	49.5	40	.404	1.186
28-2	F	90	50	52	.472	1.084
29-2	F	91	52.5	53	.318	.984
30-1	M	91	47.5	47	.454	1.072
31-3	F	97	54	65	.444	1.052
32-4	M	97	54	67	.244	.954
33-1	M	99	48.5	41	.576	1.312
34-3	M	100	54	72	.400	1.086
35-3	F	100	49.5	46	.394	1.002
36-3	M	101	55.5	68	.306	.988
37-3	F	101	49.5	50	.458	1.184
38-3	M	100	56.5	89	.364	1.068
39-3	F	102	56.5	69	.462	1.064
40-3	F	102	52.5	56	.306	1.920

Raw Data

Case	Sex	Age	Ht.	Wt.	MRT	MMT
41-3	M	103	52.5	62	.354	1.110
42-3	M	103	57.5	87	.286	.974
43-3	F	104	52.5	65	.382	.966
44-3	F	104	54	56	.250	1.036
45-3	F	104	50.5	47	.248	.888
46-3	F	106	54	52	.356	1.120
47-3	M	107	56.5	74	.304	.990
48-3	F	107	53	59	.308	.988
49-3	M	108	54.5	73	.254	1.098
50-4	F	109	52.5	62	.328	1.002
51-3	F	109	55	69	.348	1.124
52-3	F	109	48	45	.314	1.100
53-4	M	109	56	90	.196	.896
54-4	F	109	51	58	.246	.998
55-4	F	109	57	80	.368	1.072
56-3	F	109	53	66	.562	1.150
57-3	F	109	53.5	63	.260	.928
58-5	F	110	58.5	111	.254	.746
59-4	F	110	55	57	.272	.976
60-4	F	110	57.5	87	.290	.856
61-4	F	110	51	61	.284	.816
63-4	M	113	56.5	80	.378	.926
64-4	M	113	53.5	63	.262	.886
65-4	F	113	55	56	.276	1.042
66-4	M	115	56	79	.288	.928
67-4	F	115	53	57	.236	1.050
68-4	F	115	53.5	70	.306	.884
69-4	F	116	53	80	.340	1.044
70-4	F	116	54.5	70	.356	.932
71-4	M	117	52.5	71	.246	.732
72-4	M	117	57	80	.280	.858
73-4	F	118	51	54	.298	.930
74-4	F	118	55.5	62	.220	.848
75-4	M	118	57.5	99	.214	.804
76-4	M	119	57	96	.288	.936
77-4	F	119	59	66	.232	.906
78-4	F	119	56.5	73	.264	.964
79-4	M	119	53.5	67	.252	.940
80-4	M	119	56.5	103	.264	.862
81-4	M	119	55.5	81	.230	.800
82-4	F	120	55.5	57	.238	.756
83-5	M	120	57	94	.294	.890
84-5	M	123	55.5	68	.260	.892
85-5	M	124	56	81	.228	.726

Raw Data

Case	Sex	Age	Ht.	Wt.	MRT	MMT
86-4	M	124	55.5	76	.216	.718
87-4	F	125	54.5	65	.396	.900
88-5	F	125	61.5	104	.234	.958
89-5	F	125	55.5	100	.214	.928
90-5	M	125	52	77	.258	.806
91-5	M	125	54.5	60	.276	.856
92-5	M	125	52	75	.248	.814
93-5	M	126	58	79	.210	.856
94-5	F	126	58	74	.200	.846
97-5	M	126	57	71	.250	.802
98-5	F	126	63	105	.266	1.022
99-5	M	127	58	85	.272	.904
100-5	M	127	59.5	92	.214	.794
101-5	M	128	57	84	.244	.884
102-5	M	128	57	65	.218	.832
103-5	F	128	57	85	.282	.918
104-4	F	128	50	57	.316	.918
105-5	M	128	59	80	.172	.796
106-5	F	128	56.5	61	.226	.846
107-4	M	130	54	80	.274	.956
108-5	F	130	56.5	79	.262	.796
109-5	M	130	59	83	.208	.884
110-5	M	130	52.5	67	.192	.724
111-5	M	130	56.5	73	.224	.802
112-5	F	131	60.5	75	.322	1.016
113-5	M	131	59	85	.274	.930
114.5	F	131	53	61	.274	.990
115-5	F	131	59.5	91	.320	.916
116-5	M	131	59	63	.304	.866
117-5	M	131	55	69	.318	.736
118-5	M	131	59.5	75	.264	.850
119-5	M	133	57	109	.410	.824
120-6	F	133	56.5	122	.220	.884
121-6	F	133	59	110	.204	.800
122-6	M	133	54	63	.262	.784
123-5	M	134	56	70	.208	.868
124-6	F	135	59.5	83	.214	.840
125-6	M	135	53	60	.354	.892
126-6	F	135	55.5	67	.342	.894
127-6	M	136	57	75	.230	.852
128-5	M	136	58	83	.276	.776
129-5	M	136	56	83	.246	.748
130-6	F	137	63.5	114	.228	.776

Raw Data

Case	Sex	Age	Ht.	Wt.	MRT	MMT
131-6	M	138	54.5	66	.258	.802
132-6	M	138	68	74	.242	.790
133-6	M	138	55.5	60	.210	.736
134-6	F	138	53.5	70	.436	1.028
135-5	F	138	54	68	.276	.894
136-6	F	139	57.5	70	.254	.956
137-6	M	140	58.5	87	.196	.866
138-6	M	140	59	85	.230	.892
139-6	F	141	59.5	97	.236	.914
140-6	M	141	60.5	90	.240	.736
141-6	F	141	61.5	95	.298	.864
142-6	F	142	57.5	76	.464	.818
144-6	F	142	59.5	97	.268	.908
145-6	M	142	60	102	.288	.796
146-6	M	142	64	111	.220	.778
147-6	F	143	49	47	.248	.786
148-6	F	143	61	91	.164	.658
149-6	F	143	63	105	.278	.916
150-6	M	143	63	98	.212	.916

*Note - Numbers missing in list of cases denote subjects removed from study due to incomplete records.

APPENDIX B

Formula used to compute t-ratio.

$$\sigma = \sqrt{\frac{\Sigma X^2}{N} - M^2}$$

$$\sigma M_1 = \frac{\sigma}{\sqrt{N-1}}$$

$$\sigma diff = \sqrt{\sigma M_1^2 + \sigma M_2^2}$$

$$t = \frac{M_1 - M_2}{\sigma diff.}$$

Sample calculation.

$$\sigma = \sqrt{\frac{8.541}{74} - 323^2} \qquad \sigma = .105$$

$$\sigma M_1 = \frac{.105}{\sqrt{74-1}} \qquad \sigma M_1 = .012$$

$$\sigma diff = \sqrt{.012^2 + .011^2} \qquad \sigma diff = .016$$

$$t = \frac{.323 - .293}{.016} \qquad t = 1.87$$

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