

NEURO-MUSCULAR RESPONSES OF 10 ATHLETES AND
10 NON-ATHLETES IN AGE GROUPS 15, 16, AND 17
IN THE NORTH SALEM, OREGON, SENIOR HIGH SCHOOL

by

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Neuro-muscular Responses of 10 Athletes and
10 Non-athletes in Age Groups 15, 16, and 17
in the North Salem, Oregon, Senior High School

CHAPTER I

INTRODUCTION

The problem of reaction time first arose in the field of astronomy. History records that in 1796, an astronomer, working in the Greenwich Observatory in England, discovered that one of his assistants differed from him in his observation of the instant at which a star traversed a cross hair in a telescope. The assistant was subsequently dismissed and it was not until some twenty years later that the question presented here was ever taken up again. At that time, Bessel, a German astronomer, happened on a note reporting these facts in an observatory report; and he decided to make a study of astronomers by testing them against each other. His results showed that no two persons agreed precisely on the time of a given transit and that the discrepancies among them were due to more basic individual differences in manner of reaction rather than mere carelessness. Since these measurements depend upon the individual's speed of reaction, it was concluded that the differences among observers had to be explainable in terms of what

came to be called the "personal equation"--constant individual differences in speed of reaction.

This brought the problem born in astronomy into the field of psychology where the study and measurement of reaction time became quite important. It was Helmholtz(6) who, in 1850, first devised the reaction method in an attempt to determine the speed of nerve conduction in sensory nerves. Wundt(19), as early as 1861, also had recognized the significance of the personal equation psychology. It was Donders(4), however, who first devised the compound reaction time experiment for the study of mental or central processes, thus making it a realistic psychological problem. His reaction experiments made use of two stimuli. In one method he required the subject to respond to one stimulus and to refrain from responding to the other. The difference in reaction time between this method and that of the simple reaction method where only one stimulus is presented and the subject responds as soon as he is cognizant of it, Donders attributed to the time required to make the discrimination of the stimuli. In a third method where the subject is required to respond differently to each of two stimuli which may be presented, a still further increase in time was found. This further increase in time Donders

attributed to the addition of "choice" to the discrimination problem.

Jung(9), in working with what he called the Association Experiment, incorporated the reaction time method as one means of studying "complexes". He postulated that in the cases where the stimulus words become associated with complexes there results an interference with the subject's associative processes. He found that such "complex indicators" could be recognized by extreme delays of response, peculiar types of responses, or no responses at all. In terms of an "associationist" theory of memory, reaction time disturbances such as Jung found could then be accounted for easily by reference to the phenomena of conflicting associations of about equal strength. These initiate incompatible response tendencies that block any response until such time as the subject can make a choice from among those response tendencies and proceed to execute what he himself considers to be the most appropriate response under the circumstances. It, therefore, appeared that all thought processes have a preparatory phase during which time it is possible for the stimulus to make many associations. These may elicit a multitude of response tendencies from among which the subject exercises a sort

of choice in the execution of a response. The extent to which the subject was or was not capable of avoiding the elicitation of incompatible response tendencies seems to determine the amount of time needed to make a response. Those subjects that were not able to carry out these processes readily were then assumed to have encountered conflicting associations which elicited incompatible response tendencies that inhibited or blocked any response. It thus appeared to Jung that the intensity of the conflict touched upon by the stimulus word was a major factor in determining both the quality of the response and the delay of it.

In the more recently developed field of projective psychological testing, the reaction time method has also played a role of major importance. Rorschach(15), in his early research work with ink-blot stimulus cards, called attention to the use of the time for first response to each card as an important indicator of the extent to which the perceptual processes of the subject are disturbed by the perception of the stimulus and the consequent apperception derived from it. Although the originators of the Thematic Apperception Test did not include measurement of reaction time to their stimulus cards as part of their means of test analysis, many

present-day users of the test have incorporated this measurement and use it in much the same way as it is done in the Rorschach Test. Among other projective techniques in which reaction time is also being used is the Sentence Completion type of test.

Some recent studies have been made with projective instruments in which specific attention has been given to the factor of speed of response. Rapaport(14) studied this factor very extensively with both the Word Association Test and the Rorschach Test. With the former he finds that delay of response becomes more probable not only as the degree of maladjustment increases but also with the increasing likelihood that the stimulus words touch upon traumatic material and experiences. In his study with the Rorschach Test, he deals with the problem of reaction time more extensively. Although his statistical findings are not conclusive and not extensive enough to warrant the consideration of the reaction time as a diagnostic indicator, he does find consistent differences among various nosological, or disease, groups. He concludes that within the normal range, delayed reaction times may be primarily referred to an inhibition effect; while within the pathological range, delayed reaction time is more frequently indicative of depressive

psychometer retardation of pathological inhibition. In addition, he concludes that very short reaction times may be attributable to extensive ideational productivity.

In the field of physiology, much research has been done in correlating reaction time to exercises and athletics. Numerous studies have shown that athletes have a faster reaction time than non-athletes(2, 11, 18). There also seems to be some relation between reaction time and reflexes. For instance, sprinters have shorter reaction and shorter patellar reflex times than do long-distance runners(12). Physiologists have found many other factors that affect reaction time. Karpovich(10) states that the condition of the subject should be considered because fatigue slows down reaction time. He also states that reaction time has diurnal variations, the best time usually being obtainable in the afternoon. According to Atwell and Elbel(1), age also should be considered because reaction time is slower in younger children and gradually improves with age, reaching its maximum at the college-age period.

THE PURPOSE OF THIS STUDY

With knowledge of the history and the work that has been done with reaction time, it can be seen that many

factors affect individual differences noted in reaction time. This study of 15, 16, and 17 year-old athletes and non-athletes is made to further the knowledge of factors that affect reaction time.

CHAPTER II

APPARATUS AND PROCEDURE

Apparatus. The machine used for this study is the Neuromuscular Chronometer designed by Dr. C. L. Anderson, Oregon State College. The Neuromuscular Chronometer is designed to make an accurate time calibration of human responses to various stimuli. Time required for flexion and extension of the hands and arms, flexion and lateral movement of the leg, and extension of the lower leg can be measured precisely. Simple reactions without choice as well as those requiring a choice of response can be calibrated. Circuits are designed so that only the correct response will result in a recording.

The principle of operation of the chronometer is that a charged capacitor will always lose a definite percentage of its charge when it is connected across a resistor for a certain period of time. This device provides an electronic means of discharging a stable capacitor through a stable resistor for the duration of the time interval to be measured. The percentage of charge lost is accurately determined by a self-balancing potentiometer and this percentage is indicated by a mechanical pointer coupled to the potentiometer and

rotation over a clock dial calibrated in units of time. All charging and discharging is accomplished through inertialess electronic microswitches, thus permitting extremely short time intervals (.001 second) to be measured accurately. The total "lag" of the operation is calculated to be .003 second. Figure 1 shows the neuromuscular chronometer in operation.

Procedure. In administering the test, both the procedure and the explanation were consistent. Two subjects were in the room at the same time so that one could familiarize himself with procedures before taking the tests. Stimuli were reversed for every subject. For example, one subject would use red light and buzzer for the left hand or foot and green light and bell for the right hand or foot. This was reversed for the second subject. The time interval given between stimuli was varied between one and three counts. After initial explanation, the subject was told to concentrate on the stimulus and turn it off every time it came on. The subject was also told that no further explanation would be given except to change position for testing. There were no signals given such as "O.K." or "Ready", whereby the subject could anticipate and thus outguess the examiner. No attempt was made to catch the subject off guard or to

fool him, but every attempt was made to keep from forming a pattern or routine in testing so far as stimuli were concerned.

Recognizing the difference that time of day makes on reaction time, tests were given to all three ages both morning and afternoon. One half of each group took the tests in the morning, the other half took tests in the afternoon.

Figure 2 shows the score card used for testing. There are seven different positions using both light and sound. Two readings were taken for every test with the best reading used to compile statistics. In drawing histograms, only those tests showing the best example of the whole picture were drawn, thus eliminating enormous portions of insignificant statistics.

The test group consisted of sixty boys, 10 athletes and 10 non-athletes, in age groups 15, 16, and 17. All age groups were tested at North Salem Senior High School, Salem, Oregon.

To understand the machine better and to establish a pattern of test administration, a trial group of six boys was tested in a pilot study with the data obtained not used in the study.



Figure 1

NEURO-MUSCULAR RESPONSES
IN HIGH SCHOOL BOYS

Name _____ Age (years) _____ (months) _____

Date _____ Height _____ Weight _____

Handedness R _____ L _____ Both _____

LIGHT

SOUND

Test	Right	Left	Choice	Test	Right	Left	Choice
<u>Hand Flexion</u>				<u>Hand Flexion</u>			
<u>Hand Extension</u>				<u>Hand Extension</u>			
<u>Arm Flexion</u>				<u>Arm Flexion</u>			
<u>Arm Extension</u>				<u>Arm Extension</u>			
<u>Foot Extension</u>				<u>Foot Extension</u>			
<u>Combination Foot and Leg Extension</u>				<u>Combination Foot and Leg Extension</u>			
<u>Leg Flexion</u>				<u>Leg Flexion</u>			

FIGURE 2
SCORE CARD

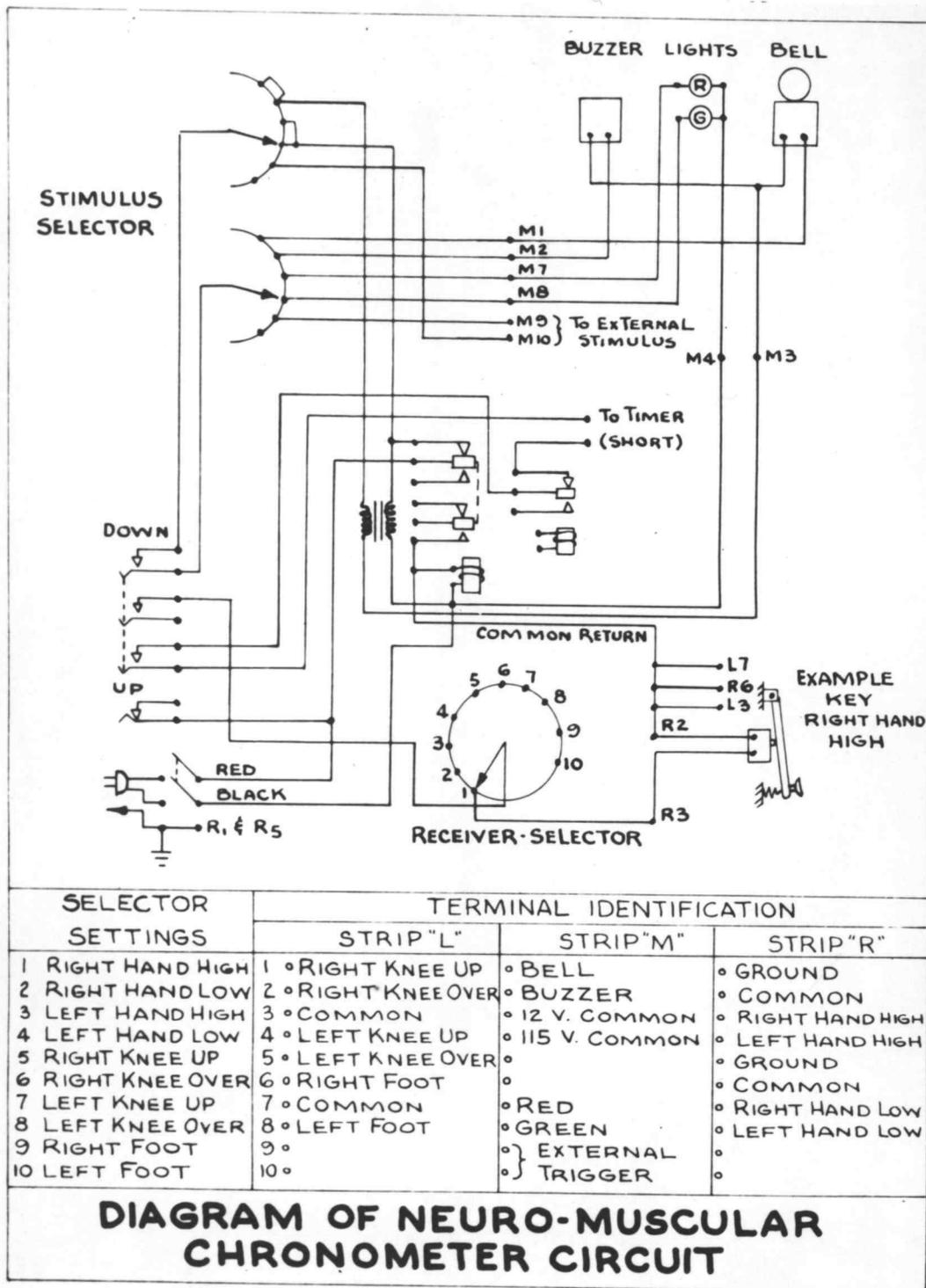


Figure 3

CHAPTER III

THE STUDY

POSITIONS AND MOVEMENTS USED IN MEASURING REACTION TIME

1. Hand Flexion- The subject sits at the machine with his finger tips resting on reaction keys C and D. He pushes down on the key when receiving either the light or sound stimulus.
2. Hand Extension- The subject sits at the machine with his arms extended and finger tips resting on reaction keys A and B on the board in front of him. He pushes forward on the key when receiving either the light or sound stimulus.
3. Arm Flexion- The subject sits at the machine with his hands resting on markers on the platform before him. When receiving the light or sound stimulus he moves his hand to key C or D located on the platform next to his hands.
4. Arm Extension- The subject sits at the machine with his hands resting on markers on the platform before him. When receiving the light or sound stimulus he extends his arms and with his finger tips strikes key A or B on the board in front of him.

5. Foot Extension- The subject sits at the machine with his feet resting on foot pedals I and J. When receiving the light or sound stimulus he presses his foot down on the pedal.
6. Combination Leg and Foot Extension- The subject sits at the machine with his feet immediately behind pedals I and J. When receiving the light or sound stimulus he moves his leg forward and presses his foot down on the pedal.
7. Leg Flexion- The subject sits at the machine with his knees below and touching the reaction keys which are located under the platform. When receiving the light or sound stimulus he raises his knee upward and strikes the reaction key.
8. Choice Reaction- The subject must make a choice and thus think before reacting. For example, if he sees a red light he will use his left hand, if he sees a green light he will use the right. The hand movement and stimulus are changed repeatedly to eliminate a fixed pattern of responding.

15 YEAR OLD REACTION TIMES

NON - ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT			GREEN LIGHT			CHOICE			WRONG CHOICE										
	RIGHT			LEFT			RIGHT			LEFT			L	R						
	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.								
HAND FLEX.	410	145	260	360	158	260	400	152	265	366	190	269	430	220	310	279	275	277	0	1
HAND EXT.	280	135	200	320	150	240	290	161	223	310	146	245	320	266	296	322	180	278	1	1
ARM FLEX.	420	170	299	400	192	286	410	180	295	401	132	244	388	255	336	358	250	318	0	3
ARM EXT.	420	185	313	385	130	314	418	122	310	390	185	317	423	320	356	380	298	339	0	0
FOOT EXT.	500	248	319	360	150	267	460	250	320	386	206	301	420	280	330	365	288	319	4	1
COMB. FOOT & LEG EXT.	420	250	347	472	244	328	432	235	346	488	220	334	426	323	354	462	292	371	0	0
LEG FLEX.	422	175	295	410	200	298	423	190	293	416	198	295	421	300	333	422	210	307	2	3

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REACTION TIME TO SOUND

TEST	BELL			BUZZER			CHOICE			WRONG CHOICE										
	RIGHT			LEFT			RIGHT			LEFT			L	R						
	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.								
HAND FLEX.	298	212	268	320	192	244	360	210	262	330	180	239	330	266	306	330	218	285	2	0
HAND EXT.	341	160	260	300	180	234	350	150	258	310	190	247	341	210	290	395	216	305	1	2
ARM FLEX.	400	182	307	401	178	289	440	170	305	390	175	285	410	286	351	388	252	324	1	1
ARM EXT.	466	198	335	488	170	314	460	170	309	450	165	301	490	212	361	425	200	324	2	1
FOOT EXT.	456	188	281	345	192	264	460	180	287	320	165	256	318	260	291	465	285	339	1	2
COMB. FOOT & LEG EXT.	412	160	314	410	200	313	425	158	318	430	220	316	435	326	378	420	220	321	0	1
LEG FLEX	406	162	313	405	128	304	440	190	327	385	210	320	320	313	316	416	222	343	3	0

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HI. - HIGH
 LO. - LOW
 AVE. - AVERAGE
 FLEX. - FLEXION
 EXT. - EXTENSION

TIME - THOUSANDS OF A SECOND

TABLE 1

15 YEAR OLD RESPONSE TIMES

ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT						GREEN LIGHT						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.		
HAND FLEX.	330	150	200	260	140	217	275	160	192	250	152	207	300	182	245	301	168	244	1	1
HAND EXT.	340	138	209	282	125	196	362	140	213	280	136	212	288	188	235	289	204	255	0	1
ARM FLEX.	335	160	234	380	182	280	318	162	234	325	192	266	338	280	300	340	200	273	2	0
ARM EXT.	400	150	321	380	100	253	402	162	310	341	198	268	369	220	324	386	192	307	1	1
FOOT EXT.	395	115	245	360	165	264	400	110	246	355	160	241	296	180	246	368	235	315	0	4
COMB. FOOT & LEG EXT.	390	148	274	390	180	303	410	152	268	402	182	297	358	301	324	421	200	293	2	2
LEG FLEX.	400	160	279	370	150	302	412	172	282	360	180	281	366	142	251	388	296	330	3	4

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REACTION TIME TO SOUND

TEST	BELL						BUZZER						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.	HI.	LO.	AVE.		
HAND FLEX.	278	150	193	240	156	195	280	145	204	250	142	193	278	197	237	286	160	213	2	0
HAND EXT.	261	130	185	260	150	211	285	120	194	240	162	220	298	170	240	280	168	211	0	2
ARM FLEX.	331	162	260	316	188	259	335	168	255	320	160	251	310	202	271	343	296	320	1	1
ARM EXT.	398	140	286	341	178	253	390	130	282	350	180	254	318	200	288	398	190	311	0	1
FOOT EXT.	392	160	247	320	171	248	385	170	257	360	120	245	398	178	277	330	212	277	2	1
COMB. FOOT & LEG EXT.	372	160	259	380	168	273	370	172	283	372	170	291	400	192	300	362	225	305	1	1
LEG FLEX.	348	150	256	360	162	263	350	148	259	370	175	262	368	249	300	377	284	311	3	2

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HI - HIGH
 LO - LOW
 AVE - AVERAGE
 FLEX - FLEXION
 EXT - EXTENSION

TIME - THOUSANDTHS OF A SECOND

TABLE 2

COMPARISON CHART OF 15 YEAR OLD ATHLETE AND NON-ATHLETE
REACTION TO LIGHT AND SOUND

TEST	LIGHT				SOUND			
	RIGHT		LEFT		RIGHT		LEFT	
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.
HAND FLEX.	196	262	212	264	198	265	194	241
HAND EXT.	211	211	204	242	190	259	216	240
ARM FLEX.	234	297	273	290	257	306	255	287
ARM EXT.	315	312	261	316	284	322	253	308
FOOT EXT.	245	319	247	284	252	284	246	260
COMB. FOOT/LEG EXT.	271	346	300	331	271	316	282	314
LEG FLEX.	280	294	291	296	257	320	262	312

RESULTS

HAND FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
HAND EXT.	THE NON-ATHLETE WAS EQUAL TO THE ATHLETE IN RIGHT HAND REACTION TIME TO LIGHT. THE ATHLETE REACTED MUCH FASTER TO EVERY OTHER STIMULUS.
ARM FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
ARM EXT.	THE NON-ATHLETE WAS SLIGHTLY FASTER THAN THE ATHLETE IN RIGHT HAND REACTION TIME TO LIGHT. THE ATHLETE REACTED MUCH FASTER TO EVERY OTHER STIMULUS.
FOOT EXT.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
COMB. FOOT/LEG EXT.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
LEG FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.

TABLE 3

TEST	LIGHT				SOUND				WRONG CHOICE	
	RIGHT		LEFT		RIGHT		LEFT		ATH.	NON.
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.		
HAND FLEX.	24 ₅	31 ₀	24 ₄	27 ₇	23 ₇	30 ₆	21 ₃	28 ₅	4	3
HAND EXT.	23 ₅	29 ₆	25 ₅	27 ₈	24 ₀	29 ₀	21 ₁	30 ₅	3	5
ARM FLEX.	30 ₀	33 ₆	27 ₃	31 ₈	27 ₁	35 ₁	32 ₀	32 ₄	4	5
ARM EXT.	32 ₄	35 ₆	30 ₇	33 ₉	28 ₀	36 ₁	31 ₁	34 ₂	3	3
FOOT EXT.	24 ₆	33 ₀	31 ₅	31 ₉	27 ₇	29 ₁	27 ₇	33 ₉	7	8
COMB FOOT & LEG EXT.	32 ₄	35 ₄	29 ₃	37 ₁	30 ₀	37 ₈	30 ₅	32 ₁	6	1
LEG FLEX.	25 ₁	33 ₃	33 ₀	30 ₇	30 ₀	31 ₆	31 ₁	34 ₃	12	8

RESULTS

HAND FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE NON-ATHLETE MADE ONE LESS WRONG CHOICE.
HAND EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE TWO LESS WRONG CHOICES.
ARM FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE ONE LESS WRONG CHOICE.
ARM EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS.
FOOT EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE ONE LESS WRONG CHOICE.
COMB FOOT & LEG EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE NON-ATHLETE MADE FIVE LESS WRONG CHOICES.
LEG FLEX.	THE NON-ATHLETE WAS FASTER THAN THE ATHLETE IN LEFT FOOT REACTION TIME TO LIGHT. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS. THE NON-ATHLETE MADE FOUR LESS WRONG CHOICES.

TABLE 4

A general summary of the reaction time tests of the fifteen year old athlete and non-athlete indicates that the athlete reacts faster than the non-athlete in all but two of the tests. The non-athlete was equal to the athlete only on reaction time to light on right hand and arm extension movements.

In choice reaction time where the subject must think before reacting, the athlete was much faster in every movement except left leg flexion in response to the light stimulus. The non-athlete made six less wrong choices than the athlete, this may be due to the fact that the non-athlete was more cautious in making his choice.

16 YEAR OLD RESPONSE TIMES

NON-ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT						GREEN LIGHT						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	360	171	249	325	185	254	298	198	233	320	190	248	395	232	303	350	220	290	1	1
HAND EXT.	282	190	236	315	169	244	285	175	231	298	198	236	328	210	273	330	210	281	5	1
ARM FLEX.	340	262	295	355	250	295	386	213	294	375	232	302	345	310	328	398	301	334	2	0
ARM EXT.	401	210	312	408	250	321	402	212	310	416	220	327	422	332	385	410	290	350	4	0
FOOT EXT.	295	161	245	285	150	230	320	168	250	312	145	237	398	242	300	480	268	314	2	5
COMB. FOOT & LEG EXT.	365	222	286	314	222	266	358	220	286	315	220	268	402	292	338	340	272	311	2	1
LEG FLEX.	310	200	271	315	200	272	306	262	285	318	202	275	301	222	281	328	290	307	4	4

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REACTION TIME TO SOUND

TEST	BELL						BUZZER						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	290	220	270	298	198	267	300	215	263	290	242	264	339	210	280	338	262	295	2	0
HAND EXT.	248	202	244	280	202	241	288	200	248	288	205	258	310	232	279	322	242	292	2	2
ARM FLEX.	388	262	303	333	260	293	350	250	307	380	248	305	398	290	322	395	325	366	1	2
ARM EXT.	366	222	307	392	210	321	400	215	315	390	230	312	415	272	331	398	302	334	1	1
FOOT EXT.	300	162	249	300	170	257	300	209	260	300	210	260	398	266	313	398	262	306	4	3
COMB. FOOT & LEG EXT.	320	248	278	310	265	290	380	240	291	365	222	298	320	301	313	380	295	327	2	0
LEG FLEX.	330	181	265	380	204	274	318	218	270	338	232	277	406	280	323	330	280	297	3	2

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HI - HIGH
 LO - LOW
 AVE - AVERAGE
 FLEX - FLEXION
 EXT. - EXTENSION

TIME - THOUSANDTHS OF SECONDS

TABLE 5

16 YEAR OLD RESPONSE TIMES

ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT						GREEN LIGHT						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	300	150	197	325	125	202	295	135	198	320	128	204	320	180	228	260	221	240	0	3
HAND EXT.	246	148	197	320	140	202	260	155	201	295	160	205	202	190	196	310	178	244	2	1
ARM FLEX.	350	158	259	340	150	249	350	140	242	333	158	254	320	248	290	362	210	296	1	2
ARM EXT.	325	150	244	410	182	286	300	168	263	405	198	268	396	212	301	412	272	318	0	2
FOOT EXT.	310	150	228	370	148	238	300	168	227	333	146	227	355	186	245	312	220	263	1	4
COMB. FOOT & LEG EXT.	400	190	297	360	168	262	395	142	275	371	180	275	380	298	329	388	210	297	1	1
LEG FLEX.	390	182	250	340	155	240	375	182	234	315	160	229	340	220	292	318	273	288	1	2

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REACTION TIME TO SOUND

TEST	BELL						BUZZER						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	312	172	243	275	142	199	340	160	235	295	130	196	288	202	250	320	198	245	0	0
HAND EXT.	300	182	218	220	130	181	310	150	219	226	150	180	320	202	246	268	210	235	0	2
ARM FLEX.	335	152	265	305	168	277	340	150	273	360	170	277	322	196	250	365	260	314	2	0
ARM EXT.	402	166	297	368	188	268	400	155	295	380	152	266	380	215	324	408	210	299	1	0
FOOT EXT.	298	150	211	266	132	215	300	140	214	298	142	215	282	187	241	310	211	266	3	3
COMB. FOOT & LEG EXT.	385	178	287	360	202	274	390	135	261	390	190	280	401	258	306	320	202	275	0	0
LEG FLEX.	300	170	236	320	175	230	340	150	240	350	160	245	310	262	288	355	190	273	3	0

9 5

HI - HIGH
 LO - LOW
 AVE - AVERAGE
 FLEX - FLEXION
 EXT - EXTENSION

TIME - THOUSANDTHS OF SECOND

TABLE 6

COMPARISON CHART OF 16 YEAR OLD ATHLETE AND NON-ATHLETE
REACTION TO LIGHT- AND SOUND

TEST	LIGHT				SOUND			
	RIGHT		LEFT		RIGHT		LEFT	
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.
HAND FLEX.	197	241	203	251	239	267	197	266
HAND EXT.	199	234	203	240	218	246	180	249
ARM FLEX.	250	295	251	298	268	305	277	299
ARM EXT.	263	311	277	324	296	311	267	316
FOOT EXT.	227	247	232	234	212	254	215	258
COMB. FOOT & LEG EXT.	286	286	268	267	254	285	277	294
LEG FLEX.	242	278	239	274	238	268	236	275

RESULTS

HAND FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
HAND EXT.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
ARM FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
ARM EXT.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
FOOT EXT.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.
COMB. FOOT & LEG EXT.	THE NON-ATHLETE WAS EQUAL TO THE ATHLETE IN COMBINATION RIGHT FOOT AND LEG EXPANSION TO THE LIGHT STIMULUS. WAS ALSO SLIGHTLY FASTER IN COMBINATION LEFT FOOT AND LEG EXTENSION TO THE LIGHT STIMULUS. THE ATHLETE REACTED FASTER TO THE SOUND STIMULUS.
LEG FLEX.	THE ATHLETE REACTED MUCH FASTER TO EVERY STIMULUS.

TABLE 7

COMPARISON CHART OF 16 YEAR OLD ATHLETE AND NON-ATHLETE

CHOICE REACTION TIME

TEST	LIGHT				SOUND				WRONG CHOICE	
	RIGHT		LEFT		RIGHT		LEFT		ATH	NON
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.		
HAND FLEX.	228	303	240	290	250	280	245	295	3	4
HAND EXT.	196	273	264	281	246	279	235	292	5	10
ARM FLEX.	240	328	296	334	250	322	314	366	5	5
ARM EXT.	301	385	318	350	324	331	293	334	3	6
FOOT EXT.	245	300	263	374	244	313	266	306	11	14
COMB. FOOT & LEG EXT.	329	338	297	311	306	313	275	327	2	5
LEG FLEX.	292	281	288	307	288	323	273	297	6	13

RESULTS

HAND FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE ONE LESS WRONG CHOICE.
HAND EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE FIVE LESS WRONG CHOICES.
ARM FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS.
ARM EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE THREE LESS WRONG CHOICES.
FOOT EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS THE ATHLETE MADE THREE LESS WRONG CHOICES.
COMB. FOOT & LEG EXT.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE THREE LESS WRONG CHOICES.
LEG FLEX.	THE NON-ATHLETE WAS FASTER THAN THE ATHLETE IN RIGHT LEG-FLEXION TO THE LIGHT STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS. THE ATHLETE MADE SEVEN LESS WRONG CHOICES.

TABLE 8

A general summary of reaction time tests of the sixteen year old athlete and non-athlete indicates that the athlete reacts faster than the non-athlete in most of the tests used. Of the many movements tested the non-athlete was equal to the athlete on reaction time to light on combination right foot and leg extension. The non-athlete also was slightly faster on reaction to light on the combination left foot and leg extension movements.

In choice reaction time the athlete was much faster in every movement, except right leg flexion in response to the light stimulus. The athletes also made twenty-two less wrong choices than the non-athletes.

17 YEAR OLD RESPONSE TIMES

NON-ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT						GREEN LIGHT						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	300	210	257	310	160	231	310	170	257	300	162	230	320	250	290	298	250	270	2	1
HAND EXT.	295	170	244	312	172	252	288	200	244	320	180	247	310	202	268	315	225	274	2	0
ARM FLEX.	320	230	285	308	240	286	315	240	286	410	230	300	418	277	331	310	248	285	1	1
ARM EXT.	340	250	315	380	200	300	386	266	325	395	210	300	410	285	349	392	289	332	0	2
FOOT EXT.	300	40	229	315	200	255	332	196	261	312	212	257	318	240	287	336	215	279	2	3
COMB. FOOT & LEG EXT.	400	242	278	412	190	289	411	200	282	418	185	297	426	310	346	348	286	312	1	0
LEG FLEX.	330	188	258	310	185	258	322	200	267	298	200	260	312	250	287	300	286	288	2	5

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REACTION TIME TO SOUND

TEST	BELL						BUZZER						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	290	135	212	288	140	233	285	140	227	278	183	224	288	232	262	310	210	260	1	0
HAND EXT.	282	155	207	298	185	224	282	160	196	300	132	211	322	250	277	310	245	283	1	1
ARM FLEX.	332	201	292	345	225	293	360	192	282	375	250	299	395	300	346	388	312	348	0	1
ARM EXT.	392	198	312	400	210	316	390	170	307	370	200	298	386	292	326	410	310	379	1	1
FOOT EXT.	310	166	235	336	205	241	295	220	241	335	180	259	346	222	277	318	245	278	1	3
COMB. FOOT & LEG EXT.	412	180	279	398	180	291	410	200	301	390	220	302	416	301	350	355	308	331	3	2
LEG FLEX.	320	212	274	310	210	268	360	220	277	312	190	246	330	198	289	366	240	309	2	2

9 10

HI - HIGH
 LO - LOW
 AVE - AVERAGE
 FLEX - FLEXION
 EXT - EXTENSION

TIME - THOUSANDTHS OF SECOND

TABLE 9

17 YEAR OLD RESPONSE TIMES ATHLETES

REACTION TIME TO LIGHT

TEST	RED LIGHT						GREEN LIGHT						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	285	140	217	320	148	217	286	148	221	302	152	212	318	165	255	310	158	234	0	0
HAND EXT.	290	138	208	300	130	204	300	132	213	298	150	209	311	220	274	288	180	235	2	0
ARM FLEX.	310	162	239	350	160	263	320	170	240	338	165	254	380	260	312	362	240	295	1	1
ARM EXT.	388	180	289	400	185	320	380	188	294	390	190	308	376	196	295	402	266	350	0	0
FOOT EXT.	340	220	272	320	240	280	340	221	274	312	200	265	330	306	317	318	230	274	1	0
COMB. FOOT/LEG EXT.	410	210	332	390	230	304	400	280	296	332	246	296	362	310	333	412	320	378	1	0
LEG FLEX.	380	180	281	272	160	211	355	192	263	286	160	225	360	194	288	326	198	274	1	2

6 3

REACTION TIME TO SOUND

TEST	BELL						BUZZER						CHOICE						WRONG CHOICE	
	RIGHT			LEFT			RIGHT			LEFT			RIGHT			LEFT			L	R
	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE	HI	LO	AVE		
HAND FLEX.	286	182	229	266	132	205	290	190	234	270	135	206	284	192	236	288	218	240	0	0
HAND EXT.	285	160	217	241	160	203	280	155	218	238	140	200	266	192	228	288	266	280	0	0
ARM FLEX.	300	160	240	345	210	286	330	140	242	365	200	285	345	212	288	370	266	312	0	0
ARM EXT.	385	168	262	395	162	296	390	172	263	400	182	305	410	310	337	346	198	295	0	1
FOOT EXT.	298	200	258	298	161	235	310	230	259	300	152	231	298	244	269	310	266	282	3	1
COMB. FOOT/LEG EXT.	388	207	315	346	282	312	380	240	307	350	270	307	395	295	339	366	318	332	0	1
LEG FLEX.	298	160	253	323	196	251	310	158	256	295	160	242	302	288	295	336	268	297	3	1

6 4

HI - HIGH
LO - LOW
AVE - AVERAGE
FLEX - FLEXION
EXT. - EXTENSION

TIME - THOUSANDTHS OF SECOND

TABLE 10

COMPARISON CHART OF 17 YEAR OLD ATHLETE AND NON-ATHLETE

REACTION TO LIGHT AND SOUND

TEST	LIGHT				SOUND			
	RIGHT		LEFT		RIGHT		LEFT	
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.
HAND FLEX.	219	257	214	230	231	220	205	229
HAND EXT.	210	244	206	249	217	202	202	218
ARM FLEX.	240	285	258	293	241	287	285	296
ARM EXT.	291	320	314	300	262	310	300	307
FOOT EXT.	273	245	272	256	258	238	282	250
COMB. FOOT & LEG EXT.	314	280	300	293	311	290	309	297
LEG FLEX.	272	263	218	259	254	275	247	257

RESULTS

HAND FLEX.	THE NON-ATHLETE WAS FASTER IN RIGHT HAND FLEXION TO THE SOUND STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS.
HAND EXT.	THE NON-ATHLETE WAS FASTER IN RIGHT HAND EXTENSION TO THE SOUND STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS.
ARM FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS.
ARM EXT.	THE NON-ATHLETE WAS FASTER IN LEFT ARM EXTENSION TO THE LIGHT STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS.
FOOT EXT.	THE NON-ATHLETE REACTED FASTER TO EVERY STIMULUS EXCEPT LEFT FOOT EXTENSION TO THE SOUND STIMULUS.
COMB. FOOT & LEG EXT.	THE NON-ATHLETE REACTED FASTER TO EVERY STIMULUS.
LEG FLEX.	THE NON-ATHLETE WAS FASTER. IN RIGHT LEG FLEXION TO THE LIGHT STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS.

TABLE 11

COMPARISON CHART OF 17 YEAR OLD ATHLETE AND NON-ATHLETE

CHOICE REACTION TIME

TEST	LIGHT				SOUND				WRONG CHOICE	
	RIGHT		LEFT		RIGHT		LEFT		ATH.	NON.
	ATH.	NON.	ATH.	NON.	ATH.	NON.	ATH.	NON.		
HAND FLEX.	255	290	234	270	236	262	240	260	0	4
HAND EXT.	274	268	225	274	228	277	280	283	2	4
ARM FLEX.	312	331	295	285	288	346	312	348	2	3
ARM EXT.	295	349	350	332	337	326	295	379	1	4
FOOT EXT.	317	287	274	279	269	277	282	278	5	9
COMB. FOOT & LEG EXT.	333	346	378	312	339	350	332	331	2	6
LEG FLEX.	288	287	274	288	295	289	297	309	7	11

RESULTS

HAND FLEX.	THE ATHLETE REACTED FASTER TO EVERY STIMULUS. THE ATHLETE MADE FOUR LESS WRONG CHOICES.
HAND EXT.	THE NON-ATHLETE WAS FASTER IN RIGHT HAND EXTENSION TO THE LIGHT STIMULUS. THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS. THE ATHLETE MADE TWO LESS WRONG CHOICES.
ARM FLEX.	THE NON-ATHLETE WAS IN LEFT ARM FLEXION TO THE LIGHT STIMULUS, ALSO THE ATHLETE REACTED FASTER TO EVERY OTHER STIMULUS. THE ATHLETE MADE ONE LESS WRONG CHOICE.
ARM EXT.	THE NON-ATHLETE WAS FASTER IN LEFT ARM EXTENSION TO THE LIGHT STIMULUS, ALSO IN RIGHT ARM EXTENSION TO THE SOUND STIMULUS. THE ATHLETE MADE THREE LESS WRONG CHOICES.
FOOT EXT.	THE NON-ATHLETE WAS FASTER IN RIGHT FOOT EXTENSION TO THE LIGHT STIMULUS, ALSO TO LEFT FOOT EXTENSION TO THE SOUND STIMULUS. THE ATHLETE MADE FOUR LESS WRONG CHOICES.
COMB. FOOT & LEG EXT.	THE NON-ATHLETE WAS FASTER IN LEFT FOOT COMBINATION FOOT AND LEG EXTENSION TO THE LIGHT STIMULUS, ALSO IN LEFT FOOT COMBINATION FOOT AND LEG EXTENSION TO SOUND STIMULUS. THE ATHLETE MADE FOUR LESS WRONG CHOICES.
LEG FLEX.	THE NON-ATHLETE WAS FASTER IN RIGHT LEG FLEXION TO THE LIGHT STIMULUS, ALSO IN RIGHT LEG FLEXION TO THE SOUND STIMULUS. THE ATHLETE MADE FOUR LESS WRONG CHOICES.

TABLE 12

A general summary of reaction time tests of seventeen year old athletes and non-athletes indicates that at this age level the non-athlete reacts almost as fast as the athlete. Of twenty-eight tests taken the non-athlete was faster in eleven of them. The non-athlete reacted faster in the following tests: right hand flexion to sound, right hand extension to sound, left arm extension to light, right foot extension to light, left foot extension to light, right foot extension to sound, right foot combination foot and leg extension to light, left foot combination foot and leg extension to light, right foot combination foot and leg extension to sound, left foot combination foot and leg extension to sound and right leg flexion to light.

In choice reaction time the non-athlete also reacts almost as fast as the athlete. Of twenty-eight tests taken the non-athlete reacted faster in ten of them. The non-athlete reacted faster in the following tests: right hand extension to light, left arm flexion to light, left arm extension to light, right arm extension to sound, right foot extension to light, left foot extension to sound, left foot combination foot and leg extension to light, left foot combination foot and leg extension to sound, right leg flexion to light, and right leg flexion to sound.

The athlete made twenty-two less wrong choices than the non-athlete.

CHAPTER IV

CONCLUSIONS

Tests with the neuromuscular chronometer of the reaction time for various neuromuscular response patterns reveal interesting differences and similarities in non-athletes and athletes at the fifteen year, sixteen year, and seventeen year levels. Among fifteen year old boys, athletes were definitely faster in right and left hand flexion in response to both the light stimulus and the sound stimulus, right and left hand extension to the sound stimulus, left hand extension to the light stimulus, right arm flexion to the light stimulus, right arm flexion to the sound stimulus, right foot extension to the light stimulus, and combination right foot and leg extension to the light stimulus, and combination right foot and leg extension to the light stimulus. The athletes were somewhat faster than non-athletes in left arm flexion to the light stimulus, left arm flexion to the sound stimulus, right arm extension to the sound stimulus, left foot extension to the light stimulus, right and left foot extension to the sound stimulus, combination left foot and leg extension to the sound stimulus and right and left leg flexion to both the light and sound stimulus.

The athletes were not faster than the non-athletes in right hand extension to the light stimulus and right arm extension to the light stimulus. In choice reaction, the athletes made six more wrong choices than the non-athletes.

Athletes were faster in the fifteen year age group especially in right and left hand flexion to both the light and sound stimulus, right and left hand extension to the sound stimulus, left hand extension to the light stimulus, right arm flexion to the light stimulus, right arm flexion to the sound stimulus, left arm extension to the light stimulus, left arm extension to the sound stimulus, right foot extension to the light stimulus, and combination right foot and leg extension to the light stimulus.

Among sixteen year old boys athletes were definitely faster in right and left hand flexion to the light stimulus, left hand flexion to the sound stimulus, left hand extension to the sound stimulus, right and left arm flexion to the light stimulus, right and left arm extension to the light stimulus, left arm extension to the sound stimulus, and left foot extension to the sound stimulus. The athletes were somewhat faster than non-athletes in right hand flexion to the sound stimulus, right and left hand extension to the light stimulus,

right hand extension to the sound stimulus, right and left arm flexion to the sound stimulus, right arm extension to the sound stimulus, right and left foot extension to the light stimulus, right foot extension to the sound stimulus, combination right and left foot and leg extension to the sound stimulus, and right and left leg flexion to both the light and sound stimulus. The athletes were not faster than the non-athletes in combination right and left foot and leg extension to the light stimulus. In choice reaction the athletes made twenty-two less wrong choices than the non-athletes.

Among seventeen year old boys athletes were definitely faster in left hand extension to the light stimulus, right arm flexion to the light stimulus, right arm flexion to the sound stimulus, right arm extension to the sound stimulus, and left leg flexion to the light stimulus. The athletes were somewhat faster than non-athletes in right and left hand flexion to the light stimulus, left hand flexion to the sound stimulus, right hand extension to the light stimulus, left hand extension to the sound stimulus, left arm flexion to the light stimulus, left arm flexion to the sound stimulus, right arm extension to the light stimulus, left arm extension to the sound stimulus, left foot extension to the sound stimulus, and

right and left leg flexion to the sound stimulus. The athletes were not faster than the non-athletes in right hand flexion to the sound stimulus, right hand extension to the sound stimulus, left arm extension to the light stimulus, right and left foot extension to the light stimulus, right foot extension to the sound stimulus, combination right and left foot and leg extension to both the light and sound stimulus, and right leg flexion to the light stimulus. In choice reaction, the athletes made twenty-two less wrong choices than the non-athletes.

These tests reveal that as age progresses the athlete compared to the non-athlete becomes progressively less superior in reaction time. This indicates that neuromuscular patterns mature earlier in some boys and thus enables these boys to be more proficient in athletics. Many of the non-athletes who are late in maturing may become more skilled during later years. Coaches need to recognize this as many potentially good athletes may be dropped from school teams before reaching their full physical development.

Sound advice to any coach is be patient with and retain on the squad all really big boys of the fifteen year age group until the coach is sure they have no chance. A six foot four inch boy, awkward as a freshman,

may win a championship as a senior. Many young big boys look hopeless when they first turn out for an athletic squad but reaction tests indicate to the coach not to be hasty in cutting his squad, it may cost him an outstanding athlete and a future championship team.

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