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The Effects of the Phenomenon of the Psychological Refractory Period Upon College Athletes and Non-Athletes

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WESTERN KENTUCKY UNIVERSITY
Athletics

THE EFFECTS OF THE PHENOMENON OF THE PSYCHOLOGICAL REFRACTORY
PERIOD UPON COLLEGE ATHLETES AND NON-ATHLETES

A Thesis

Presented to

the Faculty of the Department of Physical
Education and Recreation
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by

Jefferson C. Knott

July 1970

THE EFFECTS OF THE PHENOMENON OF THE PSYCHOLOGICAL REFRACTORY
PERIOD UPON COLLEGE ATHLETES AND NON-ATHLETES

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CHAPTER ONE

THE PROBLEM AND ITS BACKGROUND

Introduction

A considerable amount of experimentation has been undertaken since 1931 to account for the phenomenon of the psychological refractory period. This phenomenon, due to its effect on the servo-mechanism, is believed to be of importance in any human performance which requires fast responses to successive stimuli. Generally speaking, when discrete stimuli are presented to a subject in pairs at either regular or irregular time intervals, the reactive time to the second stimulus which is separated by a time interval of .5 seconds or less tends to be of a longer duration than the reaction time to the first stimulus. This additional delay to an individual's reaction time, when stimuli are presented close to each other in time is called the psychological refractory period.

Three basic theories offered to account for the phenomenon are: (1) the central refractoriness theory, (2) the preparatory state theory, and (3) the single channel theory.

The central refractoriness theory suggests that there is some physiological inhibitory effect of the first stimulus upon the second. The preparatory state theory places the reason for the delay in the second reaction time, not to the influence of the first stimulus, which is regarded as a warning signal, to the

subject's preparatory state. The single channel theory considers that within the arc of perception-response-selection-response performance, there is a "single channel" which cannot process both stimuli simultaneously but must hold the additional stimulus in store until the processing of the first stimulus is complete.

Statement of the Problem

This study was undertaken for the purpose of investigating the possible effects of the psychological refractory period upon highly selected and trained college freshman basketball players and freshman college non-athletes. More specifically, this study was conducted: (1) to investigate the simple reaction times of the left hand and the right hand, of both athletes and non-athletes, and (2) to find out the immediate effect of the refractory times of the left hand at the time intervals, 50, 100, 150, 200, 250, 300, 350, 400, 450, and 500 milli-seconds, between athletes and non-athletes.

Need for the Study

The tremendous advancement of every facet of our lives has placed heavy demands upon the human being, to the stage where the human being cannot always meet the demands of the environment. The main concern is that whereas a single stimulus given to an individual may be responded to effectively, another stimulus given to the subject at varying short time lapses after the first stimulus may cause the subject to be unable to respond to the second. Numerous investigations have produced many theories concerning the possible causes of the phenomenon. Interest in the psychological refractory

period has recently been a concern of the sport world, but as yet no one has attempted to compare the effect of the psychological refractory period of athletes and non-athletes. It is speculated that the phenomenon in question may well be one of the important reasons why selected individuals are successful in sport. The successful performer may show a different response to the second stimuli than to the first. This investigation has attempted to add to the knowledge within this field of research.

Adams¹ indicated that this topic is one of the most challenging directions for future research in motor skills. Above all else, it is hoped that this study will serve as a step in answering the question: Is there any significant difference in the reaction times of single and paired responses of athletes and non-athletes?

Underlying Hypotheses

The following hypotheses will be tested in this study:

1. There is no significant difference of single left hand reaction times between the athlete and non-athlete groups.
2. There is no significant difference of single right hand reaction times between the athlete and non-athlete groups.
3. There are no significant differences of the refractory time means at the various time intervals between stimulus presentation of athletes and non-athletes.

¹Jack A. Adams, "Motor Skills," Animal Rev. Psychology, Vol. 15, (1964), pp. 181-120.

Limitations of the Study

1. The study was limited to twelve full-time male students enrolled at Western Kentucky University, Bowling Green, Kentucky.

2. As many experimental variables as possible were controlled by the investigator. However, the researcher was aware of, but not able to control certain environmental factors which may have affected the subjects' responses, such as fatigue, emotional stability, mental attitude and the amount of sleep the night before testing.

3. It was necessary to conduct the experiment within the confines of one room. However, sufficient screening and sound-proofing was provided to eliminate or control distractions.

Definition of Terms

1. Psychological refractory period.--The delay (beyond the normal reaction time) in responding to a second stimulus which closely follows the presentation of, and response to, an initial stimulus.

2. Single reaction time.--The period of time from the stimulus to the beginning of the overt response. The time required to get the overt response started; the stimulus-response interval. It is the time interval between the onset of the stimulus and the initiation of the response by the subject, under the condition that the subject has been instructed to respond as quickly as possible.

3. Single reaction time trial.--The presentation of a preparatory signal followed by the presentation of a light

stimulus to which the subject reacted with a hand movement off a signal key.

4. Paired reaction time trial.--The presentation of a preparatory signal followed by the presentation of two separated light stimuli.

5. Catch trial for single responses.--A trial where the preparatory signal is given, but where no light flashes, and no response was expected from the subject.

6. Catch trial for refractory responses.--A manipulation of visual responses to stop the subject anticipating.

7. Light stimulus.--The lighting of two neon lights mounted on a vertical panel in front of the seated subject, at eye level.

Summary

The human finds that the speed of life in which he or she lives is accelerating. The individual is often required to cope with stimuli presented at close proximity to one another. It has also been found that there is an inhibiting factor when stimuli are presented at specific short time intervals to one another. This is known as the psychological refractory period.

While there are a number of theories concerning the psychological refractory period, researchers have confirmed that it does exist and there are varying time factors effecting the phenomenon.

There is a need for a study dealing with people who are constantly being exposed to stimuli being presented in close

proximity to one another. It may be that the athlete is better adjusted, through practice and inherent ability, to react far more successfully in such situations than the non-athlete.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

In the realm of sport where the speed of the game situations, the speed of movement of the players, and the complications of tactics and strategy can all be associated with the speed of reaction of the individual participant and the ability of the neuromuscular system to allow the organism to respond

It can be seen that during the enactment of the complex skills involved in a bat swing, and in many other similar types of motor activity, the performer is called upon to make uprated adjustments of his motor performance as the stimuli or environment change.¹

It has been observed that when the individual is presented with very closely separated stimuli the subject will often not react to the second of the stimuli, until the first one has been processed. It has further been noticed that manipulation of the interval between stimuli will frequently produce changes of speed of response. Thus, this phenomenon, associated as being the psychological refractory period, has a significant role in the execution of an activity.

¹Marilyn C. Smith, "Theories of the psychological refractory period." Psychological Bulletin. Vol. 67, (1967), p. 202.

The Psychological Refractory Period

The problem involved in the study of the nature of these repeated adjustments to stimuli resolves itself with a consideration of the human sensory response system. The phenomenon of the psychological refractory period was found through laboratory investigations that in successive stimuli at varying short time intervals after the first stimulus and response, man's response to successive discrete stimuli were far less than five per second. The maximum rate of response is closer to about two responses per second.

It would seem that the delay which has been found in the second reaction time suggests the possible presence of a limiting mechanism in the processing system. Since the late 1920's various theories have been put forward to explain this delay and the characteristics of the mechanism.

As yet, there is no solid agreement on the nature and mechanism of the psychological refractory period. Welford² had one theory for this phenomenon. He asserted that the refractoriness in responding to a given stimulus, which closely follows another stimulus, was in the central mechanism, and that it was

. . . due to the central processes concerned with two separate stimuli not being able to co-exist so that the data from a stimulus which arrives while the central mechanisms are dealing with data from a previous stimuli have to be held in store until the mechanisms have cleared.³

²A. T. Welford, "The psychological refractory period and the timing of high speed performance. A review and a theory." British Journal of Psychology, Vol. 43, (February 1957), p. 3.

³Welford, loc. cit., p. 6.

Without any question there is disagreement concerning the theoretical causes for the psychological refractory period, yet there does seem to be agreement that, "the reaction time to a second pair of stimuli is generally longer than the reaction time to the first of such stimuli when the interval between the stimuli, is very short."⁴

Kroll⁵ suggests the possibility that there is within the individual the ability to execute consecutive responses with inter-stimulus intervals of less than five seconds. This type of investigation would seem to promise more as a prediction of certain motor skills than would simple reaction time. It can readily be seen that there is a need for further investigations concerning the characteristics of the psychological refractory period before a more comprehensive evaluation of its importance in the teaching of the learning of motor skills (which require continual adjustments to changing environmental conditions) can be realized.

Theoretically, subjects with the same simple reaction time should exhibit identical delay patterns in a paired response situation. Davis⁶ found that his subjects did not have identical delay patterns. In fact no real explanation has been found for this characteristic. Davis⁷ also found an inverse relationship

⁴W. B. Koch, "The effect of the interval of the time between paired visual stimuli upon reaction time." Doctoral Dissertation, Indiana University, (May 1960).

⁵Walter Kroll, "Relationship of the interval of time between paired auditory and visual stimuli and reaction time." Research Quarterly, Vol. 32, (1961), pp. 367-381.

⁶R. Davis, "Choice reaction times and the theory of intermittency in human performance." Quarterly Journal of Experimental Psychology, Vol. 14, (1962), pp. 157-166.

⁷R. Davis, loc. cit., p. 156.

between the amount of delay in time of the reaction time of the second hand and the interval of time between the stimuli. It was also found that the psychological refractory period could in fact be different from the fifty milli-second intervals originally concluded by Craik⁸, Hick⁹, Vince^{10, 11}, and Hick and Bates¹².

More up to date research by Slater Hammel¹³ lend support to the previous reports by Hick¹⁴ and Vince¹⁵. Slater Hammel¹⁶ also supported the contention of Davis¹⁷ concerning the inverse relationship between the second reaction time and the interval between the pairs of stimuli.

⁸K. J. W. Craik, "Theory of the human operation in central systems-man as an element in a control system." British Journal of Experimental Psychology, Vol. 38, (March 1948), pp. 142-148.

⁹W. E. Hick, "Discontinuous functioning of the human operator in pursuit tasks." Quarterly Journal of Experimental Psychology, Vol. I, (April 1948), pp. 36-51.

¹⁰M. A. Vince, "The intermittency of control movements and the psychological refractory period." British Journal of Experimental Psychology, Vol. 38, (March 1948), pp. 149-157.

¹¹M. A. Vince, "Rapid response sequences and the psychological refractory period." British Journal of Psychology, Vol. 40, (September 1949), pp. 23-40.

¹²W. E. Hick and J. A. V. Bates, "The human operator of control mechanisms." London: Ministry of Supply, Permanent Records of Research and Development, Vol. 17, (1950), p. 64.

¹³A. T. Slater Hammel, "Psychological refractory period in simple paired reaction times." Research Quarterly, Vol. 29, (1958), pp. 468-481.

¹⁴Hick, loc. cit.

¹⁵Vince, loc. cit.

¹⁶Slater Hammel, loc. cit.

¹⁷R. Davis, loc. cit.

Research conducted in the field of the psychological refractory period have varied in the number of subjects used. In America, male subjects have been used in far greater numbers than elsewhere. Creamer¹⁸ used seventy-two subjects and tested for two days. Adams¹⁹ used fifty-four subjects for three days of testing. Yet only a few studies have given adequate practice time and have used a reasonable number of subjects.

The most recent studies by Slater Hammel²⁰ who used ten subjects, Koch²¹ who used twenty-five subjects and Kroll²² who used twenty-four subjects, have all suggested the importance of adequate practice periods prior to paired response reaction time (if reliable estimates of delays due to the psychological refractory periods are to be realized).

A number of theories have been put forward and similar experimentation has been done over recent years. The application of this theory to the realm of sport is a most interesting one.

It has been frequently suggested that 500 milli-seconds represents the probable minimum duration of the refractory period

¹⁸Lyle R. Creamer, "Event uncertainty, psychological refractory period and human data processing." Experimental Psychology. Vol. 66, (1963), pp. 187-194.

¹⁹J. A. Adams, "Test of the hypothesis of the psychological refractory period." Journal of Experimental Psychology, Vol. 64, (1962), pp. 280-287.

²⁰Slater Hammel; loc. cit.

²¹Koch, loc. cit.

²²Kroll; loc. cit.

for the responses of the upper extremities^{23, 24, 25, 26}. Many experiments have been conducted to explain the delay occurring in the second of two successive reactions since the first described by Telford²⁷. The delay is not due to expectancy, or readiness. Although readiness appears to play some role, it is in itself not an adequate explanation. Rather, the majority of the experiments strongly suggest the presence of some limited capacity single channel in the system, most likely at the response selection or decision stage.

The question arises as to the possible inherent difference of people to react to stimuli. This may be one of the reasons for the different results obtained by successful athletes, as contrasted by the type of person who is unable to react successfully to athletic type situations.

In particular, the psychological refractory period differences between the athlete and the non-athlete may prove to be interesting in the light of previous related literature.

²³K. J. W. Craik, loc. cit.

²⁴W. E. Hick, loc. cit.

²⁵C. W. Telford, "The refractory phase of voluntary and associative responses." Journal of Experimental Psychology, Vol. 14, (1931), pp. 1-36.

²⁶M. A. Vince, loc. cit.

²⁷C. W. Telford, "Refractory phase of voluntary and associative responses." Journal of Experimental Psychology, Vol. 14, (1931), pp. 1-35.

Summary

In receiving the related literature concerning the psychological refractory period, it was found that there were a number of questions still unanswered. There is general agreement that the response to a second stimulus would be delayed, or might even be omitted, when the interval between stimuli was 500 milliseconds or less. Also, there has been a considerable amount of investigation into the reasons for the refractory delay period. Yet there has been no solid agreement on the nature and mechanism of the psychological refractory period as considered in this study.

CHAPTER THREE

EXPERIMENTAL PROCEDURES AND EQUIPMENT

Selection of Subjects

All subjects were taken from the male student body of Western Kentucky University. The starting five plus one other member of the university freshman basketball squad were placed at the disposal of the researcher, and formed the "athlete group." Six other freshman with no athletic background were selected from a large group of non-athletes by means of the utilization of random number tables. These were assigned to the "non-athlete" group.

Experimental Design

The two groups were exposed to testing sessions extending over ten days for each student. All subjects completed the testing within a fourteen day interval. Each individual testing session lasted approximately fifty minutes.

During the first four days each subject was tested in single hand reaction times provided at varying time intervals of from one to four seconds. The subjects reacted to one hundred single reaction times for both the right and left hands. The stimuli were divided into groups of twenty-five responses each, and presented to the subjects in a randomly assigned order.

During the last six days the subjects were tested on the reaction to the presentation of two stimuli at varying time intervals to one another. The varying time intervals used were from 50-500 milli-seconds, at fifty milli-second intervals. In each testing session there were ten stimuli at each time interval randomly assigned to their position of presentation. The right hand response was always presented before the left.

Data Collection Equipment

Testing was conducted in the bioelectronic laboratory at Western Kentucky University. Every precaution was taken to eliminate auditory signals, and other outside distractions.

It was possible to have the testing within the confines of one room. The use of a screen eliminated visual distraction. The time of the testing sessions were so arranged that there were no appreciable outside auditory distractions.

All the testing took place in a darkened room. In the subject's section of the room was a rectangular table. Mounted on the table top farthest from the subject was a black vertical panel. Neon light bulbs were mounted on the face of the black vertical panel, two and one-half inches apart and fourteen inches above the table top. A vertical slit two inches long and one-fourth of an inch wide extended midway between the two neon lights which were mounted upon the face of the panel. On the table nearest the subject were two partly concealed mounted telegraph keys. The subject sat with his hands on the keys facing the panel, and reacted accordingly to the flash of the light stimulus.

The equipment in the experimenter's section of the room included two standard electric clocks, three Hunter interval timers, a microphone and an amplifier, and related apparatus. Each clock recorded to the nearest one hundredth of a second the interval of time between the light flash and the subject's key reaction. As the right light appeared, the subject removed his right hand from the key. The time taken for the subject to react to the stimulus was recorded on the number one electric clock. The same procedure was adapted for the left hand in the single reaction times. In the refractory times the right light would appear, the subject would react by taking his right hand off the key, the electric clock would measure the right hand, followed closely afterwards by the same process, with the left hand reaction time reading on the left hand (number two) clock.

Information to Subjects

Each subject was given a brief, yet comprehensive description of the purpose of the study, and a demonstration of the reaction time testing procedures for him to follow.

The standardized instructions were read by the tester at the first meeting, followed by a demonstration also given by the tester. These instructions are elucidated in Appendix A. Each subject was then given ten practice trials, with special emphasis being placed upon concentration and speed of reaction, without anticipating. This emphasis was also given on all subsequent testing days.

Once this procedure had been followed and the subject indicated that he was fully aware of what was expected of him, the

actual testing began. The tester selected the order of the time intervals between the buzzer and the initial light signal by utilization of random number tables. There were four sets of twenty-five time intervals varying from one to four seconds. The four columns were used in a randomly assigned order. The time intervals used are found in Appendix E.

Instructions found in Appendix B were used for test days two, three, and four. On the fifth day the procedure changed to dual responses. Appendix C explains the procedure the subjects followed. The subject now had two visual stimuli to which to react. The list of randomly assigned time intervals are shown in Appendix F.

Catch Trials

Catch trials for both single hand responses and paired responses were used. In catch trials the depress command was given and the buzzer sounded, but the light was not activated. There were five catch trials per day.

Catch trials for paired responses were somewhat different in operation as compared with the single hand responses. In this instance either (1) the right light would appear but not the left, or (2) after the buzzer signal neither the left nor the right light appeared. There were six catch trials per day in paired responses. All the catch trials were randomly placed within the time interval tables.

After a catch trial the investigator would ask the subject to "release," indicating that the subject should remove his hands from the keys.

Incentives

Learning graphs for each subject were prepared daily for the benefit of the subject. The left and right hand averages were shown on the first four days. On days five through day ten only the right hand reaction times were given. The daily graph was shown to the subject prior to the subject's next testing session.

Verbal encouragement was given before and during the rest periods of the testing sessions.

The Scoring and Recording of Results

Reaction times were read from the electric clocks and recorded upon mimeographed score sheets. For the recording of results, each subject's scores for the day were recorded on separate sheets. On the initial scoring sheet information such as the subject's name, age, whether he was an athlete or non-athlete, his telephone number and the test day were placed.

For single hand responses, each sheet had spaces for recording one hundred reaction times. Two of these sheets were used each day of single hand testing.

During the paired response testing, two sheets were used, each sheet carrying space for the recording of fifty dual responses.

Summary

The twelve subjects used in the study were all freshman students at Western Kentucky University. Six of the subjects were recognized as highly successful freshman basketball players and the other six were recognized as being non-athletes.

All instructions given to the subjects were standardized. No verbal encouragement was given during the actual testing. Reaction times of the single right and left hand responses were measured on the first four days. From day five to day ten paired reaction times were measured. It was then possible from the data collected of single hand responses of the first four days, and also the paired responses of the last six days, to make statistical comparisons between the mean differences from the various responses.

The subjects attended ten testing sessions over a period of fourteen days. Each subject was shown his learning curve prior to the test session of the next day. Efforts were made to avoid distractions, and to restrict as many variables as was possible during the testing period. Catch trials were included to eliminate the possibility of anticipation of visual stimuli.

CHAPTER FOUR

ANALYSIS AND INTERPRETATION OF DATA

The analysis of the data in this investigation consisted of two major sections: (1) a comparison of single reaction times of the athlete and non-athlete groups, and related discussion, and (2) a comparison of refractory times of the athlete and non-athlete groups at the 50, 100, 150, 200, 250, 300, 350, 400, 450, and 500 millisecond time intervals, and related discussion.

Single Reaction Time Analyses

On each of four successive test days, one hundred trials for each hand, to the light stimulus, was established in a single response situation. The measures which were analysed were the mean reaction times to light stimulus scored in these four days of testing by each subject for both the right and left hands.

The first day's scores were eliminated, since learning of the task could logically have been involved to a major degree. The F test was conducted between the trials on the second, third, and fourth days. The value of F for the athletes was 13.0, and for the non-athletes it was 18.2. In groups with two degrees and five degrees of freedom the null hypothesis was retained in both instances. It was therefore concluded that the simple reaction times could logically be determined by the average of performance in test days two, three, and four.

Simple t-tests were used for comparing the reaction times for the left hand of the athlete and non-athlete groups. The t-tests produced a value of 2.638, which resulted in the rejection of the null hypothesis. The athletes showed a significantly faster single left hand reaction time, as compared with the non-athlete.

TABLE 1

A STATISTICAL COMPARISON OF THE SINGLE LEFT HAND REACTION TIMES OF THE ATHLETE AND NON-ATHLETE GROUPS

FACTOR	GROUP	MEAN	S.D.	S.E. DIFF.	t
Single Left Hand	Non-Athlete	205	18.2		
	Athlete	175	13.0	11.3	2.638*

*Significant at the 5% level

A t of 2.228 is needed for significance in samples with ten degrees of freedom. The observed difference in right hand reaction times did closely approach significance at 2.212. However, the null hypothesis was retained, indicating that chance could have accounted for this difference. Thus no statistical difference was found between the athlete and non-athlete groups in right hand single reaction times.

The results obtained in single reaction times are what one would tend to expect, since the athlete is a highly trained individual, conditioned through practice to reacting quickly in competitive situations.

TABLE 2

A STATISTICAL COMPARISON OF THE SINGLE RIGHT HAND REACTION
TIMES OF THE ATHLETE AND NON-ATHLETE GROUPS

FACTOR	GROUP	MEAN	S.D.	S.E. DIFF.	t
Single Right Hand	Non-Athlete	233	28.7		
	Athlete	197	22.1	16.1	2.212*

*Non Significant

The non-athlete is less likely to be exposed to such quickness of reaction practices. In any case the non-athlete is seldom confronted in his daily life with so many responsive requests for fast reactions. There is also the possibility of the athlete being able to place considerable effort and concentration into one reaction, whereas the non-athlete is as yet unable to channel completely all his concentration and efforts into the one task. Here again, the athlete's experience under such testing conditions may well contribute to his faster reaction times.

Refractory Times

On each of six successive days, one hundred trials of a paired response nature were presented to both groups of subjects. Not only was the simple reaction to the first stimulus determined in each trial, but also a measure of the second reaction time (when the second stimulus came while the first reaction was in progress) was also made. The difference between the reaction time to this second stimulus and

the subject's previously determined single reaction time was the refractory time of each subject.

Table 3 shows the means, standard deviations and values of t when the null hypothesis was tested between refractory times at the various time intervals between the athletes and non-athletes. There were no statistically significant differences between the athlete and non-athlete groups at any of the time intervals from fifty milli-seconds through to 500 milli-seconds. Since there was no statistically significant differences at the five per cent level of confidence, the null hypothesis was retained in all cases. Chance could readily have accounted for these differences.

TABLE 3

A STATISTICAL COMPARISON OF THE REFRACTORY TIMES AT THE VARIOUS TIME INTERVALS OF FIFTY MILLI-SECONDS TO 500 MILLI-SECONDS, AT INTERVALS OF FIFTY MILLI-SECONDS, OF THE ATHLETE AND NON-ATHLETE GROUPS

FACTOR	GROUP	MEAN	S.D.	S.E. DIFF.	t
50	Non-Athlete	86	45.8	25.9	.922*
	Athlete	110	35.6		
100	Non-Athlete	54	39.3	23.4	.749*
	Athlete	72	34.8		
150	Non-Athlete	42	34.6	20.4	.771*
	Athlete	72	30.0		

TABLE 3--Continued

FACTOR	GROUP	MEAN	S.D.	S.E. DIFF.	t
200	Non-Athlete	46	41.8	21.8	.651*
	Athlete	60	25.7		
250	Non-Athlete	42	40.3	21.8	.473*
	Athlete	52	27.7		
300	Non-Athlete	22	42.5	22.4	.491*
	Athlete	33	27.0		
350	Non-Athlete	22	35.9	20.9	.101*
	Athlete	24	30.2		
400	Non-Athlete	16	30.6	18.5	.325*
	Athlete	10	28.6		
450	Non-Athlete	12	25.2	15.6	.309*
	Athlete	7	24.5		
500	Non-Athlete	13	27.1	14.9	.550*
	Athlete	4	19.3		

*Not significant at the 5% level

Although differences in refractory time of the two groups were non-significant up to the 350 milli-second time interval, from the data it would appear that the athlete has placed emphasis upon

the initial response which has detracted from the second response to some extent.

As has already been observed, the left hand single response of the athlete was significantly faster. The evidence lends support to the theory that increased attention to response to the first stimulus detracts from the second when the stimuli are given, as in this study. The evidence indicates that the athlete is better prepared to react quicker to a single stimulus than the non-athlete. Yet placed under paired response conditions, the athlete is not significantly different from the non-athlete group.

Former studies have never specifically used athletes in refractory time tests, but there is general agreement, as Koch¹ states, that with general subjects the reaction to a second pair of stimuli is generally longer than the reaction time to the first of such stimuli, when the interval between the stimuli is very short. This theory is consistent with the non-athlete refractory time results found in this study.

In relation to the detracting theory considered above of the athlete group, it was further found that the athlete group had consistently larger means at each time interval from fifty milliseconds through to 400 milliseconds. Thus it may be suggested that the emphasis of the athlete to place all his efforts into the first stimulus is greater than at first expected.

The refractory time data further produced evidence that the non-athlete group had consistently more variability in refractory

¹W. B. Koch, loc. cit.

times. This observation would support the theory that the non-athlete is less likely to be exposed in his daily life to such conditions found in the testing situation. This observation supports Davis² who found that his subjects did not have identical delay patterns.

From the data obtained in this study, it would appear that the preparatory state theory of the psychological refractory period is a sound possibility, particularly with the refractory times produced by the athlete group. There is no question that there is a delayed process within the paired response process, and that as Welford³ suggested, when one stimulus is being processed the second is being "held in store." As the first one is given extra emphasis, as in the case of the athletes in this study, the refractory times were unexpectedly slow and similar to the non-athlete group.

Summary

In both the single reaction times and the refractory times at the various time intervals, the means, the standard deviations and the standard error of difference were obtained. Once this had been achieved, the single left hand times, the single right hand times, and the refractory times at the various time intervals were subjected to simple t tests. It was found that apart from the single left hand responses there were no significant results at the five per cent level of confidence. However, athletes did tend to be slower in the second of the paired responses up to 350 milli-second intervals.

²R. Davis, loc. cit.

³Welford, loc. cit.

The common belief that the athlete is in a far better position through practice and exposure to continual rapid stimuli has been challenged by the evidence in this study. Generally there is no significant difference between the athlete and non-athlete groups in refractory times. Here again it may be concluded that the athlete places tremendous emphasis into the first stimulus and very little into the second stimulus. The non-athlete is in fact exhibiting a more individual refractory pattern in this study than the athlete.

There are no previous studies in which athletes and non-athletes have been compared in single reaction times and refractory time intervals.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The problem in this study involved an investigation of the possible differences of single left and right hand responses and also the refractory times at various time intervals, fifty milli-seconds through to 500 milli-seconds at fifty milli-second intervals between athletes and non-athletes.

Two groups of six subjects, one of six members of the Western Kentucky University freshman basketball squad and the other of six known non-athletes, in Western Kentucky University's freshman classes, were selected. Both groups were exposed to four days of single hand responses, each subject tested individually. The subjects were then exposed to dual reaction times over a further six days. All testing was conducted within the confines of fourteen days.

In order to determine the possibility of significant differences between the athlete and non-athlete groups in single and refractory times, the data was subjected to the collection of means, standard deviations, standard errors and finally simple t-tests. In the refractory times at the various intervals, each interval was exposed to simple t-tests. Thus it was possible to determine group differences at each fifty milli-second interval, between fifty milli-seconds through to 500 milli-seconds.

The t-tests indicated that apart from the single left hand reaction times, no significant differences between the athlete and the non-athlete group were found at the end of the study.

Conclusions

The results of the analysis of data permit the following conclusions:

1. There was a significant difference in the single reaction times of the left hand. The left hand of the athlete group proved to be significantly faster than that of the non-athlete group.

2. Although the differences approached significance, with the athlete showing faster times, there were no statistically significant differences between the two groups in the right hand single reaction times.

3. There were no significant differences in the refractory times at the various time intervals from fifty milli-seconds through to 500 milli-seconds, at spaced intervals of fifty milli-seconds.

Recommendations

1. A need for larger groups of athletes and non-athletes to be exposed to the same testing procedures which were administered in this study would seem to be valuable.

2. A need for a comparison of the right hand single reaction time and right hand paired response time of the athlete and non-athlete group might prove beneficial for future experimentation.

3. A need for a comparison of the total task times combination of right and left hands in paired response might prove beneficial for future experimentation.

APPENDIX A

THE INITIAL DAY'S INSTRUCTIONS TO THE SUBJECT

This is a test of the speed with which you can react to light signals. As you look at the far end of this table, you will see a black panel with an illuminated vertical slit in it. You will notice also that there are two lights, one on each side of the slit. These lights will be signals to which you will react.

A black box from which the buttons of two signal keys extend will be seen as you look at the top of the table immediately in front of me. These keys control the lights. The key to my right controls the light to the right of the vertical slit. The key to my left controls the light to the left of the vertical slit. By raising the right hand off the key, the right light is reacted to. By raising the left hand off its key, the left light is reacted to.

Today you will operate only one key at a time. In operating the right key, for example, you rest your forearm on the table like this, placing the index and third finger of the hand on the button of the key like this. Your other fingers and thumb will rest on the table top as mine are not resting. It does not require a great amount of force to hold down a key, but it will be necessary for you to keep the key completely depressed.

You will find, after a few practices, that you will be able to keep a key completely depressed with the weight of your hand. In

moving the fingers off a key, move in this manner. Do not move your whole arm like this. Make your movement from the wrist as I am now doing. Follow this same procedure when operating the left key. I am now demonstrating this left hand movement.

Prior to the presentation of the lights, a buzzer will sound. This will serve to alert you for the light's appearance. Occasionally the light will not "appear" after the buzzer sounds. Should this occur merely continue to depress the key until you are told to relax. React as quickly as you can to the appearance of the light, but do not jump the gun.

The complete test will consist of four series of twenty-five trials with each hand. After each series of twenty-five trials you'll be given a short rest. Following the rest, you'll complete the next series of trials.

In completing the test, we will follow this order of events:

1. I'll tell you to "depress," meaning that you depress the key.
2. Shortly after this, you will hear a buzzer. This will serve to let you know that the light will soon appear.
3. When the light appears, react to it by moving your finger off the key.
4. After you have made your reaction, simply relax, placing your hand on the table top until I again tell you to "depress".
5. Remember, this is a speed test. The speed of your reaction are measured by the time it takes you to react to the light during a trial. Do you have any questions?

Any questions which may be asked will be answered by the tester.

Following the initial instructions the experimenter stated:

We will start with the . . . hand today for the first series of twenty-five reactions. First, however, I will give you a few practice trials with each hand.

APPENDIX B

INSTRUCTIONS GIVEN TO SUBJECT PRIOR TO THE SECOND,
THIRD AND FOURTH DAYS OF TESTING

1. This is a speed test. React as quickly as you can to the appearance of the light.
2. We will follow the same procedures as during the last period:
 - a) I will say "depress," indicating that you are to depress the key.
 - b) The buzzer will sound.
 - c) The light will appear shortly after the sounding of the buzzer.
 - d) React as quickly as you can; but do not "jump the gun".
3. Today we will start with the . . . hand.

APPENDIX C

INSTRUCTIONS FOR THE SUBJECTS ON THE FIRST DAY OF PAIRED RESPONSES (I.E., TEST DAY FIVE)

Today the procedure will be changed. You will now react to two lights, one following the other. To do this it will be necessary for you to depress both keys, using the same techniques for releasing them which you used during the first four laboratory periods.

Following the buzzer signals, the right light will appear. Occasionally the right light may fail to appear, or the right light will appear, but the left will not. If the light does not appear, continue to depress the keys. However, I want to emphasize that you are to react as quickly as you can to the lights. The speed with which you react is very important.

In completing this test, we will follow this sequence:

1. I will tell you to "depress," meaning you depress both keys.
2. Shortly after this, you will hear the buzzer.
3. Following this, the right light will appear, and you will react to it by moving your right hand off the right key.
4. After the right light appears, the left light will appear. React to it by raising the fingers of the left hand off the left key as quickly as possible.

The sequence will always be: the buzzer, the right light, and the left light.

The complete test for today and the remainder of the laboratory periods consists of four series of thirty-two trials each. After each series, you will be able to take a short rest. You will now be given ten practice trials. Do you have any questions?

APPENDIX D

THE INSTRUCTIONS FOR THE REMAINING TEST DAYS--DAY SIX THROUGH TO DAY TEN WERE AS FOLLOWS

Remember, this is a speed test. React as quickly as you can. We will follow the same procedure as during the last period.

1. I will tell you to "depress" the keys.
2. Shortly after these instructions, you will hear the buzzer.
3. Shortly after the buzzer, the right light will appear. React to it by raising the fingers of the right hand off the right key as quickly as possible.
4. Shortly after the right light appears, the left will appear. React to it by raising the fingers of the left hand off the left key as quickly as possible. Remember, the buzzer and the right light will always come on before the left light.
5. React as quickly as you can, but do not "jump the gun". You will now be given ten practice trials after which your regular testing will begin.

APPENDIX E

EXAMPLE OF PREPARED TIME INTERVALS BETWEEN BUZZER
AND INITIAL LIGHT SIGNAL--RANDOMLY SELECTED
FROM RANDOM TABLES: THERE ARE FOUR CARDS
CONTAINING TWENTY-FIVE NUMBERS

<u>CARD FOUR--SINGLE HAND</u>			
76	1	89	4
77	3	90	3
78	3	91	4
79	4	92	3
80	3	93	4
81	2	94	3
82	3	95	4
83	4	96	1
84	4	97	1
85	4	98	3
86	3	99	1
87	1	100	1
88	4		

APPENDIX F

SAMPLE CARD OF PREPARED TIME INTERVAL SETTINGS
FOR PAIRED RESPONSE TESTING

CARD NUMBER ONE

	LEFT HAND	RIGHT HAND
1	1. 30	1
2	1.220	1
3	1. 35	1
4	1. 60	1 B Catch Test
5	3. 20	3
6	4. 40	4
7	3. 50	3
8	1. 50	1 4 Catch Test
9	2. 70	2
10	1. 20	1
11	1. 25	1
12	2. 35	2
13	2. 00	1 3 Catch Test
14	2. 55	2
15	3. 70	3
16	3. 90	3
17	2. 15	2
18	4. 50	4
19	1. 30	1
20	1. 10	1
21	3. 25	3
22	3. 25	3
23	4. 55	4
24	4. 05	4
25	3. 50	3 3 Catch Test
26	2. 60	2 B Catch Test
27	2. 20	2
28	4. 40	4
29	1. 05	1 B Catch Test
30	3. 40	3
31	2. 80	2
32	4. 60	4

APPENDIX G

MEAN REACTION TIMES IN MILLI-SECONDS OF ATHLETE
 GROUP IN SINGLE REACTION TESTS AND
 REFRACTORY INTERVALS

(A) Single Reaction Tests.--The Means for Days Two Through Four.

SUBJECTS											
1		2		3		4		5		6	
L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
18.6	19.8	16.7	19.1	18.5	19.6	15.4	15.7	18.9	20.9	16.9	23.1

(B) Refractory Intervals.--The Means for Days Five Through Ten.

SUBJECTS						
INTERVALS	1	2	3	4	5	6
50	28.7	30.0	23.6	32.2	28.6	27.6
100	24.5	26.3	20.1	28.2	24.6	24.4
150	22.4	24.8	19.6	25.4	23.1	24.2
200	23.2	24.6	20.0	25.1	25.0	23.1
250	22.3	23.9	19.3	25.1	23.8	21.8
300	20.0	20.7	18.2	23.6	22.1	20.5
350	18.9	19.4	16.7	23.5	21.4	19.7
400	18.5	17.9	15.3	21.7	19.5	17.9
450	18.0	17.8	15.0	20.1	20.2	18.1
500	18.6	17.6	15.2	18.6	19.9	17.9

APPENDIX H

MEAN REACTION TIMES IN MILLI-SECONDS OF NON-ATHLETE
GROUP IN SINGLE REACTION TESTS AND
REFRACTORY INTERVALS

(A) Single Reaction Tests.--The Means for Days Two Through Four.

SUBJECTS											
1		2		3		4		5		6	
L.	R.	L.	R.	L.	R.	L.	R.	L.	R.	L.	R.
20.9	21.6	17.5	18.2	20.4	25.3	23.6	27.3	19.5	23.1	20.9	24.1

(B) Refractory Intervals.--The Means for Days Five Through Ten.

INTERVALS	SUBJECTS					
	1	2	3	4	5	6
50	25.7	30.3	32.9	29.8	33.3	22.6
100	23.2	27.1	28.8	26.4	29.2	20.7
150	23.8	24.2	27.5	24.0	28.1	20.5
200	26.7	23.7	26.4	22.5	30.5	21.3
250	25.8	22.9	27.6	22.6	29.2	19.9
300	23.0	21.7	25.9	20.7	27.3	17.1
350	22.3	20.6	25.4	19.1	25.9	16.0
400	20.6	20.4	23.4	17.2	25.4	17.0
450	20.6	19.7	22.6	17.1	24.6	17.8
500	20.6	20.8	23.7	17.0	23.9	17.4

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