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INVESTIGATING THE AROUSAL - PERFORMANCE RELATIONSHIP IN RIFLE SHOOTING USING PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL MEASURES

BY

DARYL BRIAN MARCHANT

A thesis submitted to the faculty of graduate studies in partial fulfilment of the requirements for the degree of

MASTER OF ARTS

DEPARTMENT OF PHYSICAL EDUCATION

AND SPORT STUDIES

EDMONTON, ALBERTA

SPRING, 1992

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23 Stoneleigh Avenue, Boronia,

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DATED: November 8, 1991

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled INVESTIGATING THE AROUSAL - PERFORMANCE RELATIONSHIP IN RIFLE SHOOTING USING PSYCHOLOGICAL AND PSYCHOPHYSIOLOGICAL MEASURES submitted by DARYL BRIAN MARCHANT in partial fulfilment of the requirements for the degree of MASTER OF ARTS in Physical Education and Sport Studies.

DR R.B. ALDERMAN

DR E.J. WATKINSON

DR E.E. FOX

Date: 6 - 11 - 91

DEDICATION

This work is dedicated to my wife Tina who apart from supporting us, graciously accepted the highs and lows of graduate life, and lovingly encouraged me throughout.

ABSTRACT

The purpose of this series of studies was threefold:

a) Investigate which theory of arousal, the inverted U, quiescence, or optimal arousal theory best explains the arousal - performance relationship in rifle shooting,.

b) Identify individual zones of optimal performance using a combination of psychophysiological and psychological measures.

c) identify and examine systematic arousal patterns associated with competitions of varying importance.

The performance and arousal levels of three highly skilled rifle shooters were repeatedly monitored throughout a competitive season encompassing, practise, Provincial and National level competitions.

Three dependent measures were recorded and subsequently analyzed: heart rate, self reported anxiety (Competitive State Anxiety Inventory-2), and shooting score. A total of 20,000 heart rate recordings and 1560 scoring shots were observed, recorded and analyzed. A "within subject" experimental design was employed in order to account for individual differences in arousal susceptibility.

Successful performance in high level competition was associated with decreased autonomic activity for two of the three shooters, thus, providing partial support for quiescence theory.

In order to statistically analyze time related trends in arousal patterns a cross correlation procedure was utilized. A distinct inverted U was revealed for the

most experienced of the shooters, thereby suggesting that performance was adversely affected by either a substantial increase or decrease in heart rate for this shooter.

The combined use of psychophysiological and psychological measures, while providing valuable insights into each shooter's idiosyncratic arousal pattern, was unsuccessful in identifying zones of optimal performance.

In contrast to previous findings self reported somatic anxiety and self confidence (as measured by the CSAI-2) predicted performance more accurately than cognitive anxiety.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

The effect of anxiety on sports performance has long been a productive area of sport psychology research. A number of authors have postulated theories designed to unravel the complex relationship between arousal and performance, including: the inverted U hypothesis, optimal arousal theory, drive theory and quiescence theory. In recent years, it has become apparent that anxiety, far from being unidimentional, is a multidimensional construct. Consequently no single arousal - performance theory has received unconditional support. To date the sport of shooting has not been conclusively shown to conform to any particular theory of arousal. Therefore, further research is required to clearly elucidate how arousal relates to performance in shooting sports.

Shooting sports have recently become a popular area of research in sport psychology. Examinations of the relationship between arousal levels and performance have been particularly popular (Landers, Wang & Courtet, 1985; Gould, Petlichkoff, Simons & Verera, 1987). This is hardly surprising given the possible negative effects that over arousal can have on shooting performance (Bird, 1987; Landers, 1982). Landers et al. (1985) suggest that the inability to adapt to high levels of stress may contribute to a common occurrence, that of shooters scoring better in practise than in competition. Shooting involves fine muscle coordination, steadiness, inhibition of external distraction, high levels of concentration and a state of mental and physical calm over an extended period of time. Accomplished shooters typically develop their skills through years of instruction, coaching and disciplined practice (Daniels, Landers & Wilkinson, 1980).

Researchers seeking a more thorough understanding of the causes of anxiety, have in some cases been hampered by semantic confusion between anxiety and arousal. It is essential that a clear distinction between these two related but distinct constructs be established. Anxiety, a psychological phenomena, is best viewed as a component of arousal, a broader physiologically based state. Arousal is ever present, ranging from states of deep sleep to those of intense emotions such as anxiety, anger, and panic (Bridges, 1971). Arousal levels are in a constant state of flux, responding to a number of environmental factors. The present series of experiments measures arousal on an ongoing basis, probing for, but not assuming that anxiety is present.

Organization of the Study

Chapter 1.

Provides an introduction to arousal and anxiety and how they relate to the sport of shooting.

Chapter 11.

Consists of the Review of Literature; initially the effects of anxiety in both everyday living and sport are discussed. The relationship between arousal and anxiety, two distinct terms often used interchangeably in Sport Psychology literature, is delineated. The development of psychological instruments used to measure anxiety, a multidimensional construct, are outlined. Arousal theories are then discussed, particularly as they relate to marksmanship. A rationale justifying the use of psychophysiological measurement devices is then given. A discussion of the relative advantages of conducting field studies and the employment of a "within subject" design paradigm follows. Finally a sport specific questionnaire, the Competitive State Anxiety Inventory-2 (CSAI-2), is reviewed.

Chapter 111.

Indicates the need for the study, identifies limitations and delimitations and provides operational definitions of terms.

Chapter 1V.

Presents the methodological considerations applicable to experiments 1 and 11.

Chapter V, V1 and V11

A chapter is devoted to each of three experiments conducted simultaneously as distinct parts of the study.

Chapter V111

Provides a summary of the research and presents the conclusions and recommendations emanating from this study.

CHAPTER 11

REVIEW OF LITERATURE

Introduction

Sport is said to reflect many of the themes prevalent in everyday life. Effective communication, self discipline in achieving a desired goal, and the ability to accept both victory and defeat are skills important in both sport and life. In sport, the pressure to achieve while dealing with conflict and frustrations, mirrors the demands of coping successfully in our complex society. One manifestation of the pressure and stress associated with everyday living has been the dramatic increase in anxiety based mental illnesses. It has recently been estimated that in the United States of America alone there are some 30,000,000 people suffering from anxiety based disorders (Carson, Butcher & Coleman, 1988). Carson, et al. (1988) state,

> The speed and complexity of modern-life with its constant change and its demands for new knowledge, skills, and competencies-leave little room for contemplation or complacency .... Many of us find ourselves running full tilt just to stay in the race .... We are rapidly moving into a high-tech society for which many of us are ill-prepared. Our futures seem far from guaranteed. Worldwide economic fluctuations, unemployment, and discrimination take their toll (p. 3)

Gross family structure changes, civil unrest, increased terrorism, drug and alcohol abuse and increasing crime rates are additional uncertainties faced by individuals in our society. In all areas of society individuals are forced to deal with multiple and cumulative stressors.

In a similar manner sport, particularly at the upper echelons of competition is becoming a battlefront of increased aggression, stress, tension and other manifestations of anxiety. Never before have the extrinsic rewards been so tangible yet the demands associated with earning these rewards so intense and rigorous. From the time a little leaguer steps up to the plate in his first game to the time he retires he will encounter many anxiety inducing situations. Recent outbursts of temper in games previously considered immune to such behaviour (e.g. tennis and cricket) provide evidence of poor behavioral responses to the anxiety and frustration associated with high level competition.

In view of the threat anxiety poses in both society and sport, it is not surprising that sport psychologists and their mainstream psychology counterparts are constantly striving for a greater understanding of anxiety and its effects on human behaviour. Fortunately, as a result of many years of research, a more thorough and complete understanding of anxiety in Sport is gradually evolving.

Anxiety and Arousal

In sport psychology literature anxiety and arousal have often erroneously been used as interchangeable terms. The two terms although overlapping to some extent are distinct entities. Bridges (1971) states that arousal constitutes a continuum which includes relaxed wakefulness, curiosity and attentiveness. Increased levels of arousal may result in stronger emotions such as anxiety, panic, anger and rage. This is not to say that high levels of arousal necessarily constitute a state of anxiety, individuals may react and behave quite differently to the same level of arousal. Anxiety occurs when an individual experiences a level of arousal that disrupts integrated mental activity and cognitive functioning (Bridges, 1971).

In terms of instinct, arousal is associated with the "fight or flight response". This response is facilitated by increased sympathetic nervous system activity - a natural response to emergency situations. Bodily resources held in check during quiet times, are heavily drawn upon to increase power in attack, defence or flight (Bridges, 1971). Arousal levels are primarily controlled and mediated by the hypothalamus which triggers increases and decreases the activity of the sympathetic branch of the autonomic nervous system. In practical terms, arousal is associated with generalized physiological stimulation which includes increased blood pressure, increased heart rate, increased supplies of noradrenaline, and other associated hormonal changes, increased skin temperature, and a series of other biochemical reactions. In sport and other social situations where the fight or flight response is inappropriate, anxiety may result. Virtually all athletes experience "pre match nerves", a state which produces a level of cerebral alerting, increased reaction and physiological activation that facilitate performance. For the purposes of the present study anxiety is viewed as synonymous with arousal only at the upper extremes of the arousal continuum.

The difference between anxiety and arousal is clearly more than semantics. One example of the failure by psychologists to clearly recognize the distinct differences between anxiety and arousal is provided. Developers of the Competitive Sport Anxiety Inventory-2 (CSAI-2) have by implication failed to recognize anxiety as a sub-component of arousal. Essentially, the CSAI-2 like other so called anxiety scales measures an individual's level of arousal, not anxiety, which incidently, may or may not be present. Unfortunately, many researchers rather than using the greater precision afforded by placing anxiety on an arousal continuum discuss the differing effect of anxiety on performance as if anxiety is an ever present, pervasive phenomena. Perhaps the CSAI-2 should be renamed the Competitive State Arousal Inventory-2 ?

Anxiety a Multidimensional Construct

Sport psychologists attempting to unravel the relationship between arousal and performance are confronted by numerous, and often confounding, variables. This is not surprising in light of the increasing body of knowledge supporting the view of anxiety as a multidimensional construct (Jones, Swain, & Cale, 1990; Gould, Petlichkoff & Weinberg, 1984; Schwartz, Davidson & Coleman, 1978; Landers, 1980). Previous research emanating from the administration of general anxiety inventories, such as the Taylor, Manifest Anxiety Scale (1953), the IPAT Anxiety Scale (Catell, 1957), and the General Anxiety Scale (Sarason, Davidson, Lighthall, Waite & Ruebush. 1960), led researchers to conclude that anxiety was too amorphous to be useful as a predictor of behaviour (Martens, Vealey & Burton, 1990). Spielberger (1966) identified anxiety as a dichotomy with both acute and chronic elements. He labelled chronic anxiety as trait anxiety (A-trait) and acute anxiety as state anxiety

(A-State). Researchers soon found that situation specific anxiety scales predicted behaviour more successfully than general anxiety inventories. As a result a number of specific A-trait and A-state scales were developed, including the Sport Competitive Anxiety Test (SCAT) - the first sport specific anxiety inventory. In 1980, Martens, Burton, Rivkin and Simon collaborated in the development of the Competitive Sport Anxiety Inventory (CSAI), a sport specific A-state inventory.

Further research has led to an even greater conceptual specificity of anxiety. Liebert and Morris (1967) for example drew a distinction between worry and emotionality. These components were later renamed by Davidson and Schwartz (1976) as cognitive anxiety and somatic anxiety. Cognitive anxiety is defined as negative expectations and concerns about oneself, the situation at hand, and the potential consequences. While somatic anxiety is reflected by increased heart rate, shortness of breath, clammy hands, increased breathing and tense muscles (Martens, Vealey & Burton, 1990). From this conceptual distinction a number of inventories were constructed including the Worry-Emotionality Inventory (Liebert & Morris, 1967), the Test Anxi[illegible]ventory (Spielberger, Gonzalez, Taylor, Algaze and Anton, 1981) and the Cognitive-Somatic Anxiety Questionnaire (Schwartz, Davidson, and Goleman, 1978).

With the advent of a clear distinction between cognitive and somatic anxiety, a number of practical questions have been indentified. Do athletes respond to stress cognitively, somatically or both ? To what degree are the two components of anxiety mutually exclusive ? Do they covary and, if so, how much ? Does cognitive anxiety lead to somatic anxiety, vice versa or are both experienced simultaneously ? Are different sports affected more by one component than the other ? The distinction between components of anxiety is important because theoretical and empirical evidence demonstrates that each component is related to performance in a different manner (Gould, et al. 1987).

Research suggests that despite being conceptually independent, cognitive and somatic anxiety are likely to covary in many situations. Martens, et al (1990) argues that many situations contain elements that relate to, and elicit the arousal of both cognitive and somatic elements of anxiety. Borkovec (1976) suggests that each component may serve as a conditioning function for the other. For example, an athlete may acquire conditioned somatic responses to a particular environment such as locker room preparation, a pre-contest warm-up routine or even a particular opponent. The conditioned somatic response may then trigger the athlete to start worrying because he or she feels certain somatic symptoms of anxiety (Martens, et al. 1990).

Each athlete has or her own idiosyncratic patterns of response in stressful circumstances and consequently, may be more heavily influenced by either the cognitive or the somatic element. In addition, a person may respond in a situation specific manner demonstrating mainly cognitive symptoms in one situation and somatic symptoms in another (Borkovec, 1976). These individual differences have led some researchers to conclude that certain individuals may be termed cognitive responders while others may be defined as primarily somatic responders (Hatfield and Landers, 1983). Fortunately, standardized tests, such as the cognitive-somatic anxiety questionnaire (Schwartz, et al. 1978) have been developed to quantify individual differences in stress reactions.

Cognitive and somatic anxiety are considered independent entities because stress inducing situations do not necessarily elicit both kinds of anxiety. Consider a person who is physically tired and somatically relaxed who lies down, unable to fall asleep because their "mind is racing". Conversely, somatic anxiety is often characteristic of an individual who complains of bodily tension and autonomic stress without the accompanying cognitive symptoms (Goleman, 1971).

As a result of individual differences, anxiety responses are prone to considerable variation (Weinberg & Genuchi, 1980). High A-trait individuals for instance, perceive ego-involving situations as more threatening, and hence, more anxiety arousing than low A-trait individuals (Spielberger, 1966). Other factors that can increase or decrease stress are interpersonal factors such as an athletes spouse, team members, or a coach (Cooper & Crump, 1980). An extensive review of sport anxiety literature reveals a number of factors have been hypothesized as effecting the arousal performance relationship (see Appendix A, Figure 13, p. 112).

<u>Arousal Theories</u>

Sports psychologists have constantly speculated and tested a variety of theories in order to understand more fully the effects of arousal on performance. Three such theories bear relevance in deciphering the relationship between arousal levels and shooting accuracy. The three theories outlined below are not necessarily mutually exclusive and may overlap in the shooting sports.

It is generally accepted that a curvilinear relationship (i.e. the inverted-U theory), best explains the relationship between arousal and performance (Gould, et al. 1987; Landers, 1980; Martens, 1977). The inverted-U hypothesis predicts that performance is optimal at a moderate level of arousal, and that performance progressively declines as arousal increases or decreases from a moderate level (Weinberg & Genuchi, 1980). The essence of the inverted-U hypothesis is summed up by one athlete who commented, "good performance is dependent upon being 'psyched up' for the contest, but not being 'psyched out' (Martens, 1977). Although the inverted-U hypothesis was originally postulated by Yerkes and Dobson (1908) it is only recently that theorists have recognized its utility in delineating the arousal-performance relationship in sport. Yet, very few studies have sought to empirically test the inverted U theory. This is surprising given the general consensus reached in the sport psychology literature that an inverted-U best explains the arousal performance relationship (Gould, et al. 1987).

In reality, it is virtually impossible to conclusively refute the inverted-U arousal theory. Data showing support for drive theory (performance increases as arousal increases) can be easily incorporated into the inverted-U theory by arguing that the positive relationship between arousal and performance represents only the left half of the inverted U curve. Similarly data supporting quiescence theory (i.e. performance decreases as arousal increases) can be explained as representing only the right half of the inverted-U curve.

Quiescence theory may more adequately explain the arousal performance relationship in shooting sports. Quiescence, according to Morgan and Ellickson (1989) represents the antithesis of drive theory: it specifies that performance will increase as arousal decreases. Rather than "psyching up" athletes, this approach uses relaxation procedures to reduce the arousal level of athletes during competition. Little evidence has supported the utility of quiescence theory and some studies refute its utility outright (Morgan & Ellickson, 1989). The usefulness of quiescence theory in sports such as shooting which require reduced sympathetic nervous system activity has not been tested empirically.

Strictly speaking, quiescence theory is an impossibility. Performance cannot possibly continue to improve indefinitely because the individual would eventually be asleep. Nevertheless, in competitive shooting and similar precision type sports an athlete may not be able to relax to the point where performance declines. Further evidence supporting quiescence theory is available despite the contradiction described above.

For example the move by the governing bodies of shooting sports to prohibit the use of drugs that slow down the autonomic nervous system (e.g. Adrenergic Receptor Blockers [BB]) supports quiescence theory. The rationale behind banning such substances is that reduced sympathetic nervous system activity can enhance performance in precision sports including ballet dancing, music, archery, ski jumping and marksmanship. In a recent double blind crossover study involving 33 skilled pistol shooters, metoprolol, an adrenergic Beta Blocker, was compared to a placebo. Three variables were compared: heart rate, blood pressure and shooting points. Mean heart rates before and after shooting were 76 beats/minute and 72 beats/minute with the placebo compared to a constant 60 beats/minute with metoprolol. The median values for systolic and diastolic blood pressure were also 5-10 mmHg less before and after shooting with metoprolol than with placebo. The zero hypothesis that metoprolol does not improve shooting was also rejected by a Student *t* test (2, P <0.002). Clearly, metoprolol improves shooting performance substantially. Plots of paired values showed obvious reductions in heart rate with the most skilled athletes demonstrating the clearest metoprolol improvement. Finally, the improvement in performance was attributed to reduced hand tremor (Kruse, Ladefoged, Nielsen, Paulev & Sorensen, 1986).

Optimal arousal theory, which in some respects is similar to the inverted-U hypothesis, may best explain the arousal performance relationship. Hanin (1980) suggests that each individual has an arousal zone of optimal functioning (ZOF) and that performance efficiency is best when the individual's level of arousal falls within this zone. Unlike the inverted-U hypothesis, which predicts that performance is best when moderate arousal is achieved, optimal arousal theory predicts that some individuals will perform best when they are highly aroused, while others will perform at their peak when they are deeply relaxed (Morgan and Ellickson, 1989).

Optimal arousal theory has the advantage over other prominent theories of explaining individual and sport specific differences in arousal susceptibility. Daniels and Landers (1983) suggest than although systematic effects are often found in arousal patterns there is also a great deal of individual variation. For example one shooter may shoot better at an optimal heart rate range of 60-70 beats per minute (bpm) while another may perform better between 80-100 bpm. Oxendine pioneered research in identifying and consequently categorizing sport into different optimal arousal zones. In an updated version of Oxendine's work Landers and Boutcher (in Williams, 1986) place shooting in the lowest optimal arousal category. They suggest that the complexity of events in this category require a CSAI-2 sub-scale scores of between 10 and 14 for optimal performance.

Why Use Psychophysiological Measures ?

A number of researchers have suggested that a more comprehensive and accurate reflection of A-state can be achieved by using both psychological and psychophysiological measures (Borkovec, 1976; Caruso, et al. 1990). Martens (1977) and Weinberg (1990) both recommend that more precision is needed in the measurement of A-states in order to determine accurately the effects of A-state upon sport performance. Psychophysiology is one area where the collection of highly accurate and reliable A-state information through the use of sophisticated measuring devices is possible. Psychophysiology is defined by Sternbach (1966) as a body of knowledge concerned with the inference of psychological processes and emotional states from an examination of physiological measurements. The tools of measurement employed in psychophysiology have been used on a limited bas sport psychologists despite some obvious advantages that these tools present. Traditionally, psychophysiological instruments have been expensive, cumbersome, invasive, and difficult to operate. In recent years relatively inexpensive psychophysiological apparatus has become available at a level of sophistication, cost and ease of use previously unavailable. Moreover, shooting and other sports where minimal physical movement is required, provide opportunities to utilize psychophysiological instruments without having to control for the contaminating effects of movement artifact.

With ongoing improvements in technology and instrumentation psychophysiological instruments can provide objective and accurate measurement not always possible with the more reactive psychological measures (e.g. pencil and paper tests). A series of studies demonstrated evidence in favour of the predictive validity of psychophysiological measures over self report measures (Webb, Cambell, Schwartz & Sechrest, 1966; Light & Obrist, 1983). Recent developments in technology have allowed psychophysiology to be used in field settings with athletic populations. Such applications have been used to reduce athletes pre-competitive anxiety, to rehabilitate injured athletes, to "fine tune" technique and to provide athletes with biofeedback training (Hatfield & Landers, 1983).

While attempting to measure an individual's response to stress, psychophysiological measurements provide a continuous record of changes throughout a competition (Bird, 1987; Hatfield, Landers & Ray, 1984). A lack of technology allowing accurate measurement of actual arousal levels in competition has confined past research primarily to the measurement of pre-competitive arousal.

Using psychophysiology sport psychologists have gained valuable insights into shooting performance. Daniels, et al. (1980) examined the heart rate and cardiac cycles of elite air rifle shooters and found that performance increased significantly when shots occurred late in the cardiac cycle. Shots taken on the heart beat (R-spike) were a full point lower than those taken between beats. In a series of experiments, Landers, Christina, Hatfield, Daniels and Doyle (1980) found a number of autonomic measures that consistently related to performance: skin temperature, heart rate, breathing patterns and alpha brain activity. Gathering psychophysiological data is one possible avenue in pursuit of the helping shooters improve performance.

In order to convert knowledge into observable performance improvements, sport psychologists have used psychophysiological recordings in conjunction with psychological questionnaires to compile comprehensive profiles of each shooter's idiosyncratic shooting style. For example, Daniels, Wilkinson, Hatfield and Lewis (1981) had shooters fill out the Autonomic Perception Questionnaire (APQ) and then compared the heart rate and respiration self reports to actual physiological measurements of heart rate and respiration while shooting. The shooters whose perceptions agreed with their actual recordings were found to be more successful and were labelled synchronous. Conversely those shooters who were less perceptive of autonomic responses were labelled desynchronous. The utility of classifying performers as either synchronous or desynchronous may extend to identifying those who would benefit from biofeedback, or other forms of training, to correct poor performance attributed to a lack of autonomic awareness (Hatfield & Landers, 1983).

With psychophysiological recordings it is possible to identify a key factors limiting shooting accuracy. Daniels and Landers (1981) used a variety of instruments to establish each shooter's individual optimal autonomic response pattern, once identified the following biofeedback methods was used to correct performance. Auditory signals (ie transmitting the sounds of the subject's own heart beat) were made available to the shooter via headphones so that the shot could be placed optimally within the cardiac cycle. Other shooters were relayed a tone if they held their breath longer than the predetermined optimal duration after which the shot was aborted.

The procedure of taking pre-competition heart rates and thereby estimating an optimal performance zone, is not new in sport anxiety research (Mace, Carroll & Eastman, 1986; Fenz, 1988). Fenz and Jones (1974) found that cardiac acceleration as measured by heart rate changes was a useful indicator of subsequent parachute jumping performance. After a two year study of shooters Tretilova and Rodimki (1979) concluded that heart rates should not increase by more than 30% above resting levels otherwise decrements in performance will result.

Field Settings v Laboratory Settings

Sport psychology has been slow in recognizing field settings as viable alternatives to laboratory experiments. In studying arousal, researchers have consistently preferred laboratory settings over practical ecologically valid environments. The utility of such an approach is justified perhaps, by the gradual refinements and increasing specificity that have been achieved in anxiety theory. However, laboratory settings often lack the ability to induce stressors commensurate with those experienced in competition. Landers, et al. (1985) express concern that at present it has not been determined whether many laboratory findings generalize to more ecologically valid performance situations, such as those found in sport. Alderman (1979) and Martens (1979) have advocated a greater reliance on field research for the purposes of unravelling the complex social interactions in sport and increasing the potency of the independent variable.

There has been a gradual increase in the use of field and naturalistic settings in anxiety research. Fenz and Jones (1972) were among the first researchers to induce real life stressors in sport research. In measuring the physiological responses of individuals anticipating a parachute jump, large increases in respiration and heart rate were recorded for both experienced and novice jumpers. Novice parachutists experienced increases in heart rate up until the time they jumped, whereas more accomplished parachutists reached a peak in heart rate approximately 30 minutes prior to the jump.

Apart from the need to measure stress in ecologically valid settings there is a definite need to induce different levels of stress. Additionally, it may be valuable to induce stress commensurate with the competition environment. In an insightful review of anxiety literature, Gould, et al. (1987) criticized past researchers for failing to create or assess at least three distinct levels of stress. They argue that, in order to test the inverted U hypothesis, different levels of stress are essential.

Contemporary researchers have preferred to use mock situations to induce stress presumably because of the advantage these situations present in manipulating the independent variable (Landers et al. 1985, Bird, 1987; Gould et al. 1987; Caruso, Dzewaltowski, Gill & EcElroy, 1990). In making the transition to naturalistic settings, in order to increase external validity experimenters have often failed to recognize that induced stressors do not necessarily provide levels of stress commensurate with real competition. In the Gould, et al. (1987) investigation the elaborate experimental design, involving an experimenter created pistol shooting competition, may have lacked sufficient external validity to produce the same level of ego involvement found in real competition (Burton, 1988). As well, the use of police trainees rather than competitive shooters as the experimental group might have lacked external validity. Similarly a well designed study conducted by Bird (1987) using a nationally ranked smallbore shooter created a mock situation rather than incorporating an actual competition.

The present study follows the recent trend toward the greater use of field studies. The independent variable (arousal) will be measured over a series of situations in which different levels of stress occur naturally. Arousal will be measured both in practise, and competitions of varying importance to the athlete. Unlike a contrived situation, this procedure measures states of arousal that are a true reflection of the athlete's response to competition.

Naturalistic environments permit the measurement of the same individual on three or more occasions indigenous to the actual sport setting (Sonstroem and

Bernardo, 1982). The present study measured arousal both before and during competition with a psychological instrument, the Competitive State Anxiety Inventory-2 and a psychophysiological instrument, heart rate monitors. The majority of arousal/anxiety studies conducted in the sporting domain have used pre-competitive anxiety as an indicator of arousal (Backman & Molander, 1986; Prapavessis & Grove, 1990; Gould, et al. 1987). This method, despite providing useful information, fails to account for the inevitable fluctuations in arousal that take place over time, particularly in sports such as shooting where the competition day is often four to five hours duration.

Competitive State Anxiety Inventory-2 (CSAI-2)

The development of the CSAI-2, a sport specific state anxiety inventory marks the culmination of many years of research by Rainer Martens and colleagues at the University of Illinois. The CSAI-2, which was first presented for review in 1982, is a refinement of an earlier more lengthy inventory the CSAI-1. The CSAI-2 is a 27 item questionnaire, which includes three subscales: cognitive, somatic and self confidence, typically takes less than five minutes to fill out (Martens, et al. 1990).

The CSAI-2 underwent a rigorous process to ensure reliability, validity, syntax and clarity. Three judges originally rated 102 items and eliminated poor items leaving 78 items, which became Form A of the CSAI-2. This form was then given to 106 football players one hour before a competition, and 56 undergraduate students who based their answers on an imagined competitive situation. Responses were analyzed using item analysis, item to item sub-scale correlations, factor analysis and discriminant analysis with a view to identifying the most appropriate items (Martens, et al. 1990).

As the CSAI-2 is designed to be used in a test-retest manner, the Cronbach's alpha technique was used to ensure internal reliability. Three distinct athletic sub-populations were used: male track athletes, elite high school wrestlers and female collegiate volleyball players. The results demonstrated sufficient reliability with coefficients ranging from .79 to .90. Concurrent validity was also assessed by comparing the CSAI-2 to eight selected A-state and A-trait inventories. Again high coefficients were computed suggesting congruency between the CSAI-2 and other anxiety inventories (Martens, et al. 1990).

It has been suggested that cognitive and somatic anxiety are related to performance in different ways. Martens and colleagues (1983) argue that somatic anxiety should influence performance less than cognitive anxiety because it reaches its peak prior to and during the early stages of competition, then gradually dissipates. In contrast cognitive anxiety is more consistently associated with performance because of linkages made to increases in self and social evaluation. Gould, et al. (1987) suggest that somatic anxiety influences performance primarily when the performer becomes preoccupied with the internal functions of his or her body. A study by Daniels, Wilkinson, Hatfield and Lewis (1981) found that elite shooters were able to accurately perceive their own physiological arousal levels (e.g. respiration and heart rate). This finding indicates that shooters, while not necessarily being preoccupied with internal functions, do either consciously or unconsciously, attend to them. In a sport where reduced sympathetic nervous system activity has been linked to performance, the somatic element of arousal may be linked to performance throughout the duration of a competition rather than merely in the early stages.

The Utility of Within Subject designs

Individual responses to stress, apart from being unique, are transient over time. Two individuals may respond quite differently to an identical situation making generalizations from one group to another a hazardous process. Furthermore, individual comparisons based on a pre-post design format are also risky due to the multiplicity of factors that effect anxiety responses at any given time. Intraindividual time series designs are an effective way of establishing broad continuous measurements of an individual's response to stress across different settings.

Basic time-series designs represent the foundation of quasi-experimental designs. Kratochwill (1978) explains that "In this strategy [time-series design] well-controlled observations are taken repeatedly over some time period. At a planned point in the data series some intervention is introduced and changes in the dependent variable are noted" (p. 38). This design is different from a case study approach because a baseline or pretest data series is obtained (Kratochwill in Kratochwill, 1978).

There is a trend in contemporary sport anxiety research toward the use of "within subjects" designs (hereafter also referred to as intraindividual designs) as opposed to "between subject designs" (Landers et al. 1985; Bird, 1987; Ebbeck &

Weiss, 1988; Burton, 1988; Jones et al. 1988; Caruso, et al. 1990). Given the finding of Sonstroem and Bernardo (1982) that absolute levels of state anxiety have little relationship to performance this is not surprising. Consistent relationships were found only when the variations around a subject's optimal levels of state anxiety were examined intraindividually (Gould, Petlichkoff and Weinberg, 1984). Thus a design which controls for interpersonal variances in anxiety responsiveness seems more appropriate than "between subject designs". (Sonstroem & Bernardo, 1982). The use of an intraindividual design approach appears to be highly suitable for the study of anxiety in sport. Wilson and Heward (1988) champion the use of "within subject designs" stating:

> First, behaviour is an individual, not a group phenomenon. Groups do not behave, only individuals behave .... it follows that investigators wishing to learn about behaviour must analyze the behaviour of the individual .... Second, behaviour is a dynamic phenomenon, not a static event or state of the organism. Therefore, single measures, or multiple measures widely dispersed over time, cannot provide an accurate understanding of behaviour such measurement procedures are woefully inadequate for determining the level, trend, and variability of human behaviour (pp. 145-156).

In addition intraindividual analysis procedures allow differences in performance to be assessed on a relative basis. For example when two shooters fire markedly different scores for a relay there is no way of determining if the difference is a result of mediating factors such as anxiety or simply a result of differences in skill level. Intraindividual performance measures allow qualitative analysis of performance by making individual comparisons to averages or best previous performance (Martens, et al. 1990).

The present study attempts to determine each shooters customary level of arousal with changes from this level, and then compare the impact of these changes on shooting performance in a correlational manner.

CHAPTER 111

NEED FOR THE STUDY

Equivocal findings have resulted from studies attempting to identify the relative importance of cognitive and somatic anxiety in shooting sports. Cognitive anxiety is frequently cited as influencing performance in sport more directly than somatic anxiety (Deffenbacher, 1980; Martens, et al. 1983). Somatic anxiety, however, has previously been shown to influence performance when the performer becomes preoccupied with the internal functions of the body (Gould, et al. 1987). In shooting and similar sports competitors are often very aware of sympathetic nervous system activity, therefore, the somatic component may predict performance more accurately than the cognitive component. Additional studies, designed to further test the effects of cognitive and somatic anxiety on shooting accuracy, are necessary.

Despite a steady increase in the number of studies measuring arousal and anxiety in shooting sports, very few have utilized actual competitive situations. Typically shooters are studied in laboratory situations or in situations of low stress, such as practice or low level competitions. Martens (1977) suggests that high levels of anxiety are obtained only when the subject is placed in a situation that is ego-involving, important, and evaluative. Further studies that measure arousal in genuine shooting situations, especially in high level competitions where increased arousal levels are virtually assured, are therefore necessary.

There is a lack of current research applying theoretical knowledge to practical situations. Reasons for this include:

1) Sport psychology is a relatively new sub-discipline of psychology. To date most sport psychology research has been devoted to the development and consolidation of sport specific theories.

2) The methodological problems involved in conducting field studies make this type of investigation difficult (Martens, 1977).

3) Until recently, there was a lack of well developed and fully proven sport specific tools, such as inventories, tests, questionnaires, books, and tapes.

Theoretical and practical justifications for the proposed study include:

1) Only recently have researchers realized the limitations of making conclusions based solely on group data. In early studies, an intersubject analysis of the dependent variable(s) has been used (Sonstroem and Bernardo, 1982). This procedure, however, failed to recognize individual differences in arousal susceptibility and reactivity. Schnore (1969) suggests that arousal responses are so different between individuals that designs which control for "within subject" differences are preferred. The proposed study will demonstrate the advantages of a "within subject" designs for further illumination of the effects of arousal on shooting performance.

2) There is currently a lack of consensus among researchers as to which theory of arousal best explains the arousal-performance relationship in shooting sports. The inverted-U hypothesis has been tested and shown to have some

relevance; however, two other theories, currently untested in shooting sports, are appealing alternatives: quiescence theory and optimal arousal theory.

Limitations

1\ After initially agreeing to wear the monitors for all competitions two Junior shooters exercised their right not to wear the monitors at the National Championships. Consequently no data was collected at the National level for these two competitors apart from their total
score for each day of competition. They did, however, agree to complete the Sport Competitive Anxiety Inventory-2 (CSAI-2) prior to the first day of National level competition.

2\ Heart Rate monitors, despite being reliable psychophysiological instruments for measuring arousal, are only one indice of many that can be employed and are at best an indirect measure of arousal (see pp. 84 & 86 for an extended discussion).

3\ The predictive validity of the CSAI-2 is limited, as are many paper and pencil questionnaires, by the possibility of socially desirable responses.

4\ The testing of the athletes took place on 10 different days; differences caused by weather conditions and emotional alertness changes were not controlled for.

5\ Rifle shooting is one sport where movement artifact is minimal, thereby facilitating the use of psychophysiological measurement instruments. However, there still remains minor but consistent movement artifact, such as raising the gun into a firing position. Generally movement artifact in the prone position is negligible and thus provides a relatively 'pure' measure of arousal. The kneeling and especially standing positions require a greater physical effort to lift and maintain the gun in a steady position, thus heart rate increases are more likely to occur. Nevertheless, movements in all three positions do occur in a consistent, repetitive and predictable manner.

Delimitations

The scope of the five studies will be delimited as follows:

1\ The subject sample consisted of two sub-elite and one elite rifle shooter.

2\ All three shooters were monitored and observed only in the sporting rifle sub-discipline of rifle shooting.

3\ Data was collected in three graded competition conditions and one practice condition.

Operational Definitions

Activation - The normal level of excitement, alertness, tension or energy that exists within a person (Alderman, 1974, p. 172)

Anxiety - An emotional state consisting of subjective, consciously experienced feelings of tension, apprehension, nervousness and worry, and heightened arousal of the autonomic nervous system (Hackfort & Spielberger, 1989).

Anxiety (state) - The transitory emotional state or condition of the human organism that varies in intensity and fluctuates over time (Spielberger, 1972).

Anxiety (trait) - Relatively stable individual differences in the tendency to perceive a wide range of stimulus situations as dangerous or threatening, and in the tendency to respond to such threats with state anxiety reactions (Spielberger, 1972).

Arousal - An energizing function that is responsible for harnessing the body's resources for intense and vigorous activity (Landers and Boutcher, in Williams 1986). Arousal states vary on a continuum from deep sleep to extreme excitement or even panic (Bridges, 1971).

Drive - Internal conditions directing an organism toward a specific goal, usually involving biological rather than psychological motives.

Sport Tester PE 3000 telemetry unit - A device consisting of an electrode belt, a transmitter and a receiver. The wrist mounted units are designed to record heart rate at 5 or 15 second intervals and store them in memory. The data can be 'downloaded' to a computer by means of an interface.

Stress - A maladaptive condition that occurs when arousal levels become extremely high. Unpleasant emotional reactions, associated with the autonomic nervous system, may result (Landers and Boutcher, in Williams, 1986).

CHAPTER 1V

METHODOLOGY

EXPERIMENTS 1 & 11

Introduction

The heart rate and shooting performance of three marksmen competing in the sporting rifle event was repeatedly monitored throughout a competitive season. An intraindividual design was employed allowing qualitative comparisons of dependent measurements based on each individuals idiosyncratic arousal pattern.

Subjects

The subjects were three male members of the Northern Alberta Shooters Association who competed on a regular basis in the 50 metre Sporting Rifle event, a smallbore rifle sub-discipline. Two of the shooters were classified as Junior shooters (ages 16 and 17) and as such, are eligible to compete in both Junior and open age events. The other subject is a former National team member (age 51) who has returned to competition after spending the previous three seasons coaching. Both Junior shooters had competed for the previous three years. The open aged shooter had competed for 25 years, mainly in the match rifle sub-discipline, and had only recently started to compete seriously in the sporting rifle event.

Event Description

The 50 metre Sporting Rifle event has two components: 1, 3 x 20 shots taken from the prone position, and 2, 3 x 20 shots taken from three positions (prone, standing & kneeling). A perfect score would equal 1200 points (6 x 20 x 10). During competition each shooter participated in accordance with the format listed in Table 1. Competitions are generally held over two days, with the second day format being the reverse of the first (3 position component first).

Table 1

Sporting Rifle Event Format

Description	Duration (min)
Arrive at venue	
Prepare and shoot #1 prone relay	40
Collect and hand in targets	15
Prepare and shoot #2 prone relay	40
Collect and hand in targets	15
Prepare and shoot #3 prone relay	40
Collect and hand in targets	15
Break for Lunch	60
Prepare and shoot relay #1 of 3 position (prone)	40
Collect and hand in targets	15
Prepare and shoot relay #2 of 3 position (standing)	40
Collect and hand in targets	15
Prepare and shoot relay #3 of 3 position (kneeling)	40

Procedures and Apparatus

Instructions

Subjects were told the purpose of the study was to monitor heart rate fluctuations during both practise, and competitions, of varying importance. Before participating in the study all three subjects filled out an informed consent form (see Appendix B, p. 114). Prior to the commencement of the study, a trial and error method was used during practice in order to determine the most efficient, and least intrusive, means of fitting and replacing heart rate monitors.

Heart Rate Monitors

Before the study commencement each subject was fitted with a heart rate monitor (Polar Electro Sport Tester ™) consisting of a transmitting and a receiving unit. Each subject initially wore the Sport Tester in practice conditions in order to allow the subject to gauge whether or not the monitor was likely to interfere with performance. The transmitters were fitted to the chests of the subjects with two monitoring electrodes (3M Red Dot). The receivers were taped to the backs of the subject's shooting jackets for the duration of the study. The heart rate monitors are capable of giving continuous readings of heart rate, as well as storing heart rates in memory at 5, 15 and 30 second intervals, this data can then be 'downloaded' to a computer. The five second interval was chosen because of the greater precision provided. After a preliminary trial period all three shooters verbally acknowledged the heart rate monitors as a non intrusive instrument and as such were prepared to wear them in both practise, and competition. As a further precaution, subjects wore the monitors on the second day of the Provincial Match Rifle Championships (an unofficial testing period) in order to allow greater familiarization with the Sport Testers.

At the commencement of each day's shooting the transmitter was fitted approximately 15 minutes prior to the first relay and worn until the conclusion of the day's shooting. Due to a one hour limitation in memory capacity the receivers were changed and restarted immediately after each relay. The data collection task was further complicated in competition by a limited supply of heart rate monitors, resulting in the need for an on site personal computer to 'download' information continuously. "Hard copies" of pulse rates, pulse rate curve and pulse rate distribution for each relay, were generated by a standard 9 pin printer. All recorded heart rates were subsequently downloaded to a computer via an interfacing devise (Polar Electro ™).

Scoring

To record the exact time of each sighting and scoring shot a stop watch was activated simultaneously with the commencement of the heart rate monitors. The investigator, or an assistant, was placed in an unobtrusive position, approximately 8 feet behind the shooter. Each time the shooter squeezed the trigger, the time, in seconds, was recorded on a numbered scoring sheet (see Appendix B, p. 115). The researcher or an assistant, then visually located the placement of the shot with the aid of a telescope. The relative placement of each scoring shot was then recorded, by time and number, on a miniaturized target before the next shot was fired. The experimenter collected all official targets after they had been cleared for release by scoring officials at the completion of each day's shooting. At a later time, the unofficial scoring targets were compared with the official targets in order to ascertain the precise position of each scoring shot taken. This procedure proved to be successful, with the unofficial targets clearly identifying patterns of shots fired.

In accordance with the method used by Bird (1987) shots were scored by measuring the exact distance, in millimetres, from the centre of the bullet hole to the centre of the target. This method allows for a more finely grained analysis of performance and variability than does the traditional ordinal criteria. The latter method generally results in a preponderance of tens by sub-elite and elite marksmen.

Data Collection

Data was collected during ten separate days and in accordance with the competition and practice schedules of each shooter (see Appendix, B, tables, 24, 25 & 26, pp. 116-118).

Data Collection Limitations

The three shooters were monitored as much as practically possible; however, a number of logistical problems arose which limited the number of days for which data collection was possible.

1\ Two of the shooter live in Red Deer and have limited access to practise facilities.

2\ Red Deer and Edmonton shooting ranges are only open two and three days a week, respectively.

3\ All three shooters compete in the Match Rifle event as well as Sporting Rifle; therefore, on practise days, shooters split their practice time between the two events.

4\ Despite the similarity between the Match Rifle and Sporting Rifle events, certain fundamental differences eliminated the possibility of combining and analyzing data collectively. As there were a greater number of Sporting Rifle events scheduled, the investigator decided to concentrate exclusively on Sporting Rifle.

5\ Due to the vast amount of time involved in collecting, preparing and entering the raw data into an acceptable format for statistical analysis, a limit was placed on the quantity of data collected, and subsequently, analyzed.

6\ As mentioned previously, two of the shooters unexpectedly decided not to wear the heart rate monitors at the National championship.

<u>Heart Rate as an Indice of Sympathetic Arousal Level</u>

Ideally, a number of psychophysiological devices would have been used concurrently, in order to provide corroborating evidence of arousal states. The use of a single psychophysiological measure of arousal such as heart rate has definite limitations. Actual performance fluctuations in heart rate need to be interpreted in light of other possible confounding effects. Nevertheless despite this limitation the heart rate telemetry in this study is justified on the following grounds.

1\ Elite athletes are typically not prepared to be monitored by a number of psychophysiological instruments at once in actual competition. Perhaps the majority of arousal/anxiety studies have avoided competitive situations, for this reason rather preferring 'mock' situations. This is unfortunate because generalizations from laboratory or other contrived situations to competitive situations have obvious validity limitations. Even the use of unobtrusive heart rate monitors met with some resistance in the present study. Two shooters originally approached to participate in the study were not prepared to wear monitors in competition. Two of the three subjects who did participate were not prepared to wear the monitors in National level competition. This may have been a function of age, as all four shooters were under the age of 19. In comparison the shooter who wore the monitors through all competitions was an extremely experienced shooter. Clearly elite athletes are wary of any device that may distract them from competing to the best of their ability.

2\ The present study supplemented the use of heart rate monitors with two self report measures of arousal to provide a more eclectic picture of arousal levels.

3\ The heart rate monitors chosen are a relatively inexpensive device compared to other psychophysiological instruments. In the event that accurate zones of optimal performance were identified shooters could perhaps use the monitors in the future to first gauge and then control heart rate both before and during competition.

Independent and Dependent Variables

The independent variable, although not actively manipulated in this study was the relative importance of the competition. Powell & Verner, (1982) suggest that the best experimental situation occurs when the task itself is the stressor, and when the subject has achieved a reasonable degree of performance consistency through task practise. Two shooting officials and one competitor rated the level of competition on a 8 point scale (refer, table 2).

Table 11

Relative Importance of Competition

Level	Competition
6	International competition
5a	National senior competition
5b	National Junior competition
4a	Provincial senior competition
4b	Provincial junior competition
3	Regional
2	Practice for score - no adjustment of equipment
1	Practice for score - adjusting of equipment

Ideally, an equal quantity of data would have been collected for each level of competition and for each firing position. In reality, a number of scheduling and logistical limitations, effectively meant that data could only be collected at four levels: 2, 4a, 4b and 5a. Shooting officials and competitors alike agreed that the junior level Provincial competition, which involved a smaller number and less experienced shooters than those in senior Provincial competition, was a lower level competition.

The first dependent variable was the score, measured in millimetres from the centre of the target. The second dependent variable was the shooters heart rate throughout each shooting relay.

CHAPTER V

EXPERIMENT 1

Purpose

Experiment One provides descriptive baseline data on each shooter's heart rate and performance patterns. Relevant issues for which no a priori predictions were postulated are posed as questions. A posteriori predictions were formulated into working hypotheses.

Major Questions

1\ Does an older more experienced shooter demonstrate any systematic differences in either heart rate or shooting performance in comparison with two junior shooters ?

2\ Can optimal arousal levels (zone of optimal performance) be determined through the use of heart rate telemetry ?

Hypotheses

1\ Heart rates will be lower in practise and gradually increase as the importance of the competition increases.

Statistical Analysis

Seventy eight score sheets representing each relay fired were transferred into separate ASCII (DOS) files on a Personal Computer using the Statistical Package for Social Sciences (SPSS) Data Entry 11 software sub-module. Each relay was coded and named to uniquely distinguish it from other files. Unique descripters were person, position, relay, event, competition, and day. The three variables recorded were: time in minutes and seconds, score in millimetres from the centre of the target, and heart rate in beats per minute (see Appendix B, p. 119 & 120 for a sample of raw data). An interpolation equation was utilized to estimate the heart rate at one second intervals from the five second recorded intervals. Files were subsequently transferred and analyzed on the SPSS package installed on the Michigan Terminal System (MTS), located at the University of Alberta. A total of 1560 scoring shots and close to 20,000 heart rate readings were recorded and subsequently analyzed.

Results

Descriptive Analysis

Means, medians, and standard deviations of Distance (in millimetres) from the centre of the target and heart rate (beats per minute) were calculated for each relay fired. In addition a mean was calculated for the heart rate at the actual time of firing as opposed to the average of heart rates throughout each relay using the five second interval. Tables 3, 4, 5, 8, 9, 10, 13, 14 and 15 present descriptive results which are compiled for person x position x competition.

A one way, (person x position x competition) "within groups" analysis of variance (ANOVA) was computed for both heart rate and distance to compare the effects of the independent variable (competition level) for each shooter. Highly significant ANOVA F-ratios were computed for all three subjects. Tukey's wholly significance difference (WSD) test was utilized where significantly different position or competition effects were found (tables 6, 7, 11, 12, 16 & 17). The significance level was set at 0.05 for all post hoc multiple comparisons. A more detailed description of Tukey competition differences for each shooter is presented (refer Appendix C, tables 27, 28, 28, 29, 30 & 31 pp. 122-127).

Subject One, (Senior Shooter)

Differences for both heart rate and shooting performance (distance) between the three positions were statistically significant with one exception being between the prone and standing positions (refer, table 6). Significant overall differences were found for heart rate between all three levels of competition but not for distance (refer, table 7).

Table 111

Descriptive Heart Rate and Performance Data: Subject One, Prone Position

	National	Provincial	Practice
Mean Distance (mm)	11.88	12.34	13.43
Mean H.R (beat/min)	90.88	91.67	81.47
Mean shot H.R (beats/min)	89.78	92.15	80.57
Median Distance (mm)	11.00	10.00	NC
Median H.R (beats/min)	90.2	92.00	NC
S.D Distance (mm)	6.37	7.87	NC
S.D H.R (beats/min)	8.16	9.76	NC
No of Cases Distance	140.00	140.00	160.00
No of Cases H.R	1635.00	1312.00	1142.00

Not Computed (NC) - Four practice relays (80.00 cases) were fired six weeks after the last competition, the data from these relays was hand calculated and as such overall group medians and standard deviations were not calculated.

No significant performance differences were found between competition or practice in the prone position. A significant heart rate difference ($p < .05$) was found between the Provincial senior event and practise (refer, Appendix C, pp. 122-127).

Table 1V

Descriptive Heart Rate and Performance Data: Subject One, Standing Position

	National	Provincial	Practice
Mean Distance (mm)	25.42	29.12	27.82
Mean H.R (beats/min)	94.85	98.08	91.82
Mean shot H.R (beats/min)	91.08	92.88	87.42
Median Distance (mm)	25.00	24.00	27.00
Median H.R (beats/min)	95.00	104.00	93.00
S.D Distance (mm)	11.41	16.40	13.79
S.D H.R (beats/min)	7.56	13.88	7.12
No of Cases Distance	40.00	40.00	80.00
No of Cases H.R	627.00	619.00	629.00

No significant performance differences were found between competition or practice in the standing position. In a similar manner to the prone position a significant difference ($p < .05$) was found between the Provincial senior event and practice (refer, Appendix C, pp. 122-127).

Table V

Descriptive Heart Rate and Performance Data: Subject One, Kneeling Position

	National	Provincial	Practise
Mean Distance (mm)	21.77	21.22	20.15
Mean H.R (beats/min)	86.46	98.22	86.70
Mean shot H.R (beats/min)	84.24	94.23	83.55
Median Distance (mm)	21.00	19.00	17.00
Median H.R (beats/min)	85.00	99.00	86.00
S.D Distance (min)	11.84	10.49	13.38
S.D H.R (beats/min)	7.82	4.68	6.06
No of Cases Distance	40.00	40.00	60.00
No of Cases H.R	419.00	218.00	567.00

Again no significant performance differences in shooting were found between either competition or practice in the kneeling position. Consistent with both prone and standing positions a significant difference ($p < .05$) in heart rate was found between the Provincial senior event and practise (refer, Appendix C, pp 122-127).

Table VI

Tukey Post Hoc Comparison by Position: Subject One

Position		Prone	Standing	Kneeling
		Distance		
Prone	Req Diff	-	2.29	2.34
	Obs Diff	-	15.47*	8.75*
Standing	Req Diff	-	-	2.68
	Obs Diff	-	-	6.72*
		Heart Rate		
Prone	Req Diff	-	1.72	2.07 NC
	Obs Diff	-	0.49	4.64*
Standing	Req Diff	-	-	2.18
	Obs Diff	-	-	4.14*

* $p < .05$

Not Computed (NC) - Four practice relays fired in the prone position six weeks after the last competition were not included in either ANOVA or multiple comparison tests.

Table V11

Tukey Post Hoc Comparison by Competition: Subject One

Competition		Practice	Provincial Senior	National
		Distance		
Practice	Req Diff	-	2.17	2.12
	Obs Diff	-	0.63	0.21
Provincial Senior	Req Diff	-	-	2.36
	Obs Diff	-	-	0.84
		Heart Rate		
Practice	Req Diff	-	1.84	1.65
	Obs Diff	-	5.24*	2.11*
Provincial Senior	Req Diff	-	-	1.69
	Obs Diff	-	-	3.12*

* $p < .05$

Subject Two (Junior Shooter)

Results for subject two were similar to subject one with significant performance and heart rate differences consistently computed between the three shooting positions (refer, table 11). Competition comparisons revealed significant heart rate but not performance differences (refer, table 12).

Table V111

Descriptive Heart Rate and Performance Data: Subject Two, Prone Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	15.66	16.15	16.97
Mean H.R (beats/min)	80.49	84.35	81.14
Mean shot H.R (beats/min)	85.76	90.13	82.49
Median Distance (mm)	14.00	14.00	15.50
Median H.R (beats/min)	81.00	84.00	81.00
S.D Distance (mm)	8.96	10.41	10.08
S.D H.R (beats/min)	10.90	10.85	7.57
No of Cases Distance	160.00	80.00	40.00
No of Cases H.R	2165.00	1058.00	395.00

Consistent with the findings for subject one no significant performance differences were found for either competition or practice in the prone position. Significant heart rate differences ($p < .05$) were computed between all three levels of competition: Provincial senior, Provincial junior and practise (refer, Appendix C, pp. 122-127).

Table 1X

Descriptive Heart Rate and Performance Data: Subject Two, Standing Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	30.00	29.40	23.45
Mean H.R (beats/min)	109.53	118.77	91.64
Mean shot H.R (beats/min)	106.39	116.25	86.88
Median Distance (mm)	27.00	21.00	22.50
Median H.R (beats/min)	110.00	119.00	91.00
S.D Distance (mm)	17.42	22.33	8.31
S.D H.R (beats/min)	10.21	7.53	7.24
No of Cases Distance	20.00	20.00	20.00
No of Cases H.R	248.00	302.00	185.00

The results for the standing position mirrored the prone position, with no significant performance differences being computed and significant heart rate differences ($p < .05$) for all three competitions (refer, Appendix C, pp. 122-127).

Table X

Descriptive Heart Rate and Performance Data: Subject Two, Kneeling Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	15.25	22.30	15.70
Mean H.R (beats/min)	83.73	89.19	73.51
Mean shot H.R (beats/min)	80.97	87.09	71.09
Median Distance (mm)	13.50	20.00	15.00
Median H.R (beats/min)	82.00	88.00	73.00
S.D Distance (mm)	9.53	14.59	9.52
S.D H.R (beats/min)	7.49	7.71	5.30
No of Cases Distance	20.00	20.00	20.00
No of Cases H.R	219.00	263.00	198.00

Again Tukey WSD comparisons computed for the kneeling position produced a similar result to the standing and prone positions for subject two, ie significant differences in all three competitions for heart rate ($p < .05$) but not for performance (refer, Appendix C, pp. 122-127).

Table X1

Tukey Post Hoc Comparison by Position: Subject Two

Position		Prone	Standing	Kneeling
		Distance		
Prone	Req Diff	-	3.77	3.47
	Obs Diff	-	11.63*	1.76
Standing	Req Diff	-	-	4.46
	Obs Diff	-	-	9.87*
		Heart Rate		
Prone	Req Diff	-	2.12	2.12
	Obs Diff	-	15.56*	6.83*
Standing	Req Diff	-	-	2.95
	Obs Diff	-	-	23.39*

* $p < .05$

Table X11

Tukey Post Hoc Comparison by Competition: Subject Two

Competition		Practice	Provincial Junior	Provincial Senior
			Distance	
Practice	Req Diff	-	3.83	3.23
	Obs Diff	-	2.22	0.79
Provincial Junior	Req Diff	-	-	2.82
	Obs Diff	-	-	1.44
			Heart Rate	
Practice	Req Diff	-	2.23	1.97
	Obs Diff	-	14.10*	8.11*
Provincial Junior	Req Diff	-	-	1.72
	Obs Diff	-	-	5.99*

* $p < .05$

Subject Three (Junior Shooter)

The results computed for subject three produced an almost identical result to subject two, both for overall position/competition effects and for specific position/competition comparisons (refer, tables, 16 & 17) and (Appendix C, pp. 122-127) respectively.

Table X111

Descriptive Heart Rate and Performance Data: Subject Three, Prone Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	19.76	17.10	17.83
Mean H.R (beats/min)	91.98	98.37	92.25
Mean shot H.R (beats/min)	97.03	104.75	92.07
Median Distance (mm)	18.00	13.50	15.00
Median H.R (beats/min)	93.00	99.00	96.00
S.D Distance (mm)	12.96	13.66	11.20
S.D H.R (beats/min)	8.83	6.79	11.51
No of Cases Distance	160.00	20.00*	60.00
No of Cases H.R	2014.00	268.00	531.00

* Unfortunately three relays (60 shots) of data were lost due to a problem with heart rate transmitter electrodes. The remaining relay, fired immediately after lunch, was this subject's best performance of the four.

Table XlV

Descriptive Heart Rate and Performance Data: Subject Three, Standing Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	28.22	22.90	26.80
Mean H.R (beats/min)	99.05	109.54	86.19
Mean shot H.R (beats/min)	103.05	117.92	86.11
Median Distance (mm)	28.50	21.00	23.00
Median H.R (beats/min)	99.50	111.50	85.00
S.D Distance (mm)	13.94	14.49	15.80
S.D H.R (beats/min)	7.00	8.67	10.00
No of cases Distance	40.00	20.00	40.00
No of cases H.R	590.00	228.00	383.00

Table XV

Descriptive Heart Rate and Performance Data: Subject Three, Kneeling Position

	Provincial	Provincial Junior	Practice
Mean Distance (mm)	21.42	21.60	16.00
Mean H.R (beats/min)	87.03	94.47	87.79
Mean shot H.R (beats/min)	90.07	99.24	91.08
Median Distance (min)	21.00	20.00	14.50
Median H.R (beats/min)	87.00	95.00	89.00
S.D Distance (min)	10.16	9.73	8.08
S.D H.R (beats/min)	5.88	7.14	5.93
No of cases Distance	40.00	20.00	20.00
No of cases H.R	509.00	229.00	244.00

Table XVl

Tukey Post Hoc Multiple Comparison by Position: Subject Three

Position		Prone	Standing	Kneeling
		Distance		
Prone	Req Diff	-	3.56	3.56
	Obs Diff	-	7.53*	1.05
Standing	Req Diff	-	-	4.13
	Obs Diff	-	-	6.48*
		Heart Rate		
Prone	Req Diff	-	1.97	2.14
	Obs Diff	-	2.82*	3.81*
Standing	Req Diff	-	-	2.70
	Obs Diff	-	-	6.63*

* $p < .05$

Table XV11

Tukey Post Hoc Multiple Comparison by Competition: Subject Three

Competition		Practice	Provincial Junior	Provincial Senior
			Distance	
Practice	Req Diff	-	4.35	3.08
	Obs Diff	-	0.16	2.19
Provincial Junior	Req Diff	-	-	4.32
	Obs Diff	-	-	2.35
			Heart Rate	
Practice	Req Diff	-	2.39	1.85
	Obs Diff	-	10.60*	7.42*
Provincial Junior	Req Diff	-	-	2.84
	Obs Diff	-	-	18.02*

* $p < .05$

Overall Heart Rate v Heart Rates for Shots Fired

A comparison between mean heart rates and mean heart rates for shots fired was calculated in order to determine if heart rates typically increased or decreased at the time of firing. The mean overall heart rate is based on the number of five second heart rate intervals recorded during a relay (often in excess of 200 recordings). A mean of means was then calculated for both position and competition. In comparison the mean of shots fired is based on the heart rate at the time of firing for each relay (20 shots). Again the mean of means was then calculated for both position and competition.

The compilation of descriptive data revealed that subject one the more experienced shooter, fired his shots at a heart rate below his mean overall heart rate in all three positions and competitive conditions. In comparison the junior shooters, particularly subject three, were more likely to release shots at a heart rate higher than their mean overall heart rate (refer, figures 1, 2 & 3). There was an overall tendency for practice sessions to produce smaller discrepancies between heart rates for shots fired and overall heart rates.

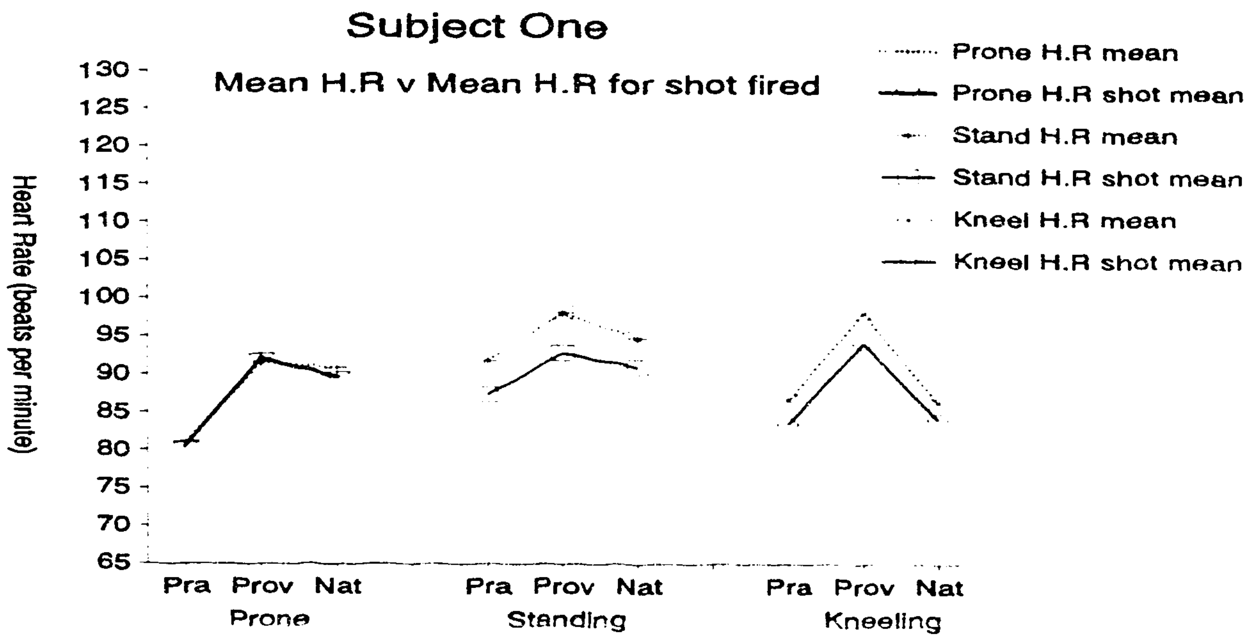

Figure 1. Subject One: Mean Overall Heart Rate v Mean Heart Rate for Shots Fired

Pra - Practice

Prov - Provincial senior event

Nat - National senior event

Figure one demonstrates how subject one consistently fires his shots at a mean heart rate equal to or below his overall mean heart rate.

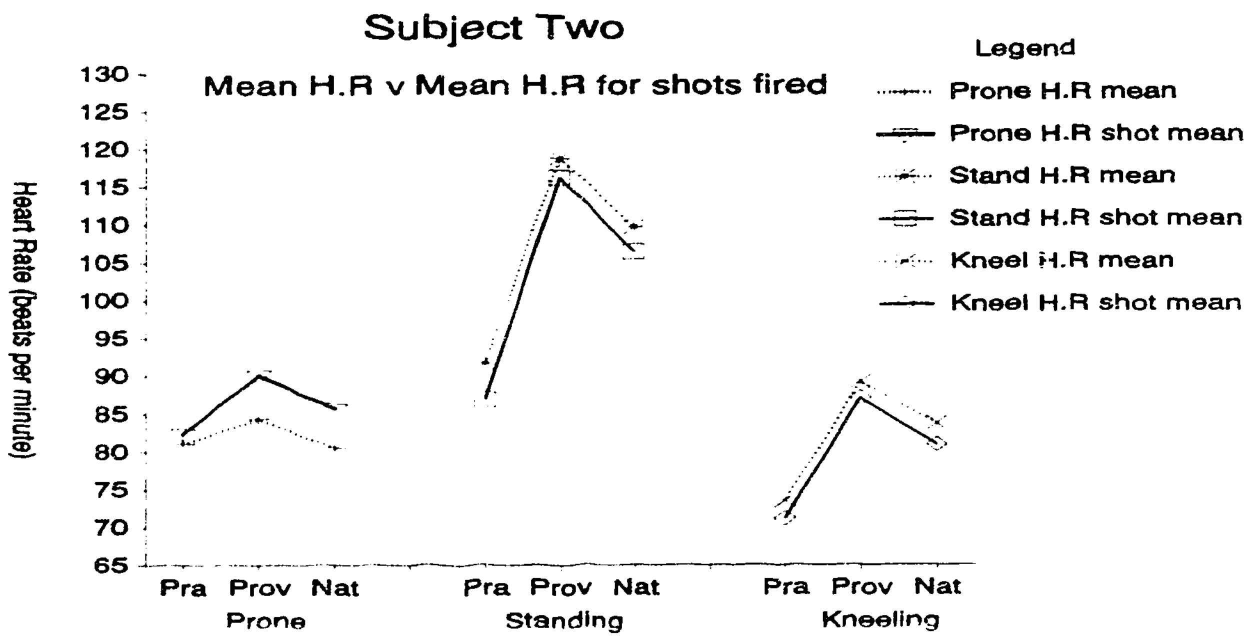

Figure 11. Subject Two: Mean Overall Heart Rate v Mean Heart Rate for Shots Fired

Pra - Practice

Prov J - Provincial junior event

Prov S - Provincial Senior event

Subject two demonstrated a similar pattern to subject one except in the prone position, where his shooting heart rate exceeded his mean overall heart rate in all three experimental conditions.

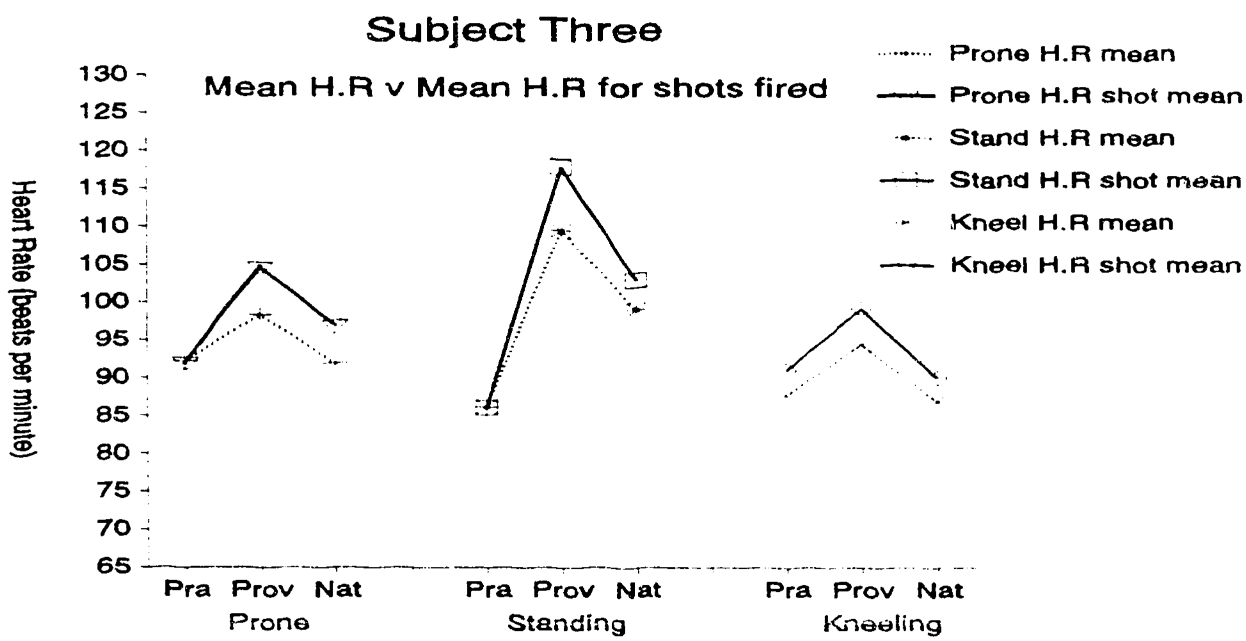

Figure 111. Subject Three: Mean Overall Heart Rate v Mean Heart Rate for Shots Fired

Pra - Practice

Prov J - Provincial junior event

Prov S - Provincial Senior event

Subject three experienced slightly elevated heart rates at the time of firing in all three positions. This trend was more evident during competition than in practice.

Performance Comparison

As expected all three shooters fired higher scores in the prone position followed by kneeling then finally the more difficult standing position (refer, figure 4).

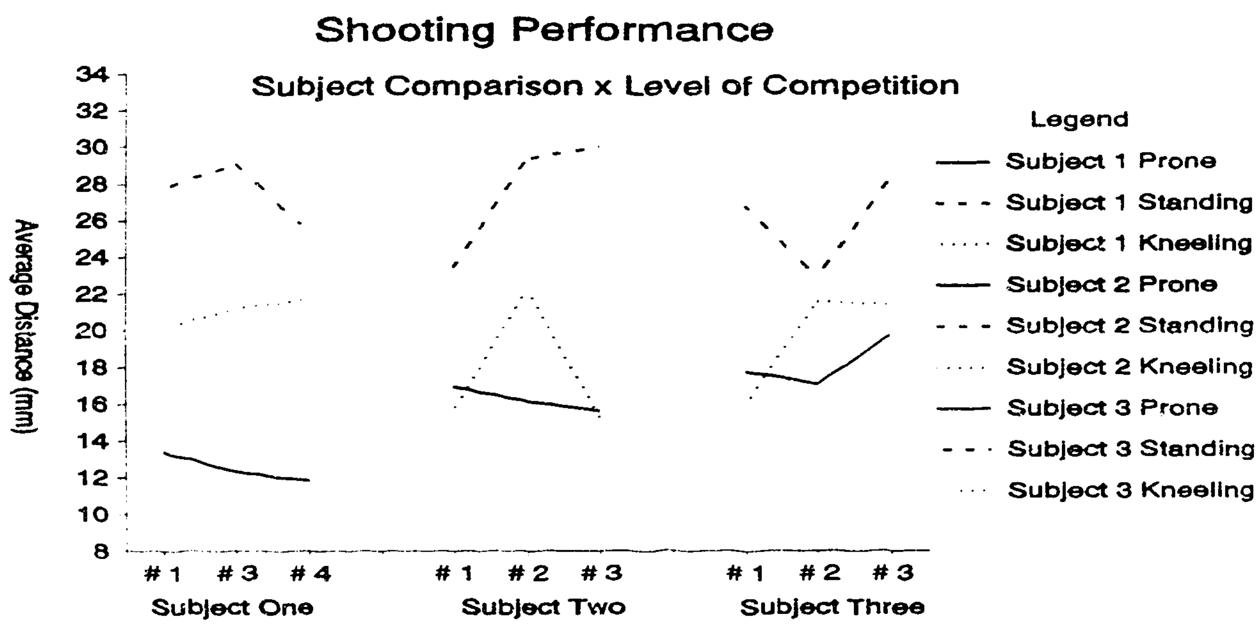

Figure 1V. Subject Comparison: Overall Shooting Performance

#1 - Practice

#2 - Provincial Junior Competition

#3 - Provincial Senior Competition

#4 - National Senior Competition

Intersubject performance differences were associated with position. Each of the three shooters performing comparatively better depending on the firing position. Subject one was the better prone shooter, subject two the more proficient kneeling shooter and subject three best in the standing position. In actual competition shooters fire four times as many prone targets as either of the other positions and hence being a proficient prone shooter relates more intimately to total score.

Discussion

Experience Related Factors

As expected the effects of movement artifact and the cardiac requirements associated with shooting in each position were substantiated by multiple comparison tests. All three shooters experienced elevated heart rates in the standing position compared to both kneeling and prone. This is not surprising given the effects of movement artifact discussed earlier. Movement artifact, in this study, refers to variations in heart rate casued by physical exertion rather than increased arousal. Unlike the older shooter, the two juniors also demonstrated elevated heart rate in the kneeling position compared to prone. This may be related to strength and endurance differences. The more experienced shooter possibly was able to withstand the physically tiring effects of constantly lifting and maintaining the gun in a steady position. Subject two, the youngest of the three shooters and the smallest in stature, despite having the lowest mean heart rate in the prone position experienced substantial increases in heart rate while shooting in the standing position, well above the increase experienced by the other two shooters. During both the Provincial senior and junior competitions when subject two experienced elevated heart rates in the standing position performance was considerably lower than during practice.

A comparison was also made between average overall heart rate and average heart rates for shots taken. It appears that subject one was able to compose himself prior to releasing shots more so than subject two and especially three (this difference being more pronounced in the prone position). A possible reason for this difference may be the use of cognitive and/or relaxation techniques applied immediately preceding the shot release. Subject one had been taught progressive relaxation while being a member of the National team and utilized this technique on occasions but unsystematically. Subject one also employed a cognitive procedure which associated words with images before releasing shots (i.e. steady-ready-blank-square). The two junior shooters, however, had not been taught either a known relaxation technique or cognitive strategy.

A possible intervening factor for elevated heart rates in some cases is the length it takes a shooter to complete a relay of shots. All shooters are given a maximum of 30 minutes to complete their relay of 20 shots. Often, however, they complete their shots in 15 minutes or less. As a consequence increases in heart rate due to physical factors (ie lifting and holding the gun) are more likely when a shooter takes longer to shoot a relay. Thus, decreased practice heart rates especially in standing and kneeling positions may have resulted from quicker relay times rather than reductions in arousal. While no computations of average relay times were made, it was clear that subject one usually shot the quickest, followed by subject two then subject three.

In answer to question one posed earlier, subject one, the more experienced shooter did demonstrate clear differences in arousal reactivity and performance when compared to the two junior shooters. However, a larger sample size would be needed in order to test if these differences hold true for shooters in general.

No shooter demonstrated any clearly identifiable heart rate range where performance was optimal. Individual heart rate were unexpectedly varied, on occasions large variances were recorded for two consecutive relays fired in the same position. Furthermore, elevated heart rates did not necessarily produce detrimental effects on performance

(refer pp. 84-86 for an extended discussion). There are a number of possible interceding factors which could perhaps influence heart rate including a) effect of eating and drinking, b) weather, c) time of day, d) personal stress level, e) physical activity, and f) excitement. Therefore, heart rate far from being a constant unwavering measure of arousal, is susceptible to considerable variance. These possible confounding factors do not necessarily invalidate heart rate as a useful psychophysiological measure but need to be either adequately accounted for or controlled.

While it is impossible to conclusively state that heart rate monitors can not identify zones of optimal performance the findings of the present experiments suggest that a number of intervening factors make identification of individual zones a difficult task. A tightly controlled experiment may conceivably be capable of identifying optimal zones. However, in the process of gaining adequate experimental control, validity may be sacrificed.

The present findings call into question the conclusion of Rodimki and Tretilova who are quoted in related literature as advocating that a shooter's heart rate should not rise more than 30 percent above resting levels otherwise decrements in performance will occur (Bird, 1987). These same two researchers are also reported to have clearly identified optimal zones of functioning using heart rate telemetry (Landers, et al. 1985; Hatfield & Landers, 1983). Landers, et al. (1985) report that Tretilova and Rodimki found best performances were scored when heart rate values were between 4 and 50 bpm above resting levels. These so called zones, far from being a narrow or even moderate range are so broad they are rendered useless as a practical heart rate guide, to the shooter or coach.

Hypothesis one which stated that heart rate increases would correspond to increases in competition was partially supported. A uniform increase in heart rate between practice and competition was found for all three subjects. In a similar manner and contrary to hypothesis one each subject consistently experienced elevated heart rates at an intermediate level of competition, rather than the most important competition as expected. In the case of subject one the increase in heart rate at the Provincial compared to the National Championship may be related to the timing of the two events. Subject one had not competed in a sporting rifle event for a number of years, the Provincial event which was held two weeks prior to the National competition was his first sporting rifle competition for approximately 10 years. At one stage he remarked "I think I was more nervous at this competition (Provincial event) than I was at times competing for the National team". In the case of the two younger shooters the elevated heart rate at the Provincial junior compared to the Provincial senior event may be attributed to outcome possibilities. In the junior event both shooters had a legitimate chance of winning the competition (they placed 1st and 2nd) and may as a result experienced elevated heart rates in response to this outcome possibility. Perhaps if the two Juniors had agreed to wear the heart rate monitors at the Nationals a clearer heart rate pattern may have emerged.

V

EXPERIMENT 11

Purpose

This study investigated which arousal theory best explains the relationship between heart rate and shooting performance for rifle shooters. A second purpose was to investigate if the relative importance of the competition resulted in heart rate and shooting accuracy differences. Relevant issues for which no a priori predictions were postulated were posed as questions. A posteriori predictions were formulated into working hypotheses.

Major Question

1\ Which arousal theory best explains the arousal-performance relationship in rifle shooting: the inverted U, quiescence theory or optimal arousal theory ?

Hypotheses

1\ Heart rates during high level competition will demonstrate evidence in favour of the quiescence theory of arousal.

Statistical Analysis

Correlational Analysis

Two distinct correlation procedures were utilized to uncover both direct arousal-performance relationships and time dependent changes in arousal. First, Pearson correlation coefficients were computed to measure the direct association between heart rate and performance at the actual time of firing. This method is commensurate with previous Sport Psychology studies which have typically plotted performance and arousal in a correlational manner. This simple procedure while providing a direct indice of the arousal - performance relationship ignores the inevitable oscillations in arousal that occur over time. Since heart rate fluctuated quite substantially from competition to competition, day to day and even relay to relay Fisher Z transformations were calculated when compilated data so as to control for these heart rate fluctuations.

Attention to time related trends in arousal reactivity is commonly overlooked by sport psychology researchers. Sport researchers have typically tested the arousal - performance relationships using only direct arousal - performance criteria thereby treating arousal as a static unwavering phenomena. Simpl[illegible]ng performance and arousal in a correlational manner masks important tim[illegible] changes taking place in arousal levels. The present study, apart from using time - distance correlations, employed a cross correlation procedure to analyze time related trends in heart rate and performance. Correlation coefficients, were calculated for both time - distance and time - heart rate for each relay fired, allowing heart rate and performance changes to be tracked over each relay (approximately 15 - 25 minutes). This method is justified on the grounds that arousal occurs in a transient manner ebbing and declining constantly.

Heart rate increases caused by fundamental differences in the cardiac requirements of each shooting position normally preclude a combined analysis of all three positions. The cross correlation method allows presentation of data for all three positions in a compilated manner. For each relay, heart rate and performance act as their own controls thereby avoiding the confounding effects of heart rate fluctuations. This is achieved by converting all values into correlations thus providing a common ground for direct comparisons to be made.

Correlations Computed

Heart - Distance This correlation measures the association between heart rate at the time of firing and the distance of a shot in millimetres from the centre of the target. Each heart - distance correlation computed represents a relay of 20 shots.

Time - Heart: This correlations measure the amount of variance in heart rate during the course of a relay. For example a correlation of -.5 suggest that heart rate slowed moderately during a relay. In comparison an increase of .5 indicates that the shooter's heart rate gradually increased during the course of a relay.

Time - Distance: This correlations measure how stable performance was during the course of a relay ie was performance stable, better in the early part of a relay or toward the end. A neutral time - distance correlation would suggest that shooting accuracy did not vary, a postive relay suggests that performance (e.g. measured in millimetres from the centre of the target) declined.

Results

In keeping with intraindividual design methodology the results recorded for each subject will be presented as separate entities.

Individual correlational values for all 78 relays fired during the study are presented in Appendix D, tables, 33, 34, 35, 36, & 37, pp. 129-133).

Subject One

Heart - Distance

Significant correlations were computed for subject one in the prone position at both the National and Provincial competitions ($r=.160$, $p<.05$) and ($r=.146$, $p<.01$), (refer table 18). A combination of the two competitions revealed a highly significant correlation of ($r=.155$, $p<.01$). These positive correlations indicate that subject one performed better in high level competition at the low end of his heart rate range. Conversely a weak significant negative correlation ($r=-.133$ $p<.10$) was computed when shooting practice rounds in the prone position. For a graphical representation of the relationship between heart rate and performance for each relay fired (refer to figure 5, p. 68).

Generally, non significant correlations were computed in the standing position. Results in the kneeling position demonstrated a similar pattern to the prone position with a positive correlation emerging in National level competition ($r=.324$, $p<.05$), (refer, table 18)

In summary the strength of the correlations generally declined as the relative importance of the competition. This trend held true for each of the firing positions.

Time - Heart

In all three positions highly significant correlations revealed a strong downward trend in heart rate during Provincial/National level competitions: Prone (r=.195 p <.001), Standing (r=.177 p <.001) and Kneeling (r=.421 p <.001), (refer, table 18).

Table XV111

Fisher Z Correlation Transformations: Subject One

Prone Position				
Competition	National Day 1 & 2	Provincial Day 1 & 2	National Provincial Combined	Practice
Distance-Heart	.152*	.146*	.149***	-.133*
Time-Heart	-.241****	-.1312****	-.195****	-.380****
Time-Distance	-.08	-.212***	-.142*	.148*

Standing Position				
Competition	National Day 1 & 2	Provincial Day 1 & 2	National Provincial Combined	Practice
Distance-Heart	.270*	-.069	.104	.005
Time-Heart	.005	.342****	.177****	.251****
Time-Distance	-.174	-.120	-.146	.176

Kneeling Position				
Competition	National Day 1 & 2	Provincial Day 1 & 2	National Provincial Combined	Practice
Distance-Heart	.324**	.075	.190*	.042
Time-Heart	.395****	.446****	.421****	.141****
Time-Distance	.181	-.007	.09	.211*

* $p < .1$, ** $p < .05$, *** $p < .01$, **** $p < .001$

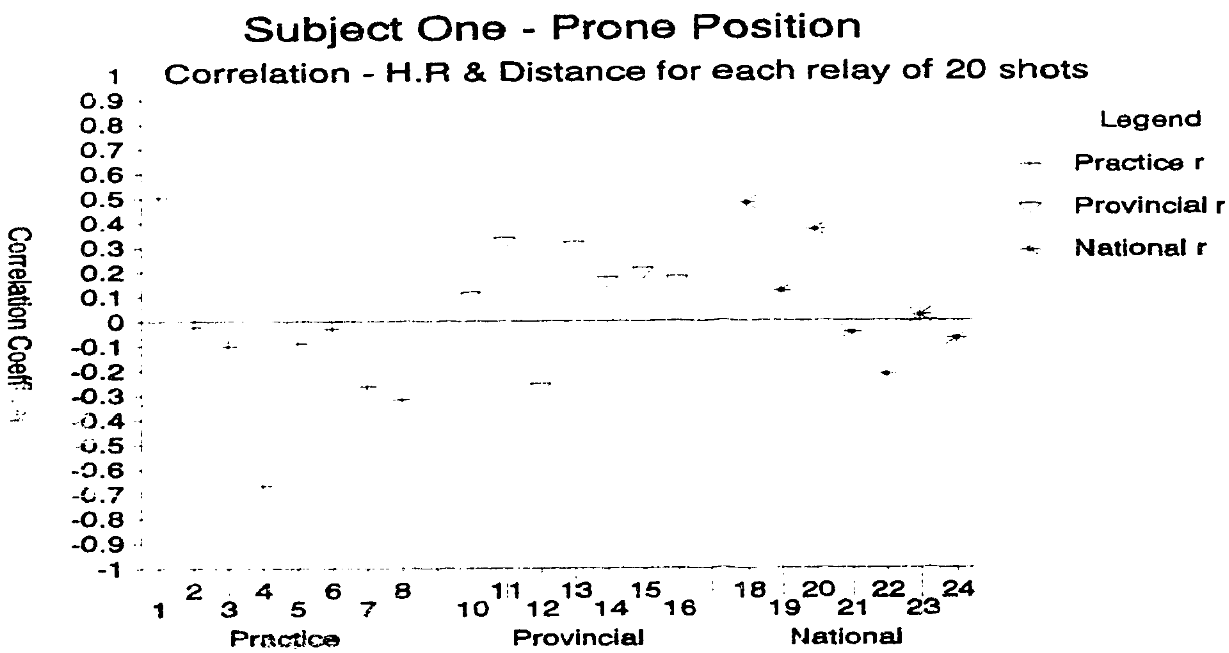

Figure V. Scatter Plot: Subject One, Heart - Distance Correlations

X axis 1 - 8 Practice correlations for each relay fired

10 - 16 Provincial correlations for each relay fired

18 - 22 National correlations for each relay fired

Note - Due to the scoring procedure employed (ie low scores indicate more accurate shots) positive correlations indicate improved performance at lower heart rates.

Time - Distance

Non significant relationships were generally correlated for all three positions, indicating that the quality of performance was evenly distributed within each relay. One notable exception was a significant negative correlation recorded during the Provincial Championships in the prone position ($r = .-212$ $p < .01$).

Subject Two

Heart - Distance

Results ... a similar pattern to subject one, however, the strength of correlations was far weaker with only two significant correlations being computed (refer, Appendix D, pp. 129-133). A significant correlation was recorded when Provincial senior and Provincial junior competitions were combined in the prone position ($r = .13$ $p < .05$), (refer, table 19). Non significant positive correlations were computed for both standing and kneeling positions. For a graphical representation between heart rate and performance in the prone position refer to figure 6, p. 75).

Time - Heart

Unlike subject one, subject two experienced heart rate increases rather than decreases as a function of time. Highly significant positive correlations were recorded in all three positions at both the National and Provincial Championships. Prone ($r = .193$ $p < .001$), Standing ($r = .370$ $p < .001$) and Kneeling ($r = .198$ $p < .001$), (refer, Table 19).

Time - Distance

Performance and time were significantly correlated for the prone position in only the Provincial level competition ($r = .202$ $p < .01$).

Table 1XX

Fisher Z Correlation Transformations: Subject Two

	Prone Position			
	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	.096	.196*	.13**	-.08
Time-Heart	.212****	.157****	.193****	.02
Time-Distance	.202***	.066	.154**	-.045

	Standing Position			
	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	-.15	-.113	.131	.18
Time-Heart	.412****	.364****	.370****	.13*
Time-Distance	-.09	.225	.067	.14

	Kneeling Position			
	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	.01	.063	.036	.05
Time-Heart	.245****	.151**	.198****	-.21***
Time-Distance	.09	.269	.179	-.22

* $p < .1$, ** $p < .05$, *** $p < .01$, **** $p < .001$

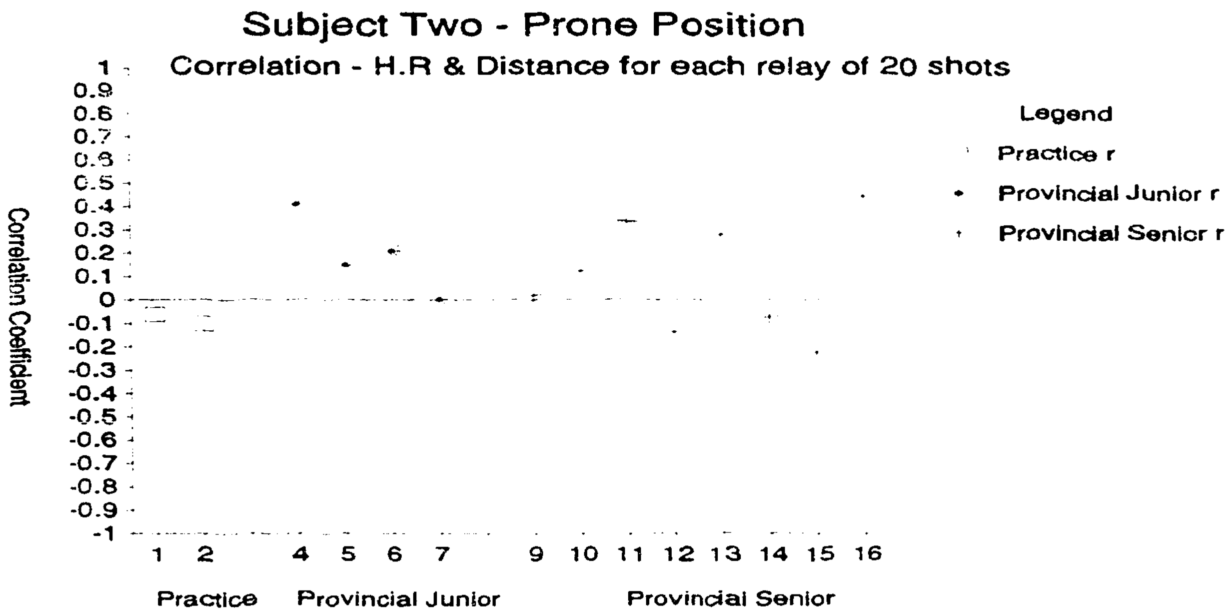

Figure V1. Scatter Plot: Subject Three, Heart - Distance Correlations

X axis 1 - 2 Practice

4 - 7 Provincial Junior Championships

9 - 15 Provincial Senior Championships

Note - Due to the scoring procedure employed (ie low scores indicate more accurate shots) positive correlations indicate improved performance at lower [illegible].

Subject Three

Heart - Distance

Results revealed that subject three shot considerably better in the prone position when his heart rate was higher. A significant combined Provincial senior and junior correlation was recorded in the prone position (r=-.209 p <.01), (refer table 20). No consistent trend was found for either the standing or kneeling positions. For a graphical representation of the relationship between heart rate and performance in the prone position refer to figure 7, p. 78. In a similar manner to both other subjects, non significant correlations were computed for practice days.

Time - Heart

Gradual increases in heart rate over the course of time were consistently observed. In an identical fashion to Subject two, highly significant correlations were recorded in all three positions at National and Provincial level competition; Prone (r=.278 p <.001), Standing (r=.487 p <.001) and Kneeling (r=.300 p <.001), (refer, table 20).

Time - Distance

As a general rule performance deteriorated over time in all three positions, this is again consistent with the trend found for subject two. However, only one correlation reached significance.

Table XX

Fisher Z Correlation Transformations: Subject Three

Prone Position

Competition	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	-.193*	-.346	-.209***	.03
Time-Heart	.266****	.386****	.278****	.104**
Time-Distance	.118	-.251	.07	.077

Standing Position

Competition	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	-.023	.06	.003	-.092
Time-Heart	.466****	.504****	.482****	-.036
Time-Distance	.214	.438*	.291**	.009

Kneeling Position

Competition	Provincial Senior Day 1 & 2	Provincial Junior	Provincial Senior & Junior Combined	Practice
Distance-Heart	.02	.563***	.198	.167
Time-Heart	.33****	.24****	.30****	.441****
Time-Distance	.02	.265	.095	.369

* $p < .1$, ** $p < .05$, ***$p < .01$, **** $p < .001$

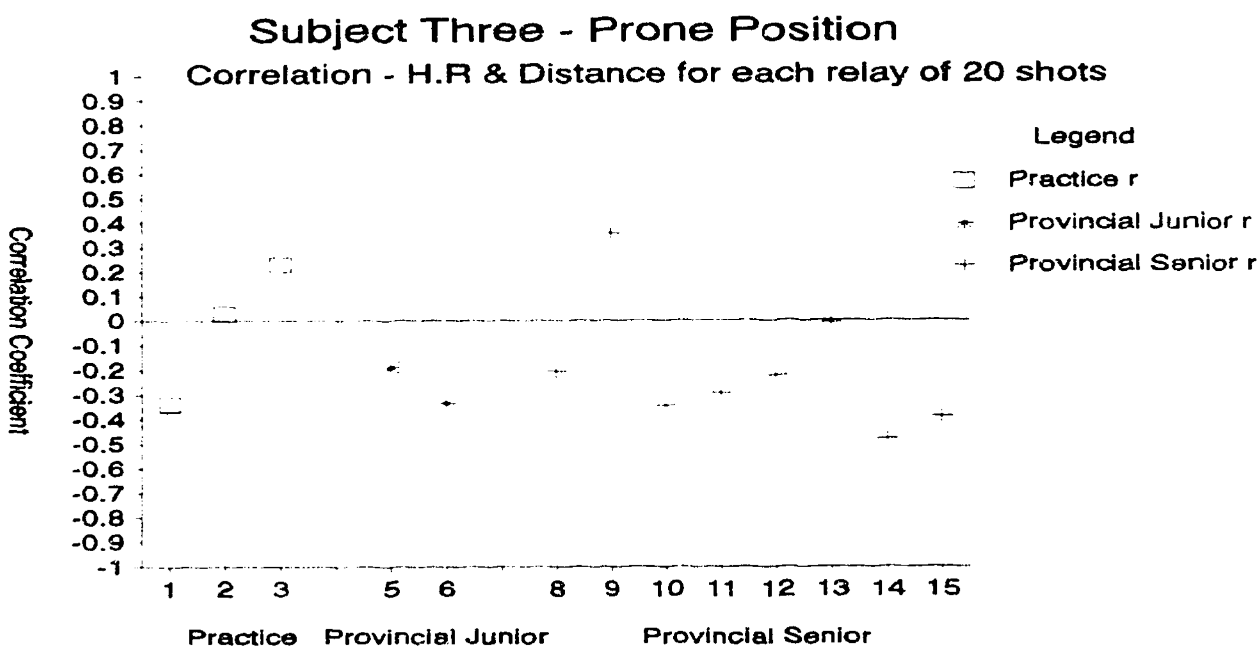

Figure V11. Scatter Plot: Subject Three, Heart - Distance Correlations

X axis 1 - 3 Practice

5 - 6 Provincial Junior Competition

8 - 15 Provincial Senior Competition

Note - Due to the scoring procedure employed (low scores indicate more accurate shots) positive correlations indicate improved performance at lower heart rates.

Cross Correlational Analysis

As previously described a cross correlation procedure was instigated to depict time dependent trends. The time - distance correlations which are plotted on the ordinate axis have been inverted so as to represent the data in accordance with traditional methods of plotting the arousal - performance relationship.

An inverted U relationship emerged for subject one especially in the prone and standing positions. When time/heart rate correlations fell below -.50 performance invariably suffered (refer, figure 8). Similarly, when time/heart rate correlations rose above .10 performance again steadily declined.

Since subject two and three were not monitored as frequently as subject one fewer data points were available for cross correlational analysis. Plotting the cross correlational failed to clearly identify a time related trend for either subject two or three (refer figures 9 & 10).

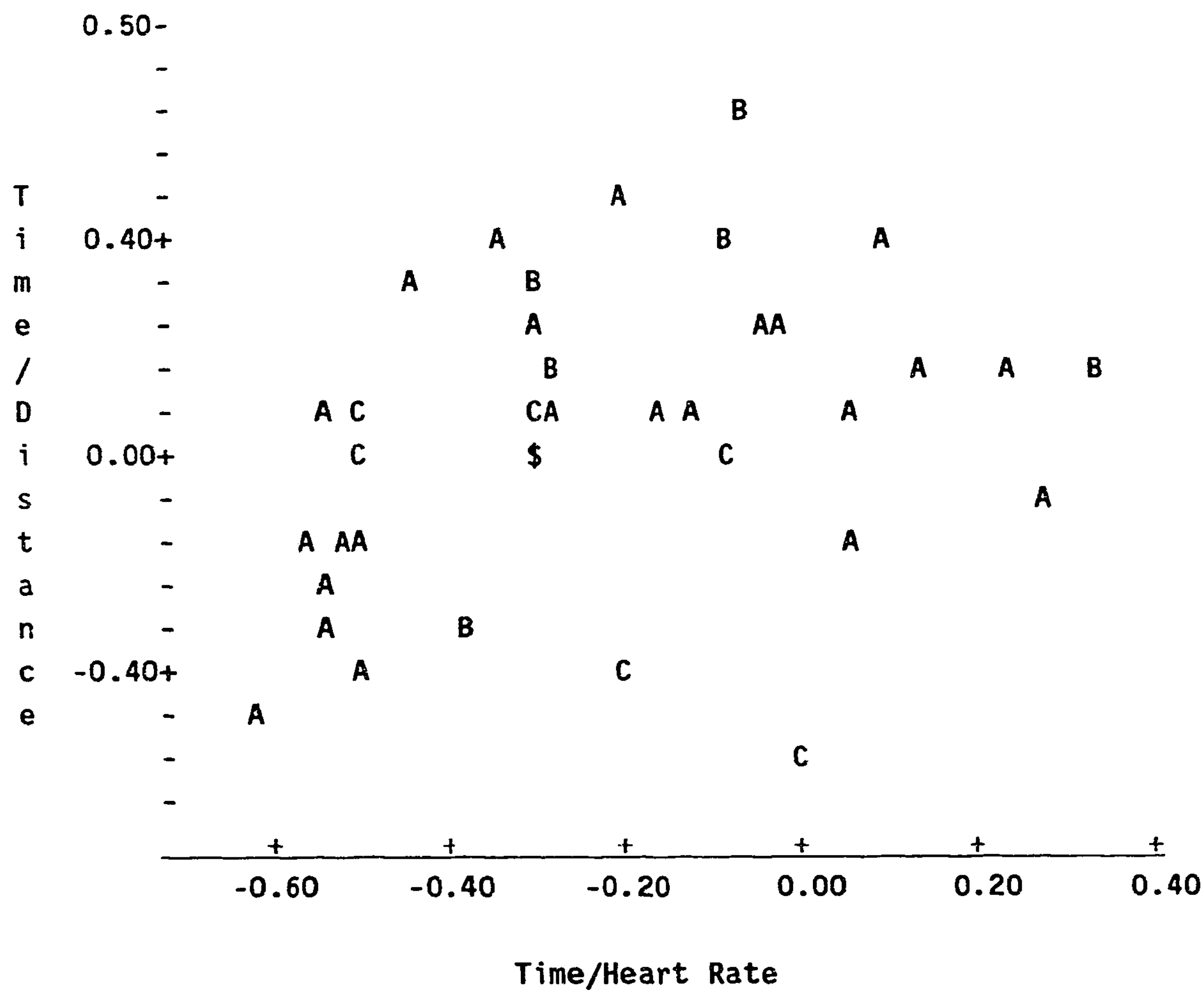

Figure V111. Cross Correlation Plot: Subject One

Prone Position - A

Standing Position - B

Kneeling Position - C

Multiple cases - $ (two standing)

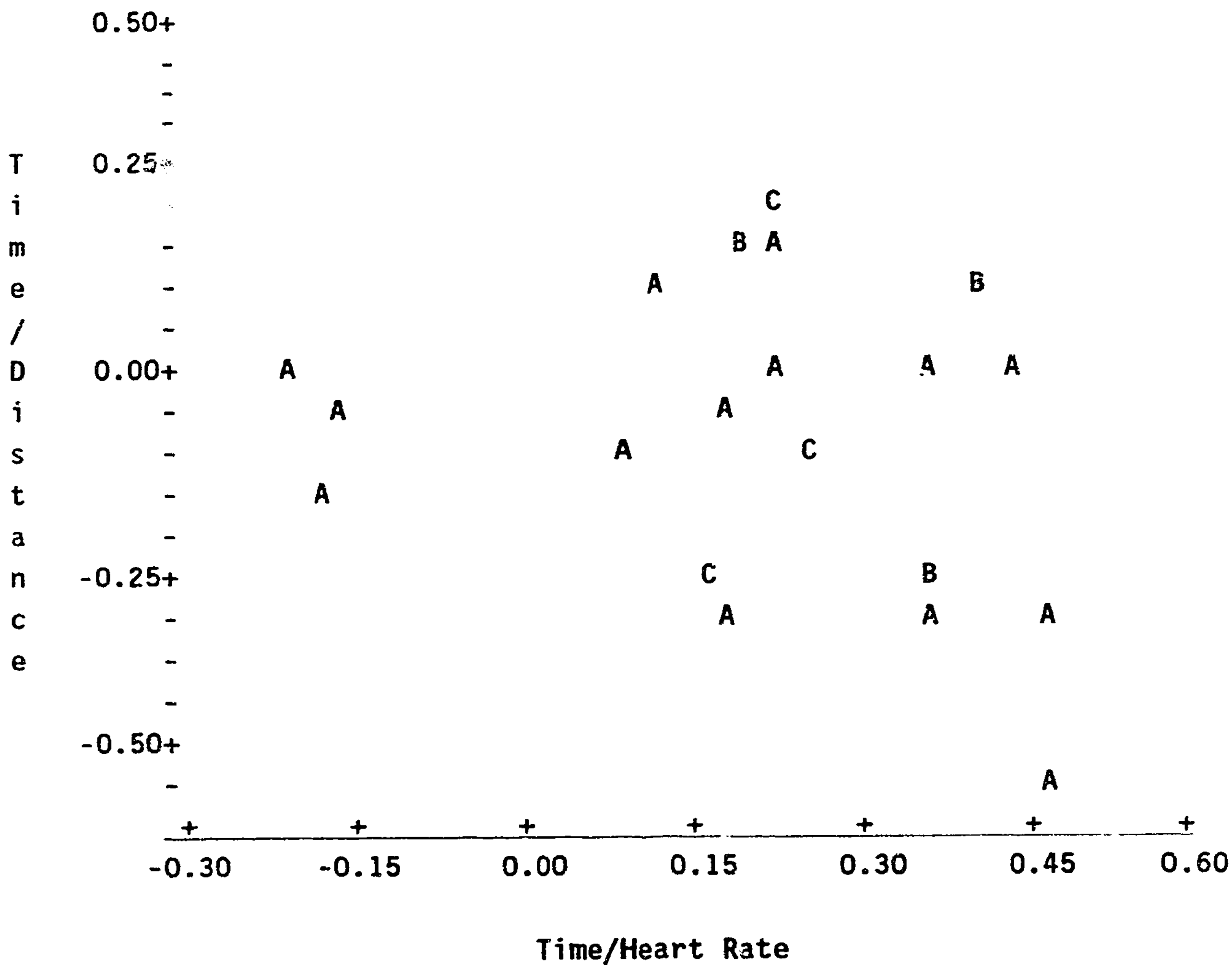

Figure 1X. Cross Correlation Plot: Subject Two

Prone Position - A

Standing Position - B

Kneeling Position - C

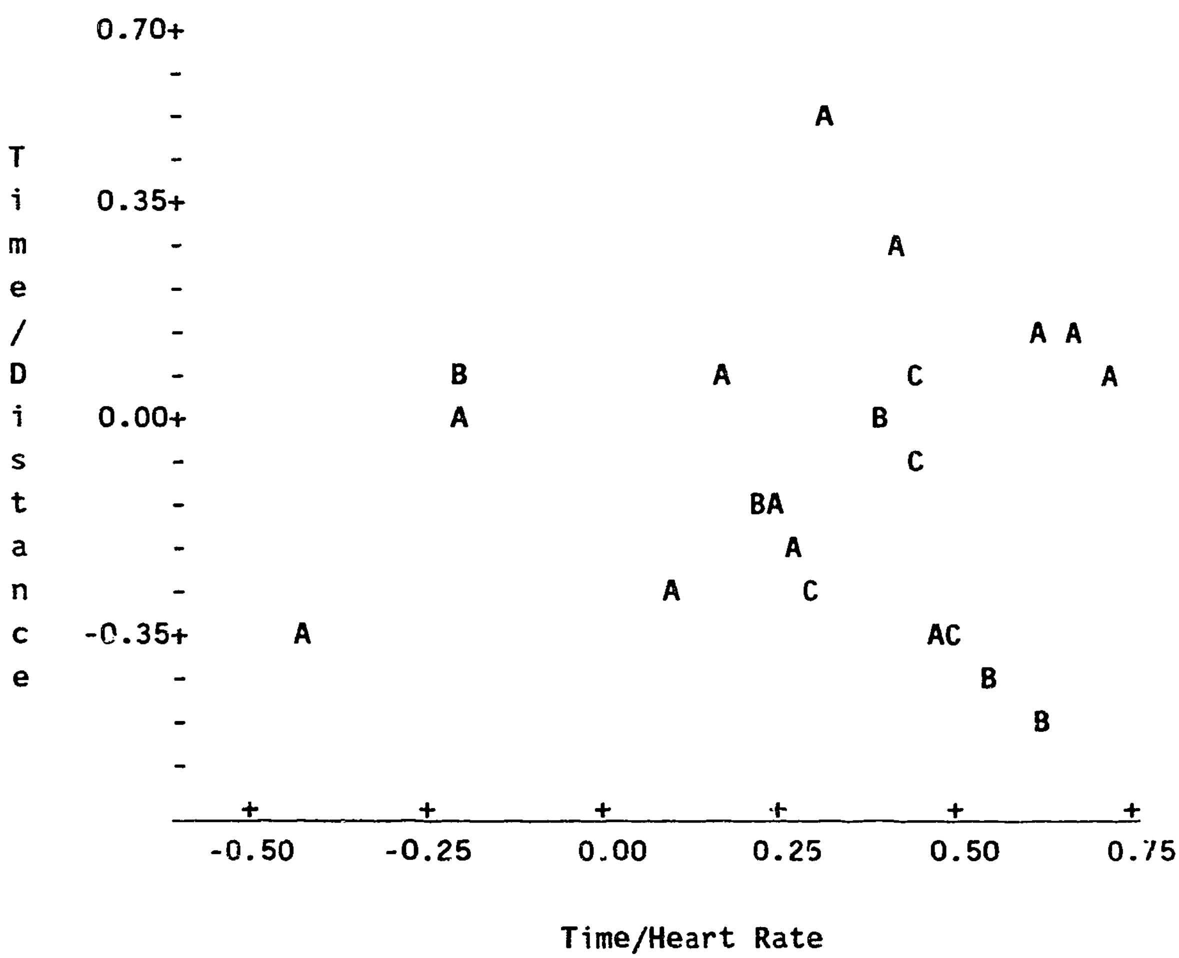

Figure X. Cross Correlation Plot: Subject Three

Prone Position - A

Standing Position - B

Kneeling Position - C

Discussion

Subject One

Quality of performance tended to be associated with decreased heart rate for subject one, particularly as competition importance increased. During the National Championships seven of the eight prone relays fired produced positive correlations (the exception being a neutral correlation) Thus, for subject one, performance was better when heart rate was lower Interestingly, the Provincial Championships produced a similar result with seven of the eight relays again producing positive correlations. In contrast practice rounds fired in the prone position produced negative correlations in the majority of cases. Presumably, subject one was not as highly aroused in practice compared to competition, thus producing lower heart rates.

An inspection of heart - distance correlations for both standing and kneeling positions confirms the arousal - performance differences exist in competition compared to practice for subject one. Both standing and kneeling positions produced similar trends to the prone position with a majority of positive correlations in competition and primarily negative correlations in practice. Again, significant correlations were computed in both positions at the National Championship, however, non significant correlations were computed at the Provincial level.

Of particular importance was the highly significant positive correlation ($r = .149$ $p < .001$) found for subject one during the National/Provincial competitions in the prone position. A total of 300 prone shots were observed during these competitions in comparison to 80 standing and 80 kneeling shots. Therefore the correlation coefficient for the prone position can be viewed as a more stable calculation.

Despite a few notable exceptions most correlations computed failed to reach levels of significance when examined in isolation. It was only with the greater statistical power provided by compilating data that significant relationships were found. The present findings suggest that heart rate and performance are not linked in a consistent predictable manner.

Theoretically, quiescence theory is more relevant in situations producing extremes in somatic arousal such as International competitions and the early stages of all but the lowest level competitions. In these situations some highly state anxious competitors may be unable to reduce somatic anxiety to levels where performance is adversely effected. Unfortunately as no data was collected during International competition these comments remain speculative based on extrapolation of the present findings.

Although these results provide clear support for quiescence theory there still remained instances where performance was not affected by a high heart rate. To illustrate this point two specific situations where heart rate increased dramatically for subject one in the prone position will be discussed. It is highly likely that the causes of increased heart rate in these two situations where quite different.

Shortly before shooters were called by the range officer into their firing positions for the first relay at the National Championships a heavy fog descended on the rifle range. The fog was sufficiently heavy to prevent shooters from clearly seeing the targets situated 50 metres away. It quickly became apparent that the fog was not going to lift before the 30 minute relay time period elapsed. Most shooters were forced to lie waiting for fleeting moments where they could view the target sufficiently to sight and release their shots. Subject one, along with other shooters, remarked how anxious he became as the fog persisted, and despite being an extremely experienced shooter had never shot in those (fog) type of conditions before. His heart rate for this round was unusually high averaging 100 bpm compared to an average of 91 bpm for all other rounds observed during the study. It was probably no coincidence that he shot his worst prone score at the National Championships during the fog affected round (refer, Appendix D, p. 129). Somatic anxiety has been shown to climax prior to and during the early stages of an event and then gradually decline (Martens, et al. 1990). In the scenario described above the usual somatic responses associated with the initial stage of competition were probably exacerbated by the onset of the fog.

A second unusual situation occurred two weeks prior the National Championships in Calgary at the Provincial Sporting rifle Championship. Once again subject one shooting in the prone position averaged an extremely high heart rate of 108 bpm during the relay. This was 17 bpm higher than his average heart rate for all other prone rounds. His score far from being adversely effected was substantially better than all other scores observed throughout the entire study (refer

Appendix D, p. 129). During this round he scored 198 out of a possible 200 and averaged 8.5 millimetres from the centre of the target compared to nearly 13 millimetres for all other prone rounds. Clearly the increase in heart rate was not a function of anxiety. What then caused the increased heart

rate ? In attempting to answer this question it is first necessary to present the mean heart rates for all relays fired during day one of the Provincial competition (refer, table 23).

Table XXI

Mean Heart Rates: Subject One, Day One, Provincial Competition.

	Mean Heart Rate
Relay 1 (prone position)	91.96
Relay 2 (prone position)	82.80
Relay 3 (prone position)	80.85
One hour lunch Break	
Relay 4 (prone position)	108.20
Relay 5 (standing position)	110.18
Relay 6 (kneeling position)	98.23

It is immediately apparent that during rounds 4, 5 and 6 fired after the lunch break unusually high heart rates prevailed. A subsequent interview with subject one revealed that during lunch he had consumed food that may have caused the increased heart rate; he had eaten chinese food [commonly containing high quantities of Monosodium Glutamate (MSG)] and also drank a large quantity of Pepsi Cola (which contains large quantities of caffeine). A further investigation of post lunch heart rates on other days of competition confirmed that heart rates increased over pre lunch heart rates by between 7 and 17 bpm for all three subjects. While it can only be speculated that food and drink produced the dramatic increase in heart rate, the fact that scores were not affected may indicate that anxiety was not present. The possible effects of food digestion on heart rate appears to be one of a number of reasons why heart rate may increases independent of anxiety related reasons.

Cross Correlations

A clear inverted U pattern was unearthed for subject one using the cross correlation procedure, particularly in the prone and standing positions. When heart rates declined beyond a correlation of -.5 performance suffered. In addition, when heart rate increased beyond a correlation of .10 performance also gradually declined. This is an important finding because despite the intuitive and widespread belief in the inverted U theory of arousal very few studies have substantiated the theory in genuine competitive situations. As no time - heart correlations increased beyond .037 in any position it appears that whatever the circumstances or score obtained subject one is able to circumvent substantial increases in heart rate. This may be a function of experience. Subject one has competed in rifle shooting for 25 years. He had also been a National team member for five years and as such would have experienced a number of anxiety inducing situations.

The strong negative heart - time correlations, which indicate reduced sympathetic nervous system activity over time, may be a result of reduced ego involvement by subject one. Having achieved a great deal of success in the past this shooter may not have been as highly motivated as other shooters attempting to gain selection in the National team. As mentioned previously he had retired from shooting, and, in his first year back in competition he may not have been as ego involved relative to many shooters. Furthermore, the match rifle rather than sporting rifle was the subject's principal event in which he competed at the International level. Therefore his expectations may not have been as high (i.e. for the sporting rifle event).

Subject Two

Again, heart - distance correlations provide generalized support for quiescence theory in competition but not for practice. An overall positive correlation in the prone position (r=.13 p <.05) was computed. Positive correlations were also computed in both Standing and Kneeling positions but neither computation reached significance. In contrast practice correlations were low and well short of significance criteria.

Cross Correlations

No clear support was found for a recognized arousal theory. There was a distinct absence of time - heart data points below zero for subject two. Ideally an even spread of time - heart correlations would have been recorded, thus facilitating an analysis directed at identifying an optimal performance zone, if indeed one existed. Only with a more complete spread of time related data points could a more decisive statement be made regarding subject two's arousal - performance tendencies. Although unlikely it is conceivable that with the addition of more data points evidence in favour of a recognized theory of arousal would have emerged. The different cross correlation pattern for subject two compared to subject one, may be related to the general trend for heart rate to increase during a relay rather than decrease, as was the pattern with subject one.

Subject Three

The results computed for subject three demonstrate a different trend to either of the other two subjects. The correlations calculated between heart rate and performance suggest that subject three performs better at higher heart rates during competition in the prone position. This is perplexing because, apart from being directly opposite to the trend found for the other two subjects. This relationship was only apparent in the prone position. This unusual trend may be due in part to the results being based purely on eight Provincial senior relays and one Provincial junior relay. Perhaps some unique condition, either mental or physical closely present in the Provincial senior event may have been the cause. It is tempting to suggest that perhaps the subject was under aroused on occasions, yet this seems be too simplistic and is not born out by a self reported anxiety (refer, experiment 111, pp. 96 & 97).

Cross Correlations

Again no clear support was found for any recognized arousal - performance theory. The pattern that this subject displayed was very similar to subject two. Typically heart rate would increase over the course of a relay and performance would usually but not always decline. A distinct lack of time - heart data points around and below zero was found making more decisive conclusions difficult due to the same reasons outlined for subject two.

Summary

Due to the variance in individual arousal patterns and the limited number of subjects used in this experiment no definitive support for one arousal theory over other recognized theories was found. However, quiescence theory appears to be most relevant in high level competition where arousal levels are usually at their highest. Piecemeal support was also found for the inverted-U and optimal arousal theory in specific situations, or for one particular shooter.

CHAPTER V11

EXPERIMENT 111

Methodology

Introduction

Two Junior rifle shooters were repeatedly administered the Competitiv Anxiety Inventory (CSAI-2) under three different competitive conditions: Pro Junior, Provincial Senior and National Senior Championships. The perform: each subject was recorded and relationships between self report anxie performance were then studied.

Subjects

Subjects were two male junior (ages 16 and 17) members of the . Shooting Association, who compete in the 50 metre sporting rifle sub-disciplir shooters were relatively experienced shooters for their age, having competet sport for three and four years respectively.

Procedures

Before agreeing to participate in the study subjects were told they w asked to fill out a questionnaire (the CSAI-2) on repeated occasions, before t day of all competitions. They were shown a copy of the CSAI-2, and inform the inventory usually takes approximately five minutes to complete (refer, A| E, p. 135 for a copy of the CSAI-2).

Shooters were administered the CSAI-2 at the Provincial match rifle event (an unofficial testing competition) so as to familiarize then with the questions and adminstration procedures.

In accordance with recommendations made by the authors the CSAI-2 was administered as close as possible to the commencement of competition. In all competitions the subjects completed the questionnaire within 25 minutes prior to the commencement of the days competition. The inventory was completed on only the first day of competition in each event because it was felt that at this time A-state is likely to peak.

Limitations

Contrary to the authors recommendations the correct title of the inventory (Competitive State Anxiety Inventory-2) was used rather than the deliberately vague name suggested: The Illinois Self-Evaluation Questionnaire. The authors suggest this name to minimize the likelihood of socially desirable responses.

Delimitations

Subjects were administrated the CSAI-2 on competition days only and not before practise sessions. Data was therefore, collected on three days the forst day of the Provincial Junior, Provincial Senior and the National Senior events.

Experimental Measures

The CSAI-2 consists of 27 statements which ask the responder to report "how do you feel right now - at this moment". The subjects rate themselves on a four point scale: "not at all", "somewhat", moderately so" and "very much so". The 27 items are arranged in alternate order relating to three sub-scales: cognitive, somatic and self-confidence.

Scoring

The CSAI-2 is scored by computing a separate total for each of the three sub-scales with scores ranging from a low of 9 to a high of 36. The higher the score the greater the cognitive or somatic A-state or the greater the self-confidence. The test developers provide a number of specific norm referenced samples including: type of sport and competition level (Martens, et al. 1990).

Shooting performance was measured using the traditional ordinal scoring procedure recommended by the International Shooting Union. Due to the length of a full day of competition scores were only recorded for the morning rounds of shooting (e.g. a perfect score for a morning of competition equals 600 points). It was felt that comparisons between the CSAI-2 and shooting performance for a full day were not justified due to the length of a day's competition.

Purpose

The present study had a threefold purpose: The first purpose was to investigate relationships between shooting performance, level of competition and pre-competitive arousal (as measured by the CSAI-2). A second related purpose was to examine which sub-scale of the CSAI-2 best predicted performance. A third purpose was to measure the association between the three subscales of the CSAI-2.

Statistical Analysis

Pearson coefficient correlations were computed to determine both the association between the three CSAI-2 sub-scales and possible linkages between each sub-scale and shooting performance.

Results

Subject Two

Subject two reported a linear increase in somatic anxiety as the importance of competition increased. An overall increase was also reported for cognitive anxiety. However, it was prior to the Provincial event rather than the National event where cognitive anxiety peaked for subject two. Self confidence decreased in line with increases in competition importance, the lowest score being reported for the National competition (refer, figure, 11). Performance was stable in all three competitions with scores falling within an extremely tight range (ie 573 - 575 points). Thus, the relative importance of competition was strongly related to self report anxiety and self confidence but not resultant score for subject two.

Due to a distict lack in performance variablity (ie scores of 574, 574, & 575) no correlations between score and self reported anxiety are presented for subject two. Calculating correlations with such small variations in score might result in spurious significant correlations being computed.

Pearson correlations confirmed the finding of previous research suggesting that the cognitive and somatic sub-scales of the CSAI-2 are statistically independent (Martens. et al 1990). However, a significant negative correlation between the cognitive and self confidence sub-scales ($\underline{r}$=-.98 $\underline{p}$ <.01) suggests a reverse relationship between these two scales (refer, table 22).

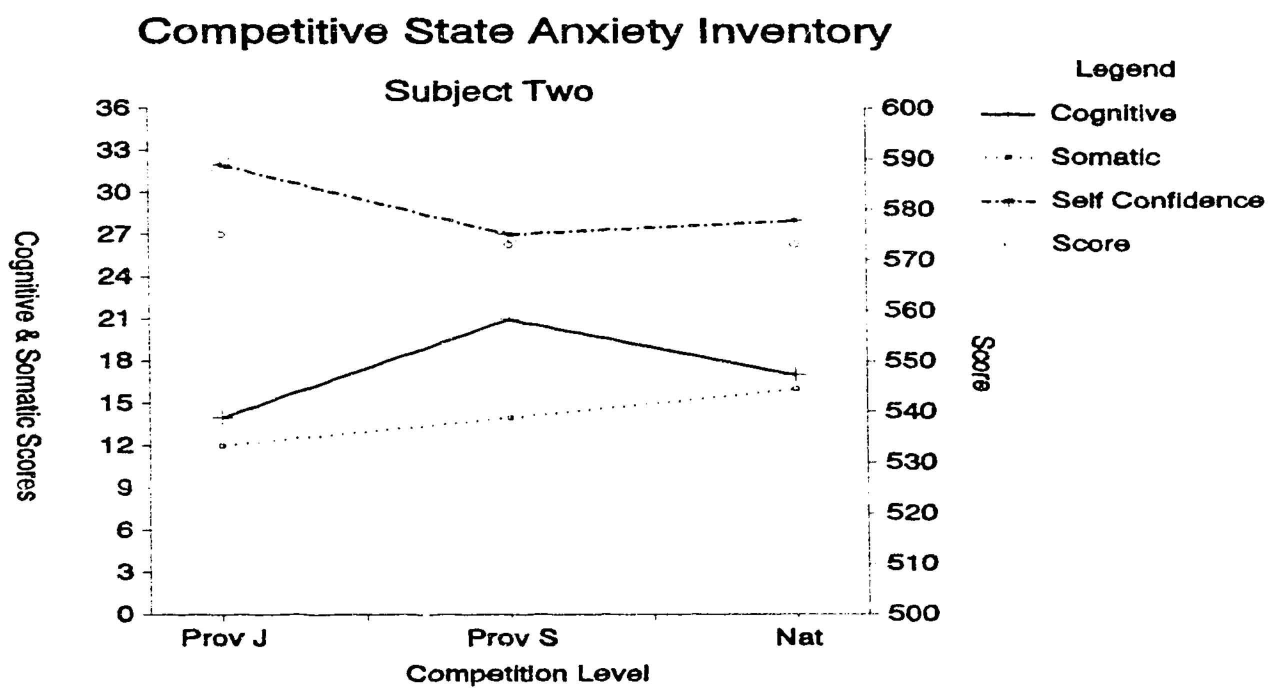

Figure X1. Effect of Competition on CSAI-2 Score and Shooting Performance: Subject Two

Table XXll

CSAI-2 and Score Correlations: Subject Two

Sub-Scale	Cognitive	Somatic	Self Conf
Cognitive	-	.59	-.96**
Somatic	-	-	-.79
Self Confidence	-	-	-

* p < .1, ** p < .05, *** p < .01

Subject Three

Subject three reported a linear increase for cognitive anxiety as the importance of competition increased. Somatic anxiety also increased with competition, however, it peaked at the Provincial Senior event. In a similar manner to subject two self confidence declined as competition importance increased.

Performance fluctuated far more widely than subject two with scores ranging from 529 to 573 with the low score being at the Provincial senior event, the high score at the Provincial junior event and the intermediate score at the National competition. Somatic anxiety was the most accurate predictor of performance with a significant (r= -.98 p <.01) correlation being computed (refer, table 23).

A similar pattern of sub-scale interrelationships was calculated to subject two. Again the cognitive and self confidence sub-scales were highly related (r=-.91 p <.01). Weaker relationships were computed between other sub-scale correlations, these were again consistent with the findings for subject one (refer, table 23).

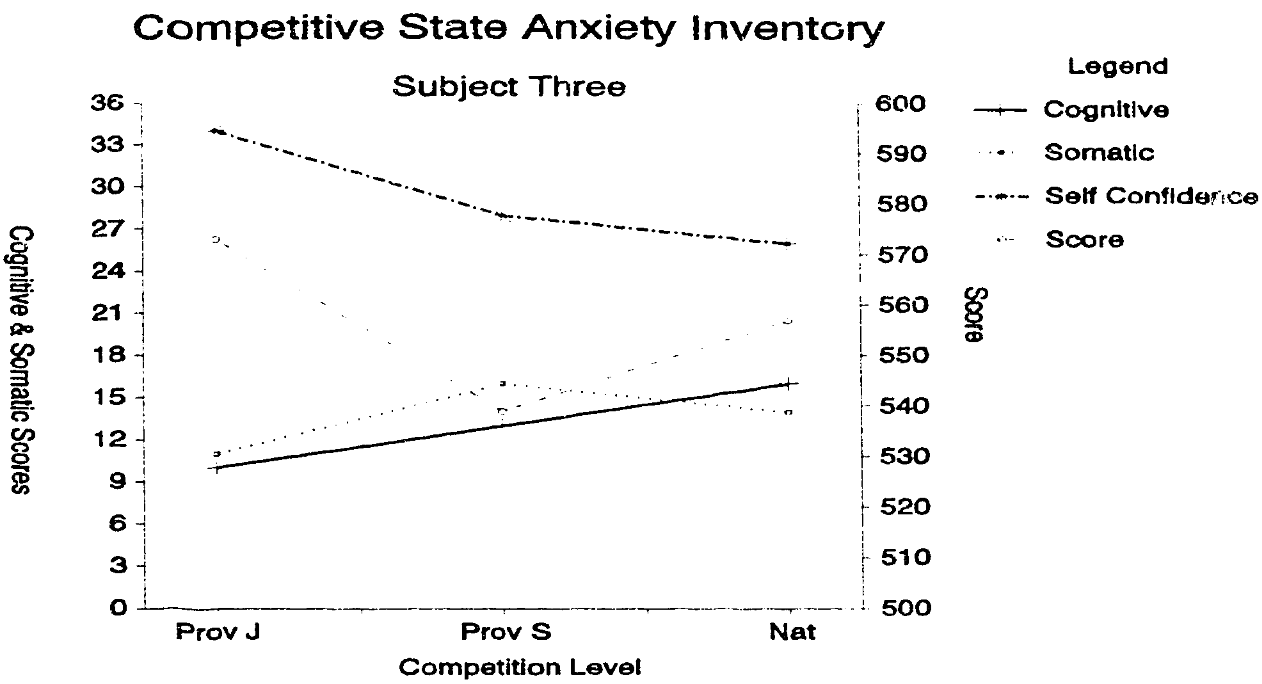

Figure XX11. Effects of Competition on CSAI-2 Scores and Shooting Performance: Subject Three

Table XX111

CSAI-2 and Score Correlations: Subject Three

Sub-scale	Cognitive	Somatic	Self Conf	Score
Cognitive	-	.42	-.91**	-.47
Somatic	-	-	-.75	-.98***
Self Confidence	-	-	-	.70

* p < .1 ** p < .05 *** p < .01

Discussion

Subject Two

No direct association was found between the shooting performance of subject two and the level of competition. Shooting performance was remarkably consistent over the three competitions observed. Identical scores were fired at both the Provincial senior and National competitions and a marginal improvement at the Provincial junior event. Therefore, despite increases in self reported anxiety in conjunction with increased competition importance no substantial decrements in performance resulted. Possibly, the increases in anxiety were not sufficient to precipitate decrements in performance. Landers and Boutcher (in Williams, 1986) suggest, CSAI-2 sub-scale scores between 10 and 14 are ideal in sports where reduced arousal levels are desirable (e.g. archery, golf putting, field goal kicking). As subject two, reported CSAI-2 sub-scale scores of between 14 and 21 for Provincial and National competitions arousal levels were in excess of the optimal zone suggested by Landers and Boutcher. Unrelated compensating factors often associated with high level competition may have offset the effects of increased arousal during high level competition. It is not uncommon for athletes to prepare more thoroughly (e.g. mentally & physically) and display heightened concentration at more important events.

Subject Three

An interesting performance fluctuation was observed for subject three, with the Provincial senior event producing a relatively poor score. Self reported anxiety was also elevated prior to the Provincial senior event and an overall significant association calculated between self report somatic anxiety and performance was found ($r = -.98$ $p < .01$). This is a noteworthy finding because self reported cognitive anxiety has consistently been shown to predict performance better than self reported somatic anxiety in other sports (Martens, et al. 1990).

The strong association between somatic anxiety and performance ties in with the suggestion (refer p. 21) that in sports where athletes are attentive to sympathetic arousal somatic anxiety levels predicts performance over an extended period of competition not just in the early stages of competition. The present study deliberately correlated self reported anxiety measures with score over a protracted period of time (eg 2.5 to 3 hours). Furthermore, both shooters who participated in this study and well as subject one were well aware of their physiological responses while shooting (refer, Appendix F, pp 138-139 for individual responses to the Post Shooting-1 Questionnaire).

CHAPTER V111

SUMMARY, CONCLUSIONS & RECOMMENDATIONS

The present series of experiments confirms that arousal/anxiety patterns are subject to substantial variation. As expected the three individuals who participated in this study each displayed an idiosyncratic patterns of arousal susceptibility. Surprisingly, the arousal levels of each shooter as measured by heart rate monitors fluctuated quite dramatically. A number of confounding transitory factors independent of competition importance and shooting position may have been responsible for heart rate variance from one relay to the next. Fortunately a sufficient number of data collection days were included in the present study to reduce the overall effect of transitory factors on heart rate. However, in future, researchers utilizing heart rate monitors would be well advised to attempt to reduce the mitigating effects that transitory factors have on heart rate (ie control for effects of food).

Traditional methods of plotting performance and arousal in a correlational manner were considered inappropriate for providing a clear picture of the arousal - performance relationship. Heart rate variations from relay to relay effectively thwarted attempts to simply combine the data. However, individual arousal - performance correlations for individual relays were effectively highlighted with this method. More sophisticated statistical techniques were sought to extricate the arousal - performance relationship. Fisher Z transformations were computed to equally weight each individual correlation calculation for the purposes of studying overall arousal - performance effects.

Unequivocal support was not found for either the inverted U, optimal arousal or quiescence theories which had been postulated as possible explanations for the arousal - performance relationship in rifle shooting. Quiescence theory received strong empirical support for two of the three competitions at the higher levels of competition. Further research including the full gamut of naturally occurring shooting conditions from practice through to International events would be a useful adjunct to the findings of this study.

The inverted U theory explained the arousal - performance relationship most adequately when practice data was also considered. Heart rates were consistently lower in practice for subjects one (who was the only subject for which sufficient practice data was observed to make conclusions), performance was generally inferior also in practice.

Given that arousal is only one of a number of performance related factors the preceding comments are made tentatively.

No clear heart rate range was identified where performance was optimal (optimal arousal theory). The findings of the present study call into question previous research, where optimal heart rate ranges are reported to have been identified. It is suggested that in order to be of practical use to the shooter heart rate ranges need to within a tight range.

It was also considered that a further limitation associated with relying solely on direct arousal - performance relationships is the inherent inability of this procedure to account for time dependant fluctuations in arousal. A cross correlation procedure was utilized to trace changes in both heart rate and shooting performance over time. Cross correlations revealed a well defined inverted U pattern for subject one, an elite shooter. This pattern was strongly anchored at one end of the curve by a number of computations for the prone position, where performance was negatively related to dramatic decreases in arousal. No clear pattern was revealed for either of the junior shooters.

An implication for future research, aimed at uncovering arousal/anxiety patterns, is the need to treat, and subsequently analyze anxiety as a ever changing rather than a static and unwavering phenomena.

The use of psychophysiological instruments provides a useful avenues of tracking the inevitable changes in arousal that take place. The use of a combination of psychophysiological instruments should if possible be employed, however, in actual competitive situations. This may be unrealistic and invasive.

A comparison between subject one (highly experienced) and subject two and three (moderate experience) uncovered two clear differences in heart rate patterns. First, subject one consistently fired his shots at heart rates below his mean overall heart rate, in comparison the two juniors where more inclined to fire when heart rate was higher than mean overall heart rate. Second, the two junior shooters typically experienced gradual increases in heart rate during the course of a relay, whereas subject one typically experience gradual reductions in heart rate. It was suggested that these differences may have been related to previous cognitive and/or relaxation techniques utilized by the more experienced marksman.

The use of the Competitive State Anxiety Inventory-2 apart from being a useful tool which can be used quickly in competitive situations, can be administered on repeated occasions. The CSAI-2 was effective in identifying which component of anxiety (cognitive, somatic or self confidence) was most closely associated with performance.

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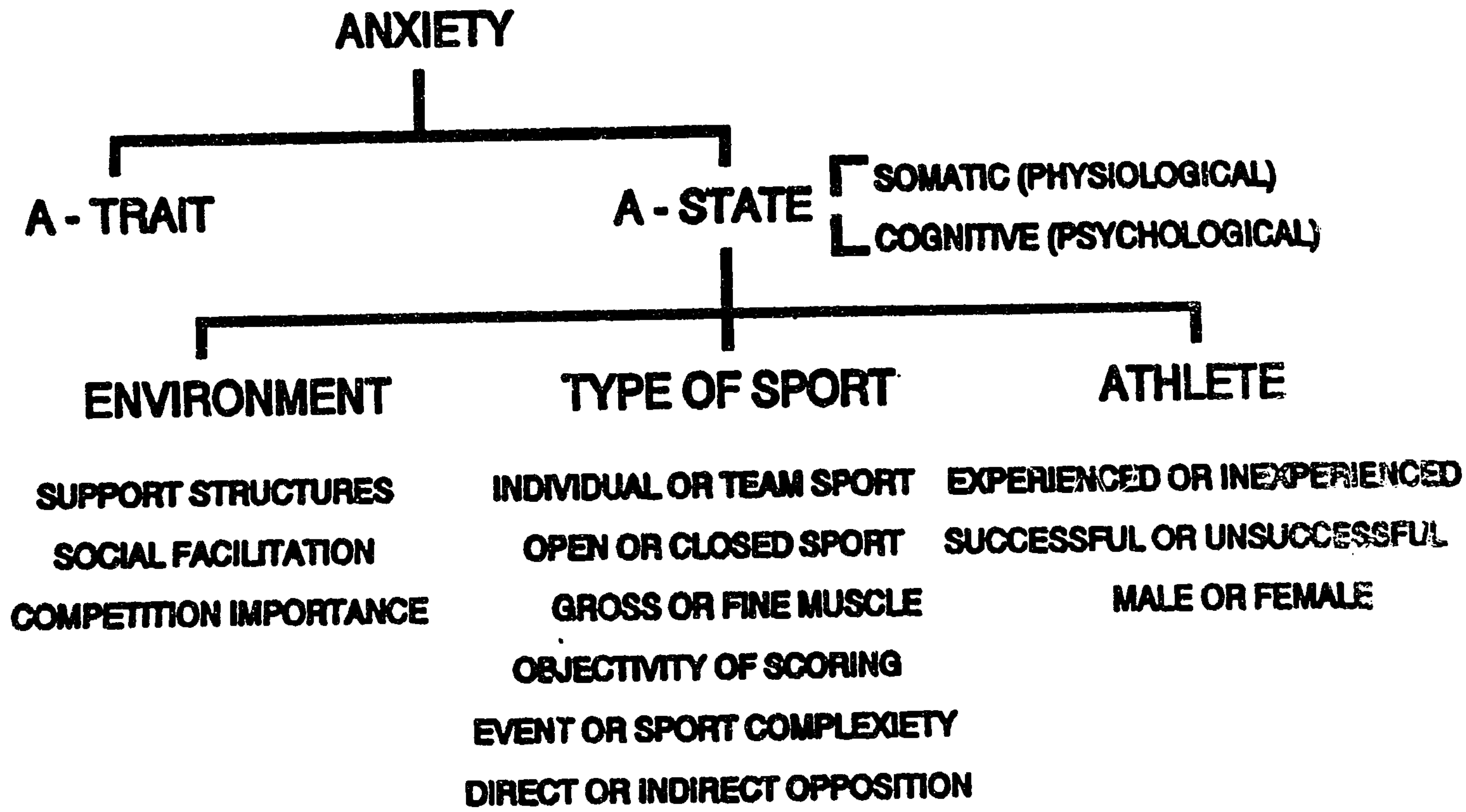
APPENDICES

APPENDIX A

ANXIETY A MULTIDIMENSIONAL CONSTRUCT

ANXIETY IN SPORT: A MULTI - DIMENSIONAL CONSTRUCT



(Marchant, 1991)

APPENDIX B

METHODOLOGICAL CONSIDERATIONS

Informed Consent Form

Title: An Investigation of Rifle Shooting Accuracy Using Psychological and Psychophysiological Measures of Arousal and Relaxation Training.

Investigators: Daryl Marchant 437-6147
Rick Alderman 492-3839

Purpose: The purpose of this study is twofold: First to investigate arousal levels Junior shooters both in practise and competition over a six week period. Second to teach the subjects a relaxation and breathing technique to reduce arousal levels over a two week period. Heart Rate monitors will be fitted to the subjects prior to five practise and five competition sessions. Subjects will also fill out the Competitive State Anxiety Inventory-2 approximately 30 min before all shooting in both practise and competition. Subjects will also fill out the Post Shooting-1 Questionnaire on one occasion and a Relaxation Evaluation Form on one occasion. Total time will is estimated to be 3 hours on competition days, 2 hours and 30 minutes on practise days and 20 min a day throughout the two week relaxation training phase. The identity of the subjects will be kept confidential by assigning a number to each subject.

* If you do not understand the procedures, please ask the investigator immediately.*

* If at any time you want to withdraw from the study, you may do so without any consequences.*

I, the subject understand the above information and give consent to participate in this study. I acknowledge that I received a copy of the signed consent form.

Name	Date
Guardian	Date
Investigator	Witness

SCORE SHEET RECORDING OF DATA

NAME: ______________________________

DATE: ______________ RELAY: __________ POSITION: ______________

EVENT: ______________________________

NO	TIME	H/R	SCORE	NO	TIME	H/R	SCORE
1				17			
2				18			
3				19			
4				20			
5				21			
6				22			
7				23			
8				24			
9				25			
10				26			
11				27			
12				28			
13				29			
14				30			
15				31			
16				32			

Table XXIV.

<u>Subject One - Data Collection Schedule</u>

						Relay				
Event	Day	Date	Prone 1	Prone 2	Prone 3	Prone 4	Stand 1	Stand 2	Kneel 1	Kneel 2
Provincial Senior	Day 1	15/6/91	yes	yes	yes	yes	yes	-	yes	-
Provincial Senior	Day 2	16/6/91	*	yes	yes	yes	yes	-	yes	-
National Senior	Day 1	30/6/91	yes	yes	yes	*	yes	-	yes	-
National Senior	Day 2	1/7/91	yes	yes	yes	yes	yes	-	yes	-
Practice	Day 1	12/6/91	yes	-	-	-	yes	yes	yes	yes
Practice	Day 2	22/6/91	yes	yes	-	-	yes	yes	-	-
Practice	Day 3	27/6/91	yes	-	-	-	*	-	yes	-
Practice	Day 4	7/9/91	yes	yes	yes	yes	-	-	-	-

Table XXV.

Subject Two - Data Collection Schedule

Event	Day	Date	Prone 1	Prone 2	Prone 3	Relay Prone 4	Stand 1	Stand 2	Kneel 1	Kneel 2
Provincial Junior	Day 1	1/6/91	yes	yes	yes	yes	yes	-	yes	-
Provincial Senior	Day 1	15/6/91	yes	yes	yes	yes	yes	-	yes	-
Provincial Senior	Day 2	16/6/91	*	yes	yes	yes	*	-	*	-
Practice	Day 1	20/6/91	yes	yes	-	-	yes	-	*	-

Table XXV1

Subject Three - Data Collection Schedule

							Relay			
Event	Day	Date	Prone 1	Prone 2	Prone 3	Prone 4	Stand 1	Stand 2	Kneel 1	Kneel 2
Provincial Junior	Day 1	1/6/91	*	*	*	yes	yes	-	yes	-
Provincial Senior	Day 1	15/6/91	yes	yes	yes	yes	yes	-	yes	-
Provincial Senior	Day 2	16/6/91	yes	yes	yes	yes	yes	-	yes	-
Practice	Day 1	12/6/91	yes	-	-	-	yes	-	-	-
Practice	Day 2	20/6/91	yes	yes	-	-	yes	-	yes	-

HEART	SCORE	TIME	DIST	COMPET	EVENT	DAY	POSITION	RELAY	PERSON	INT
87.20	0.00	124300	14.00	4.00	1.00	1.00	1.00	1.00	2.00	5.00
83.00	.	124540	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
80.00	.	124840	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
81.00	.	125140	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
81.00	.	125400	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
83.00	.	125740	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
82.00	.	126000	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
78.05	0.00	126280	21.00	4.00	1.00	1.00	1.00	1.00	2.00	5.00
77.00	.	126340	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
76.00	.	126640	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
74.00	.	126940	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
80.00	.	127240	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
83.00	.	127500	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
87.00	.	127840	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
82.00	.	128100	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
78.00	.	128440	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
88.00	.	128740	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
88.00	.	129000	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
81.00	.	129340	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
78.00		[illegible]	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
78.00	.	129940	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
77.80	0.50	130000	15.00	4.00	1.00	1.00	1.00	1.00	2.00	5.00
76.00	.	130240	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
80.00	.	130540	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
80.00	.	130840	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
84.00	.	131100	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
111.00	.	131440	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
121.00	.	131740	.	4.00	1.00	1.00	1.00	1.00	2.00	5.00
87.00	.	43840.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
93.00	.	44140.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
90.00	.	44440.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
81.00	.	44700.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
93.00	.	45040.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
93.00	.	45340.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
78.00	.	45640.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
.	.	45760.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
76.00	.	45940.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
70.00	.	46200.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
76.00	.	46540.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
77.00	.	46800.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
80.00	.	47140.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
84.00	.	47440.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
84.00	.	47740.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
86.00	.	48040.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
83.00	.	48300.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
90.00	.	48640.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
81.00	.	48940.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
80.00	.	49240.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
82.40	.	49540.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
.	.	46720.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00
82.00	.	49800.0	.	1.00	1.00	2.00	1.00	1.00	3.00	5.00

PERSON: 1.00 POSITION: 3.00 RELAY: 2.00 COMPET: 2.00 DAY: 2.00

\- P L O T -

Data Information

330 unweighted cases accepted.

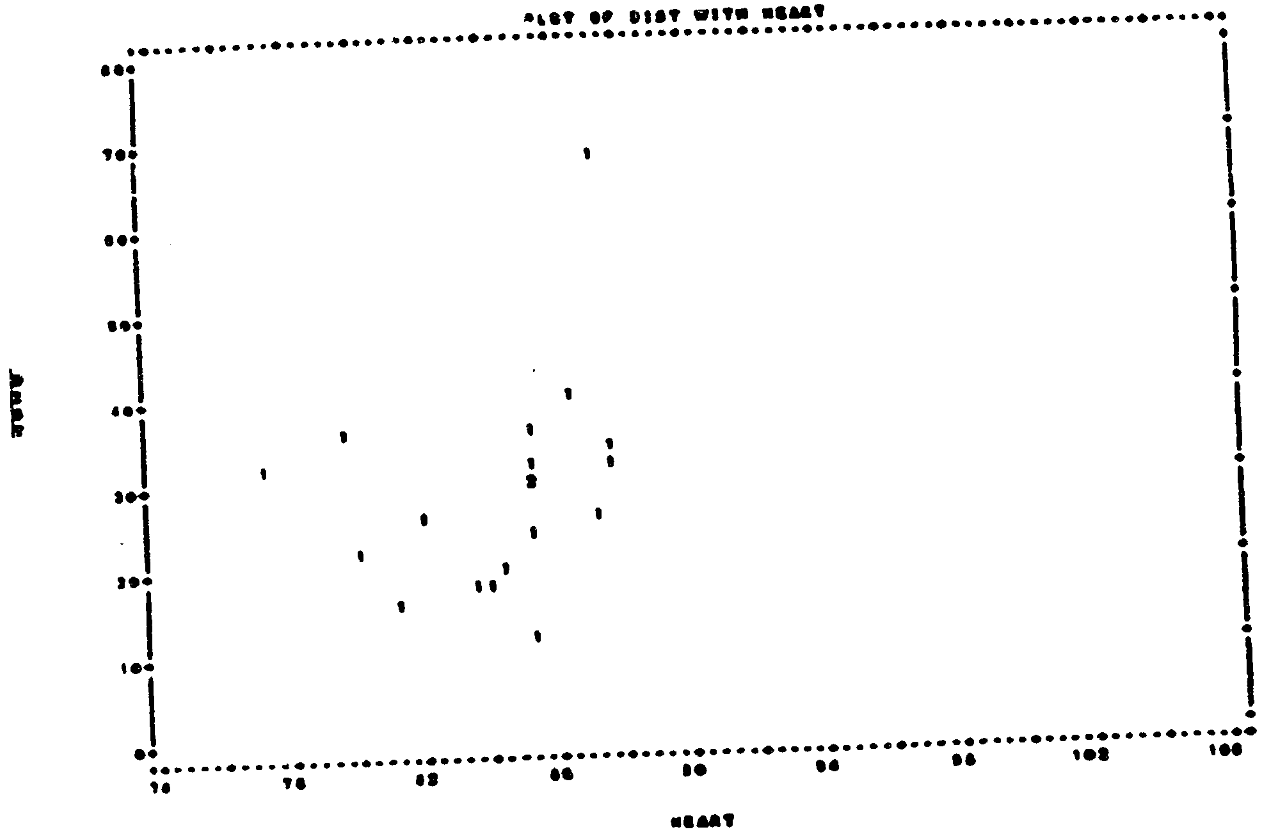
Size of the plots

Horizontal size is 80
Vertical size is 40

Frequencies and symbols used (not applicable for control or overlay plots)

1 - 1	11 - B	21 - L	31 - V
2 - 2	12 - C	22 - M	32 - W
3 - 3	13 - D	23 - N	33 - X
4 - 4	14 - E	24 - O	34 - Y
5 - 5	15 - F	25 - P	35 - Z
6 - 6	16 - G	26 - Q	36 - *
7 - 7	17 - H	27 - R	
8 - 8	18 - I	28 - S	
9 - 9	19 - J	29 - T	
10 - A	20 - K	30 - U	

PLOT OF DIST WITH HEART



20 cases plotted.

APPENDIX C

TUKEY (WSD) TABLES

Table XXV11

Tukey Multiple Comparison Test: Subject One, Distance x Competition

Competition		Practice	Provincial Senior	National
		Prone		
Practice	Req Diff	-	3.65	3.65
	Obs Diff		0.37	0.08
Provincial Senior	Req Diff	-	-	3.34
	Obs Diff			0.45
National	Req Diff	-	-	-
	Obs Diff			
		Standing		
Practice	Req Diff	-	5.05	5.05
	Obs Diff		1.30	2.40
Provincial Senior	Req Diff	-	-	6.26
	Obs Diff			3.70
National	Req Diff	-	-	-
	Obs Diff			
		Kneeling		
Practice	Req Diff	-	6.73	5.71
	Obs Diff		0.80	1.62
Provincial Senior	Req Diff	-	-	7.14
	Obs Diff			0.82
National	Req Diff	-	-	-
	Obs Diff			

* < .05 level

Table XXV111

Tukey Multiple Comparison Test: Subject One, Heart Rate x Competition

Competition		Practice	Provincial Senior	National
		Prone		
Practice	Req Diff	-	3.19	2.85
	Obs Diff		4.66*	2.29
Provincial Senior	Req Diff	-	-	2.61
	Obs Diff			2.37
National	Req Diff	-	-	-
	Obs Diff			
		Standing		
Practice	Req Diff	-	4.62	4.40
	Obs Diff		5.47*	3.67
Provincial Senior	Req Diff	-	-	4.88
	Obs Diff			1.80
National	Req Diff	-	-	-
	Obs Diff			
		Kneeling		
Practice	Req Diff	-	6.41	4.15
	Obs Diff		10.68*	0.69
Provincial Senior	Req Diff	-	-	6.73
	Obs Diff			9.99
National	Req Diff	-	-	-
	Obs Diff			

* < .05 level

Table XX1X

Tukey Multiple Comparison Test: Subject Two, Distance x Competition

Competition		Practice	Provincial Junior	Provincial Senior
		Prone		
Practice	Req Diff Obs Diff	-	5.55 0.82	5.67 1.31
Provincial Junior	Req Diff Obs Diff	-	-	4.21 0.49
Provincial Senior	Req Diff Obs Diff	-	-	-
		Standing		
Practice	Req Diff Obs Diff	-	9.07 5.95	9.73 6.55
Provincial Junior	Req Diff Obs Diff	-	-	9.07 0.60
Provincial Senior	Req Diff Obs Diff	-	-	-
		Kneeling		
Practice	Req Diff Obs Diff	-	10.13 6.60	9.73 0.45
Provincial Junior	Req Diff Obs Diff	-	-	10.63 7.05
Provincial Senior	Req Diff Obs Diff	-	-	-

* < .05 level

Table XXX

Tukey Multiple Comparison Test: Subject Two, Heart Rate x Competition

Competition		Practice	Provincial Junior	Provincial Senior
		Prone		
Practice	Req Diff	-	3.89	3.09
	Obs Diff		7.64*	3.26*
Provincial Junior	Req Diff	-	-	2.68
	Obs Diff			4.37*
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Standing		
Practice	Req Diff	-	6.35	6.18
	Obs Diff		29.57*	19.71*
Provincial Junior	Req Diff	-	-	5.53
	Obs Diff			9.86*
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Kneeling		
Practice	Req Diff	-	6.48	5.53
	Obs Diff		16.00*	9.88*
Provincial Junior	Req Diff	-	-	6.35
	Obs Diff			6.12
Provincial Senior	Req Diff	-	-	-
	Obs Diff			

* < .05 level

Table XXXI

Tukey Multiple Comparison Test: Subject Three, Distance x Competition

Competition		Practice	Provincial Junior	Provincial Senior
		Prone		
Practice	Req Diff	-	8.35	4.90
	Obs Diff		0.73	1.93
Provincial Junior	Req Diff	-	-	8.24
	Obs Diff			2.67
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Standing		
Practice	Req Diff	-	8.85	7.23
	Obs Diff		3.90	1.42
Provincial Junior	Req Diff	-	-	9.51
	Obs Diff			5.32
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Kneeling		
Practice	Req Diff	-	11.99	10.17
	Obs Diff		5.60	5.42
Provincial Junior	Req Diff	-	-	8.85
	Obs Diff			0.17
Provincial Senior	Req Diff	-	-	-
	Obs Diff			

* < .05 level

Table XXX11

Tukey Multiple Comparison Test: Subject Three, Heart Rate x Competition

Competition		Practice	Provincial Junior	Provincial Senior
		Prone		
Practice	Req Diff	-	5.56	2.94
	Obs Diff		12.68*	4.96*
Provincial Junior	Req Diff	-	-	5.15
	Obs Diff			7.72*
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Standing		
Practice	Req Diff	-	6.50	5.18
	Obs Diff		31.80*	16.93*
Provincial Junior	Req Diff	-	-	5.71
	Obs Diff			14.87*
Provincial Senior	Req Diff	-	-	-
	Obs Diff			
		Kneeling		
Practice	Req Diff	-	6.87	5.32
	Obs Diff		8.16*	1.01
Provincial Junior	Req Diff	-	-	6.11
	Obs Diff			9.17*
Provincial Senior	Req Diff	-	-	-
	Obs Diff			

* < .05 level

APPENDIX D

CORRELATION COEFFICIENT'S TABLES

Table XXX111

Competition Correlation Coefficients: Subject One

Relay Number	Relay 1	Relay 2	Relay 3	Relay 4	Relay 5	Relay 6
		National Senior Championship Day 1				
Position	P	P	P		S	K
Distance-Heart	.48*	.121	.369		.285	.11
Time-Heart	-.054	-.382**	-.192**		.331**	-.53**
Time-Distance	-.26	-.365	-.06		-.173	-.04
Score	14.30	12.50	11.60		22.60	20.95
		National Senior Championship Day 2				
Position	P	S	K	P	P	P
Distance-Heart	-.045	.257	.475*	-.217	.021	-.071
Time-Heart	-.549**	-.309**	-.241**	-.572**	-.302**	-.34**
Time-Distance	.363	-.176	.386	.164	-.048	-.277
Score	11.45	28.65	22.60	10.35	12.85	10.15
		Provincial Senior Championship Day 1				
Position	P	P	P	P	S	K
Distance-Heart	.105	.324	-.266	.306	-.381	.317
Time-Heart	-.585**	-.233**	.058	.047	-.34**	-.54**
Time-Distance	-.067	-.499*	-.408	-.068	.094	-.034
Score	13.25	14.05	13.30	8.50	25.90	20.95
		Provincial Senior Championship Day 2				
Position		S	K	P	P	P
Distance-Heart		.256	-.185	.164	.202	.166
Time-Heart		-.343**	-.345**	.275**	-.498**	-.056
Time-Distance		-.32	.02	.087	-.296	-.256
Score		31.42	21.50	11.30	14.65	11.05

* < 0.05 level
** < 0.01 level

Table XXX1V

Practice Correlation Coefficient: Subject One

	Relay 1	Relay 2	Relay 3	Relay 4	Relay 5
			Practice Day 1		
Position	S	S	K	K	P
Distance-Heart	-.186	.552*	-.045	.385	.505*
Time-Heart	-.123	-.096	-.345	.003	-.143
Time-Distance	-.37	-.61**	-.02	.551*	-.08
Score	26.90	27.90	25.70	17.05	14.05
			Practice Day 2		
Position	P	P	S	S	
Distance-Heart	-.021	-.102	-.082	-.317	
Time-Heart	-.595**	-.58**	-.34**	-.422**	
Time-Distance	.125	.339	.047	.33	
Score	11.45	11.70	28.60	28.40	
			Practice Day 3		
Position	P		K		
Distance-Heart	-.67**		-.229		
Time-Heart	-.548**		-.069		
Time-Distance	.132		.003		
Score	10.65		17.80		
			Practice Day 4		
Position	P		P	P	P
Distance-Heart	-.09		-.03	-.26	-.32
Time-Heart	.20		-.66**	-.55**	.11
Time-Distance	-.15*		.52**	.12	.19
Score	13.75		14.20	15.95	15.75

* < 0.05 level
** < 0.01 level

Table XXXV

Correlation Coefficients: Subject Two

	Relay 1	Relay 2	Relay 3	Relay 4	Relay 5	Relay 6
	Provincial Senior Championship Day 1					
Position	P	P	P	P	S	K
Distance-Heart	-.02	.12	.34	-.14	-.15	.01
Time-Heart	.42**	.16**	.16**	.35**	.39**	.24**
Time-Distance	.01	.33	.03	.33	-.09	.09
Score	15.35	15.20	15.55	17.30	30.00	15.25
	Provincial Senior Championship Day 2					
	P			P	P	P
Distance-Heart	.277			-.075	-.222	.444*
Time-Heart	.455**			-.201**	.209**	.079
Time-Distance	.532*			.126	-.007	.115
Score	11.60			19.70	13.55	16.95
	Provincial Junior Championship					
	P	P	P	P	S	K
Distance-Heart	.409	.148	.21	.001	-.113	.063
Time-Heart	-.229**	.343**	.446**	.106	.349**	.15*
Time-Distance	-.025	.012	.364	-.087	.225	.269
Score	17.95	16.05	13.95	16.65	29.40	22.30
	Practice Day 1					
	P	P	K	S		
Distance-Heart	-.06	-.10	.05	-.13		
Time-Heart	-.19**	.21**	.21**	.17*		
Time-Distance	.04	-.13	-.22	-.14		
Score	17.30	16.65	15.70	23.45		

* < 0.05 level
** < 0.01 level

Figure XXXV1

Competition Correlation Coefficients: Subject Three

	Relay 1	Relay 2	Relay 3	Relay 4	Relay 5	Relay 6
	Provincial Senior Championship Day 1					
Position	P	P	P	P	S	K
Distance-Heart	-.205	.357	-.343	-.203	.043	-.141
Time-Heart	.203**	.24**	-.472**	.67**	.567**	.40**
Time-Distance	.147	.213	.333	-.064	.466*	.094
Score	24.40	16.60	30.50	24.30	30.15	24.45
	Provincial Senior Championship Day 2					
Position	P	S	K	P	P	P
Distance-Heart	-.222	-.09	.18	-.01	-.48*	-.39
Time-Heart	.629**	.353**	.411**	.05	.276**	.58**
Time-Distance	-.13	-.031	-.074	.26	-.503*	-.115
Score	24.40	26.30	18.40	14.40	19.15	11.55
	Provincial Junior Championship					
Position				P	S	K
Distance-Heart				-.333	.06	-.51*
Time-Heart				.386**	.504**	.24**
Time-Distance				-.246	.438	.259
Score				17.10	22.90	21.60

* < 0.05 level
** < 0.01 level

Table XXXVll

Practice Correlation Coefficients: Subject Three

Practice Day 1

Position	P	S
Distance-Heart	-.339	-.111
Time-Heart	-.25**	.178*
Time-Distance	-.03	.108
Score	21.45	26.60

Practice Day 2

Position	P	P	K	S
Distance-Heart	.028	.231	.165	-.092
Time-Heart	.117	.421**	.441**	-.25**
Time-Distance	-.064	.316	.369	-.099
Score	16.35	15.70	16.00	27.00

* < 0.05 level
** < 0.01 level

APPENDIX E

COMPETITIVE STATE ANXIETY INVENTORY-2

The Competitive State Anxiety Inventory-2 (CSAI-2) was utilized to identify each subject's pre-competitive state anxiety. Copyright permission was not obtained.

Martens, Burton, Vealey, Bump & Smith (1983). Competitive State Anxiety Inventory-2. Symposium conducted at the meeting of the North American Society for Psychology of Sport and Physical Activity (NASPSPA), College Park, MD.

APPENDIX F

POST SHOOTING-1 QUESTIONNAIRE

The Post-Shooting-1 Questionnaire was used to identify the level of physiological awareness of each shooter. Copyright permission was not obtained.

Daniels, F.S., and Landers, D.M. (1982).

POST SHOOTING-1 QUESTIONNAIRE RESPONSES

Question 1

Subject 1 - "I'm not sure, For my matches I get aroused, nervous and the main thing I need to do is control my emotions at (for) trigger release time.

Subject 2 - " Yes I can't explain"

Subject 3 - "Yes, I can feel my limbs, I know where they are while I'm shooting".

Question 2

Subject 1 - "A good shot usually reduces nerves, a bad shot (or poor score for a shot) usually creates anxiety - increased heart beat especially if I have a good score (or target) going.

Subject 2 - "Yes, when shoot a good shot, I feel relaxed and a after a bad shot, I feel tense".

Subject 3 - Yes, when I have a bad shot my heart beats faster".

Question 3

Subject 1 - "After good shots, recognition by my peers, after bad shots, a) sometimes bad shots settles nervousness, b) why did I have to do that, c) whoops, now I need to shoot the rest good to get a good score".

Subject 2 - "After a good shot I think just do everything the same, after a bad shot I think now I have to shoot a ten and correct my problem".

Subject 3 - After a good shot I feel good and you can do it again, after a bad shot, you feel nervous shooting the next shot".

Question 4

Subject 1 - "No, except in ISU prone (match rifle event) you can see your pulse rate on your sight picture as the barrel moves up and down".

Subject 2 - "Sometimes I can, but not all the time".

Subject 3 - "Yes, when your (my) heart goes faster, I shake a lot more, sometimes you can feel your (my) pulse on my cheek.