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A psychophysiological examination of the emotions-performance relationship

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DECLARATION

I declare that this thesis is my own composition, and that the material contained in it describes my own work. It has not been submitted for any other degree or professional qualification. All quotations have been distinguished by quotation marks and the sources of information acknowledged.

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I would like to thank Professor Lew Hardy for giving me the opportunity to carry out this work. I would like to thank Dr. Andy Cooke for his positive attitude, prompt help when needed, and valuable insights on research. I would like to thank Dr. Rich Neil for helping me negotiate through some challenging statistical analyses in the few times I felt a bit lost. I would like to thank Dr. Rob Udewitz for making the fencing study possible.

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Author note

Purpose of the Research Project

The purpose of this research project was to examine the relationship between anger and performance within the context of physical activity of gross and fine motor skill tasks and to investigate the moderating role of state-hope and self-efficacy within this relationship. More specifically, this research project examined: (a) state-anger and performance of middle distance running; (b) state-anger and rifle shooting performance; (c) state-hope and self-efficacy's moderating role in the anger-performance relationship; (d) the influence of state-anger on fencers' precision, reaction-time, and peak muscle activity in a laboratory-based experiment.

Structure of the Thesis

This thesis is written as a collection of research papers. It is the policy of the School of Sport, Health, and Exercise Sciences to submit doctoral theses in this fashion.

Chapter 1 of the thesis is a review of the literature in the area of anger in general, and in the context of sport performance more specifically. This chapter provides operational definitions of the main concepts of interest in this thesis. Also, the chapter provides a detailed and critical overview of the research conducted to date. The chapter critically appraises proposed theories and models in the area. Finally, applied implications for best practice and future directions for the research are proposed.

Chapter 2 reports on three cross-sectional studies: state-anger and 2000m running performance and state-anger and shooting performance; state-hope was investigated as a moderating variable in these relationships. State-anger and shooting performance, where self-efficacy was included as a moderator in this relationship.

Chapter 3 reports on an innovative, laboratory-based, single-case research experiment on the effect of state-anger on fencing performance. This experiment included measures of precision, reaction-time, and peak muscle contraction.

Chapter 4 provides a summary and discussion of the thesis findings. In particular, this chapter discusses the implications of these findings from an applied and theoretical perspective. Finally, future directions are offered in the area of anger in competitive sport.

Abstract

As anger is one of the most commonly experienced emotions in sport competition, this research project aimed to explore the effect of anger on physical activities of gross and fine muscular skill tasks, and to test the moderating roll of state-hope and self-efficacy in these relationships. Following Lazarus's (1991, 2000a) framework, we examined the positive and negative impact that anger may have on a gross motor 2000m run task, and fine motor rifle-shooting and fencing tasks, in intermediate and highly trained performers. We proposed that anger would benefit the performance of a gross motor skill task regardless of the level of hope. We also hypothesised that, on the fine motor skill task, anger would have a negative effect on performance, but that this negative effect would be attenuated by hope/self-efficacy. We conducted three studies, Study 1 revealed that anger was associated with enhanced gross muscular performance, in addition anger was positively associated with better fine motor task performance. The results for the moderating effect of hope partially supported our hypothesis, the positive effect of state-anger was not moderated by state-hope in the gross motor skill performances as expected. Contrary to our hypothesis, state-hope did not attune the relationship between state-anger and the fine motor skill performance. No significant association between state-anger and shooting task performance was revealed in Study 2, furthermore, we did not identify any moderating influence of self-efficacy in the anger-performance relationship. In study 3 we conducted a novel, laboratory-based, single-case research experiment in order to test athletes' fine motor task performance (i.e., a fencing flèche attack) under two emotional states: anger and neutral. As hypothesized, state-anger had a positive effect on response-time, and a negative effect on precision. In addition, state-anger was positively associated with greater muscle activity during a fencing attack. Results are discussed and future research directions are offered.

Contents

Table of Figures

Chapter 1

"'Anger is an energy', was an open statement, saying,
'Don't view anger negatively, don't deny it – use it to be creative.'"

- *John Lydon (Sex Pistols)*

Emotions and performance

Emotions have long been recognized as taking a central role in eliciting changes in human's cognition, behaviour and physiology (Christie & Friedman, 2004; Lazarus, 1991; Lench, Flores, & Bench, 2011; Sinha, Lovallo, & Parsons, 1992; Stemmler, 2004). It is only natural that much of the scientific literature in sport psychology consists of efforts to illuminate the influence of emotions on performance outcome (Crocker, Kowalski, Graham, & Kowalski, 2002; Gould et al., 2000; Hardy, 1990; Lazarus, 2000a; Pensgaard & Duda, 2003; Uphill & Jones, 2007). These efforts include cross-sectional field studies (Robazza & Bortoli, 2007), qualitative studies (Martinent, Campo, & Ferrand, 2012; Neil, Hanton, & Mellalieu, 2013), and laboratory-based experiments (Davis, Woodman, & Callow, 2010; Woodman et al., 2009) across different sports, including bowling (Mesagno, Marchant, & Morris, 2008), table tennis (Martinent et al., 2012), and rugby (Robazza & Bortoli, 2007), and across all skill levels (Gould et al., 2000; Martinent et al., 2012; Pensgaard & Duda, 2003; Ruiz & Hanin, 2011).

Operational definition of emotion

Any attempt to enhance our understanding of the emotion-performance relationship must first overcome the challenge of accurately defining *emotion*. Constructs such as mood, affect, temperament, emotion, and state have been used by researchers interchangeably in order to describe different affective phenomena (Crocker et al., 2002). Because the concept of emotion is ambiguous, there is a lack of clarity as to what are discrete emotions and non-emotions (Hanin, 2007). The identification and classification of emotion has been the subject of extensive academic debate. Specifically, conflicting theoretical approaches have debated whether the experience of emotion can be categorized into discrete "basic" emotions (Ekman, 1992), where each discrete emotion elicits unique cognitive, behavioural and physiological changes, or whether emotions occur in relation to two underpinning dimensions reflecting activation (i.e., activation/deactivation) and pleasantness (i.e., pleasant/unpleasant; Posner, Russell, & Peterson, 2005).

Moreover, due to the complex nature of the experience of emotions, multiple theories have been presented in an attempt to elucidate the origin of emotion (Cabanac, 2002; Fridja, 2000). For example, multiple frameworks posit that emotions occur independently of cognition (Berkowitz & Harmon-Jones, 2004; Zajonc, 1984). The James-Lange Theory (Cannon, 1927; James, 1890) was one of the earliest theories to suggest that physiological arousal initiates the process of emotional experience, in other words, one's subjective feeling of physiological changes is consciously perceived as an emotion and followed by a reaction. For instance, instead of "I see a bear, I fear it, my heart begins to race" it is "I see a bear, my heart begins to race, so I fear the bear".

Later theories challenged the notion that physiological changes precede emotions, for example the Cannon-Bard theory (Bard, 1934) postulated that physiological changes follow emotions. Accordingly, emotional feeling results from stimulations of the dorsal thalamus and physiological changes and subjective feeling of an emotion in response to a stimulus are separate and independent; physiological arousal does not have to occur before the emotion. Other theories, such as the two factor theory of emotion (S. Schachter & Singer, 1962) argued that cognition are involved in the experience of emotions, and are used to interpret the meaning of physiological reactions to outside events. For example, the increased arousal experienced while crossing a tall bridge may be interpreted as fear of heights, or alternatively as affection if done with a partner on a first date.

Discrete emotions theories suggest the existence of basic emotions, such as anger and fear, defined as biologically programmed adaptive responses, characterized by prototypical facial expressions, physical reactions and action tendencies, to specific eliciting situation (Ekman, 1992, 1994, 1999, 2004). According to this perspective, emotions are relatively of short duration and include multicomponent response tendencies. For example, an emotion begins with a conscious or unconscious assessment of the personal meaning of some antecedent event, which triggers a number of response tendencies such as subjective experience, facial expression, cognitive processing, and physiological changes.

Instead, Ortony and Turner (1990) in their attempt to classify the basic emotions argued that a satisfactory criterion of basic emotion does not exist. They claim that there are some basic classes of appraisals, such as for example, the perception of an intentional or unintentional insult by others. These are associated with response patterns, such as responding or ignoring, and such responses occur in physiological, cognitive, phenomenal, and behavioural complexes. In other words, a cluster of such components constitutes an emotion, rather than a single constituent of them.

A number of models of emotion have suggested that cognitive processes such as attributions (Weiner, 1985), goal orientations (Carver, 2004; Carver & Harmon-Jones, 2009; Carver & Scheier, 1990), and appraisals (Lazarus, 1982, 1991, 2000a) are central to the experience of emotion. These appraisal theories explain how and why specific emotions emerge and why not everyone will have the same emotional response to any given situation. For example, anger is elicited when an individual evaluates that an important goal has been obstructed (e.g., the goalkeeper saving the penalty kick may be considered as an obstructed goal by most football players). However, goal obstruction is the basis for many emotions and not unique to anger. Anger is experienced because one believes that an agent (e.g., in the case of our prior example, the goalkeeper) has intentionally obstructed this important goal.

Each emotion theory assumes a specific perspective, which may have specific advantages and disadvantages for guiding research and practical application. The recent acknowledgment that no emotion can be perfectly explained has shifted the focus from finding the perfect definition of emotion to discussing dimensions, categories, and components of emotion (Vallerand & Blanchard, 2000). These dimensions could aid in distinguishing emotion using its defining characteristics, antecedents, and consequences (Crocker et al., 2002). Consequently, a constructive operational definition may address emotion as a system with certain observable elements that function as a set of organized psychophysiological reactions across ongoing person-environment relationships (Lazarus, 1991, 2000a; Lench et al., 2011; Mandler, 1975). That is to say, emotion is an evolutionarily adaptive response to the environment that involves cognitive, physiological, and behavioural reactions such as changes in attentional focus, muscles tension, and approach/withdrawal behaviour.

Anger and performance

Of the many emotions, studies show that it is particularly anger that is frequently experienced and expressed by athletes in particular during competitions (Gould et al., 2000; Martinent et al., 2012; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Uphill & Jones, 2007). For example, Pensgaard and Duda (2003) showed that, out of 61 Olympic-level athletes who participated in the Sydney 2000 Olympic games, 58 participants reported having experienced anger when competing (in comparison, anxiety was reported 57 times). In a study by Martinent et al. (2012), national-level table-tennis players reported anger as the most commonly experienced emotion during competition. Anger is a common product of competitive environments, such as an athletic competition, where opposing forces are locked together (Brunelle, Janelle, & Tennant, 1999) creating many anger evoking situations such as frustration, disrespect, threats to reputation, rule violation, and an overall sense of injustice (Potegal & Stemmler, 2010).

Although the definition of emotion remains somewhat vague (Vallerand & Blanchard, 2000), *anger* is widely considered a basic emotion (Ortony & Turner, 1990; Potegal & Stemmler, 2010), partly because it is similarly expressed in all cultures and has specific physiological responses such as elevated heart rate and skin temperature (Ekman, 1992, 1994, 1999). Anger has played a powerful role in human affairs since the beginning of recorded history (Michael & Novaco, 2010). In fact, choleric temperament was acknowledged by ancient Greek thinkers around 400 BC and was included as one of the four humours (i.e., yellow bile) of Hippocratic medicine. Anger is a force present in stories, myths, religious narratives and moral rule, and it is fundamentally linked to our representations of personal and societal order and disorder. As an emotion, anger consists of distinct characteristics that include peripheral physiological responses (e.g., elevated heart rate) and brain activation, physical sensations (e.g., irritation), subjective feelings and experience, cognitions (e.g., determination), and action tendencies (e.g., physical assault; Carver & Harmon-Jones, 2009; Harmon-Jones, 2003; Harmon-Jones, Peterson, & Harmon-Jones, 2010; Litvak, Lerner, Tiedens, & Shonk, 2010; Potegal & Stemmler, 2010; Stemmler, 2010). In many languages, the subjective physical sensations and subjective feelings associated with anger are illustrated as a hot liquid under pressure (Kovecses, 2010). There are similarities between these linguistic metaphors and the distinctive autonomic physiology of anger that involves increased blood pressure, total peripheral resistance, and facial warming (Stemmler, 2010).

As early as two months of age, anger’s evolutionarily derived action tendency and problem-solving response can already be observed within a human subject (Lewis, 2010). Most authors agree that anger ranges along a dimension of intensity (Potegal & Stemmler, 2010) from mild frustration and annoyance (i.e., “sub-anger”) to rage, which could lead to aggression. At a theoretical level, however, anger is different from aggression, because anger has more complex social and cognitive antecedents and functions than aggression (Tavris, 1989). Aggression is not typically the dominant response to human anger. For example, nonaggressive anger-derived behaviours include cognitive reappraisal, tension-reduction, and communication (Averill, 1982; Van Coillie, Van Mechelen, & Ceulemans, 2006). Therefore, anger without overt aggression is the norm in many situations (Hubbard, Romano, McAuliffe, & Morrow, 2010).

Anger is a neurobehavioral system that motivates individuals to protect themselves from feeling inferior, either physically or socially (Stemmler, 2010). Attack, either physical or verbal, is a common behaviour response when angry that demands a persistent muscular tension and requires a strong activation of sympathetic systems for its support. Under such conditions, the levels of diastolic blood pressure and vascular resistance increase in order to force blood into the muscles when the contractions have squeezed and reduced their vascular supply (Buell, Alpert, & McCrory, 1986).

Anger's somatovisceral reaction enables continued exertion of the muscles, sustained alertness, vigilance, and preparedness to react (Stemmler, Heldmann, Pauls, & Scherer, 2001). These coordinated changes help in the pursuit and achievement of the goal of anger, which is to regain physical or social sense of superiority (Stemmler, 2010). Anger involves an active approach and may increase alertness, strength, confidence, and determination (Harmon-Jones et al., 2010; Litvak et al., 2010). Research on anger shows that this emotion is often associated with attack and approach motivations (Harmon-Jones et al., 2010) and that anger may help people to feel stronger and more energized when dealing with the cause of their anger (Frijda, Kuipers, & ter Schure, 1989).

Electroencephalogram (EEG) and imaging studies have demonstrated that anger is associated with hemispheric asymmetry characterised by relatively greater left-frontal cortical activity. This frontal asymmetry pattern corresponds with approach motivation and positive affective processes (Coan & Allen, 2003; Davidson, Jackson, & Kalin, 2000). Anger may also be exhilarating when one is seeking revenge or punishment (Carlsmith, Wilson, & Gilbert, 2008). For example, participants who felt anger after an anger-induced manipulation reported feeling stronger and more active than the control condition participants (Harmon-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004).

The measurement of anger

The first attempts in the literature to assess anger included clinical interviews, behavioural observations and projective techniques (e.g., Rorschach Inkblots; Spielberger & Reheiser, 2010). The first self-report psychometric scales, such as the Buss-Durkee Hostility

Inventory (BDHI), were constructed in the 1950s to measure hostility (Buss & Durkee, 1957). In the early 1970s, researchers started to distinguish between anger and hostility, which was marked by the appearance in the psychological literature of three anger measures: The Reaction Inventory (RI; Evans & Stangeland, 1971), Anger Inventory (AI; Novaco, 1975), and Anger Self-Report (ASR; Zelin, Adler, & Myerson, 1972). However, a more coherent theoretical framework was required because the latter measures did not account for situational factors and personality traits, which might each confound angry reactions.

Consequently, the *State-Trait Anger Scale* (STAS; Spielberger, 1980) was constructed to measure the intensity of anger as an emotional state and individual differences in anger proneness as a personality trait. Spielberger also formulated definitions of state and trait anger. He defined state anger as a psychobiological state or condition consisting of subjective feelings that vary in intensity, from mild irritation or annoyance to intense fury and rage, with concomitant activation or arousal of the autonomic nervous system. He defined trait anger in terms of individual differences in the frequency that state anger was experienced over time.

As the research on anger has progressed, it has become important to also measure the characteristic ways in which people express and control their anger. Specifically, Lazarus (1991) observed that there must be high goal relevance, obstruction of a goal, and a threat to ego identity for anger to be experienced. A careful analysis of anger, hostility, and aggression indicated that anger was strongly associated with hostility and often motivated aggressive behaviour (Spielberger & Reheiser, 2010). Consequently, the State–Trait Anger Expression Inventory (STAXI-2; Spielberger, 1999), which includes scales that assess state and trait anger, anger expression, and anger control, was developed.

Physiological measures have also been investigated in numerous studies (Spielberger & Reheiser, 2010). For example, a meta-analysis of anger, based on 15 studies which reported anger and fear contrasts in at least two somatovisceral responses, Stemmler (2004) revealed that, compared to control, anger elicited greater increases in heart rate, skin conductance, and facial skin temperature.

Cognitive-motivational-relational theory

In the context of anger within athletic performance, Lazarus's (1991, 2000a) cognitive-motivational-relational (CMR) theory is especially useful in explaining the nature of emotion and its potential influence on performance. According to Lazarus (2000a, 2000b), emotion is conceptualized as a dynamic process that unfolds in accordance to environmental interactions. These interactions are appraised constantly, and a situation is given meaning that later exerts influence on the emotional experiences related to performance.

Prior to and during activity, individuals engage in a process of appraisals aimed at evaluating the risk and reward within a particular situation. Sport competition can be appraised in different ways: as a challenge, as a threat, and as a loss or harm (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004; M. Jones, Meijen, McCarthy, & Sheffield, 2009; Lazarus, 2000a; Skinner & Brewer, 2002). The weighing up of demands (e.g., danger, uncertainty, required effort) and resources (e.g., skills, knowledge, external support) allows athletes to appraise each competition as either a challenge or a threat (Blascovich et al., 2004).

Accordingly, athletes who appraise a competition as a threat (negatively) feel that they cannot deal with the demands of the competition (i.e., competition demands exceed athletes' resources). Alternatively, those who appraise it as a challenge (positively) feel that they are able to deal with the competition's demands (i.e., athletes' resources exceed competition demands). The dichotomy between threat and challenge appraisals concurs with the popular belief that some individuals will deal with the demands of competition and show a good performance, and others would not be able to deal with the pressure and show a bad performance.

These appraisals culminate in a *core relational theme* that summarizes the transaction between the individual and the environment (Lazarus, 1991, 2000a). Emotions arise from the core relational theme and are associated with an action tendency reflecting the evaluation of the situational stimulus in relation to the individual (Lazarus, 2000b). For example, anger's core relational theme is "a demeaning offense against me and mine" (Lazarus, 2000a, p. 234), which triggers "a powerful impulse to counterattack in order to get revenge for an affront or repair a wounded self-esteem" (Lazarus, 2000a, p. 243).

The positive and negative effects of anger on performance

Lazarus (2000a) posits that each specific emotion will differentially influence performance depending on the relationship between the athlete and the situation. For example, he proposes that the emotion of anger may be detrimental to performance if it draws resources away from the primary task at hand (Lazarus, 2000a). In anger there is a powerful impulse to counter attack that may be so strong that it is difficult to inhibit. For instance, increased anger may compromise a gymnastic routine because the performer is using extra energy in attempting to suppress his/her elevated anger, and not allow anger's action tendency negatively affect her fine muscular control. However, if the physical skill requires a "lashing out" motion as can be seen in combative or contact sports such as ice-hockey, American football, boxing and karate (Maxwell, 2004; Ruiz & Hanin, 2004a) performance may be facilitated due to its close association with anger's action tendency (Lazarus, 2000a). Due to the complex emotion-performance relationship illustrated above, Lazarus's (1991, 2000a, 2000b) CMR theory offers a potentially fruitful theoretical framework for investigating the influence of anger on performance.

Anger may be associated with both negative and positive outcomes. In a study by Ruiz and Hanin (2011) highly skilled karate athletes reported their anger experiences as facilitating their performance. The beneficial impact of anger was related to the production and generation of additional energy (Ruiz & Hanin, 2011). These athletes stated that anger had made them feel more alert, motivated, strong, and fast. When anger was perceived as detrimental to their performance, it was usually associated with a lack of energy, resources, or an inability to use those resources constructively (Ruiz & Hanin, 2011). This resulted in feelings such as fury, inferiority, and a lack of concentration and limited sensations.

Anger in and anger out

Recent research has explored individuals' attempts to regulate anger (Smits & De Boeck, 2007). This research has focused on the direction of one's anger; more specifically, *anger-in and anger-out* (Averill, 1982; Smits & De Boeck, 2007; Smits & Kuppens, 2005; Spielberger & Reheiser, 2003). The State-Anger Inventory (Spielberger, Jacobs, Russell, & Crane, 1983) comprises five "feeling angry" (anger-in) items, and five "feeling like expressing anger" (anger-out) items. Anger-in refers to the tendency to direct one's anger inward, toward the self and has been associated with attempts to suppress anger's action tendency (Smits & De Boeck, 2007; Smits, De Boeck, & Vansteelandt, 2004). Anger-out refers to the predisposition to convey one's anger outward, toward anger's agent, and corresponds with the release of anger's action tendency (Smits & Kuppens, 2005).

Consequently, some researchers suggest that, on a task that requires the execution of a lashing out motion, an action that is more closely aligned with anger's action tendency, anger-out should be associated with enhanced performance on the peak force task and anger-in should be associated with reduced performance (Davis et al., 2010; Robazza, Bertollo, & Bortoli, 2006). In a study by Davis et al. (2010) anger-out had a facilitative effect on a five-second gross motor peak-force kicking task. They found no relationship between anger-in and performance on the kicking task.

Given the activation of the sympathetic system that is associated with the action tendency for anger, anger may have a positive impact on performance when the physical skill involved requires a high-energy, physical motion of relatively short duration. In a study by Gould et al. (2000) with university level athletes from a variety of sports (i.e., cross-country, baseball, golf, lacrosse, football, softball, tennis, taekwondo, and volleyball), the only context in which anger was reported to be good for performance was in competition. Woodman et al. (2009) showed how anger may be beneficial to performance when the required skill closely mirrors anger's associated action tendency. Anger was induced within the participants via an imagery script, and the participants were then asked to perform (i.e., "as fast and as hard as you can") a gross muscular physical task that included extension of the right leg for five seconds against a Kin Com Muscle Testing adjustable dynamometer. In this study, participants produced greater physical force when "lashing out" under anger conditions than when acting under emotion-neutral conditions.

Moderating factors in the anger-performance relationship

In real-life situations, athletes usually report having experienced mixed emotions rather than a particular selected emotion. During a competitive event, an athlete can feel confident, determined, excited while also feeling uncertain and anxious (Gould & Tuffey, 1996; Hanin, 2000; G. Jones & Hanton, 2001). In predicting athletic performance and gaining a better understanding of the athlete's experience, researchers have begun to expand their interest in a wide range of emotions related to performance (Cerin, 2003; Cerin, Szabo, Hunt, & Williams, 2000; Gould, Greenleaf, & Krane, 2002; Hanin, 2007) and examined a variety of emotional states evident in the sports environment (Gould & Udry, 1994; Vallerand & Blanchard, 2000). For example, in a study by Hanin (2003) a junior international-level tennis player, prior to performing in his best-ever game, described feeling determined, confident, excited, dynamic, and comfortable while also feeling alarmed, moderately aggressive, and slightly uncertain. In another study by Hardy, Woodman, and Carrington (2004), the effect of somatic anxiety on performance (i.e., golf) was moderated by self-confidence. High levels of self-confidence allowed performers to tolerate increased bodily activation, leading to good performance. Conversely, under the similar bodily activation levels, poor performance outcome was associated with low levels of self-confidence. Thus, the effect of discrete emotions (e.g., anxiety, anger) should be studied in the context of other related emotions (Hanin, 2007).

Investigations have been limited in explaining why athletes' anger may be helpful or harmful (Pensgaard & Duda, 2003). In parallel with the study described above (see Hardy et al., 2004), anger may be facilitative as long as the individual's expectancies of being able to cope and achieve his or her goal remain positive. If athletes become hopeless and/or lacks confidence in their capability to reach their goal, then anger can be perceived as debilitative. Thus, interpretations of angry symptoms as facilitative or debilitative often depend on the performer's cognitive appraisal of being able to control their environment and themselves as well as to produce constructive ways in achieving their goals. For example, In a study by Robazza and Bortoli (2007), successful rugby players experienced anger as a useful emotion because the players felt confident in their ability to constructively control, and possibly channel, its energising effects towards their performance.

It could be predicted that perceived ability to handle anger successfully and exert control in a competitive situation would enable the symptoms of anger to be perceived as beneficial or advantageous to performance; conversely, low mastery expectancy would result in the perception of harm. This argument is consistent with the view of perceptions of emotion as a type of coping response (Folkman & Lazarus, 1988; Lazarus, 1991, 1999, 2000a, 2000b), and empirical findings showing that having greater control over one's self and environment has been associated with increasingly beneficial perceptions (G. Jones, Swain, & Hardy, 1993). Coping has to do with how one manages or regulates their emotions, for example by suppressing one's expression, reappraising what has happened in relation to its personal significance, or by changing the environmental or personality conditions that provoked it (Lazarus, 2000a).

As can be seen, anger may have both positive and negative effects on performance. Anger has been linked with better performance when the performer can see a constructive way forward and has a greater sense of control (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003; Robazza & Bortoli, 2007), both of which can also affect motivational intensity (Brehm & Self, 1989).

Hope theory

Snyder (2002) in his *Hope* theory argues that high-hope individuals have better *coping* (Lazarus, 1999) ability than low-hope individuals when in a situation that elicits an unpleasant and/or negative emotion. The regulative thought process and actions of high-hope people help to reduce any negative effects that an unpleasant emotion may have during the goal pursuit process. High-hope people have been found to be very good at finding new routes, particularly when facing difficulties (Irving, Snyder, & Crowson Jr, 1998; Snyder et al., 1996).

Self-efficacy theory

Similarly, the *self-efficacy* theory states that confidence in one's ability to conduct a given task or behaviour is strongly related to one's ability to perform that behaviour (Bandura, 1997). Self-efficacy, referring to the individual evaluation of the possibility of regulating a given behaviour or action, is dependent on the abilities and individual expectations of mastering specific actions. Self-efficacy also refers to conquering general barriers in an effort to change major or minor parts of a habitual lifestyle so as to achieve a desired goal (Bandura, 1986, 1997; Haney & Long, 1995). For example, Hanton, Mellalieu, and Hall (2004) showed that elite performers used mental skills strategies such as mental rehearsal, thought stopping and positive self-talk to manage confidence by protecting against debilitating interpretations of anxiety. Furthermore, in another study with elite and non-elite sport performers, Mellalieu, Neil, and Hanton (2006) showed that, among the elite performers, self-confidence acted as a moderator in the relationship between worry symptoms (i.e., cognitive anxiety) and directional interpretations (i.e., facilitative or debilitative). The higher the levels of self-confidence, the more facilitative the interpretation became.

Self-efficacy could also be hypothesised to moderate the interpretation of competitive anger symptoms, where high confidence should protect against debilitative interpretations. Therefore, it is important to study self-efficacy, both as a cause and an effect in relation to the individual's perceived ability to handle anger and exert control in a competitive situation, an ability that could possibly stand in the way of converting anger into constructive action.

Gross and fine motor performance

A final consideration concerns the effects of the activation levels required to perform optimally. In this instance, activation refers to the appropriate mental and physical state that athletes need to be ready to perform. Perhaps the most effective way to illustrate this point is to consider the levels of activation required in two different tasks. For example, the desirable mental and physical state needed to demonstrate readiness to perform as an Olympic boxer is very different from the state of readiness needed to perform well as an Olympic target rifle shooter. For example, strength, power, and aggression are key determinants of performance within the gross muscular activity of boxing, whereas composure, control, and calmness are key factors within the fine muscular control event of target-shooting. For example, anger's arousing effect and action (approach) tendency may be helpful when a boxer is required to perform a powerful strike (Woodman et al., 2009). Conversely, when the task requires greater fine motor tuning and less explosive motion (such as in table-tennis serve), increased anger may be detrimental to performance outcome (Martinent et al., 2012). It is clear that the two appropriate activation states fall at different ends of a continuum.

Research project hypotheses

To summarize, the main purpose of the present thesis was to enrich the existing scarce scientific evidence on the anger-performance relationship within the sport context, and to address some of the limitations highlighted in previous studies (Martinent et al., 2012; Robazza et al., 2006; Robazza & Bortoli, 2007; Ruiz & Hanin, 2004a, 2011; Woodman et al., 2009). First, to provide stronger ecological validity to previous studies that used methods of recalled measures as a valid instrument to assess athletes' emotional experiences (Robazza & Bortoli, 2007; Ruiz & Hanin, 2011) and tasks that are not sport specific (Davis et al., 2010; Woodman et al., 2009). Second, to examine anger in the context of mixed emotions, more specifically to investigate the role of hope and self-efficacy as moderating variables in the anger-performance relationship. Third, to study anger within gross and fine motor skills tasks. Fourth, to provide, via laboratory-based experiment, an insight into the mechanism that may illuminate the effects of anger on a sport-related task.

The first empirical chapter (Chapter 2 in the thesis) addresses the ecological validity limitation by conducting two cross-sectional studies with military paratroopers. The finding from these studies indicated a positive relationship between state-anger and performance of both gross and fine motor tasks among skilled and experienced performers. As to one of the central interests in this investigation, to explore the moderating role of state-hope and self-efficacy in the anger-performance relationship, as expected we found no moderating effect in the gross motor performance. However, contrary to our expectations, the fine motor performance was also not attuned by state-hope or self-efficacy.

The second empirical chapter (Chapter 3 in the thesis) addresses the lack of scientific literature as to the mechanism behind the effect of anger on athletes. This chapter presents a novel withdrawal multiple-baseline single-case study with elite and intermediate fencers.

This laboratory-based study examines anger-performance relationship during a repeated measure fencing task, and includes putative psychophysiological indices of anger alongside measures of muscle activity, precision and response-time. This study thereby offers a unique experimental methodology and helps paint a richer picture of the anger and athletic performance relationship over time.

These chapters are written in the APA journal format in preparation for peer review.

Chapter 2

Athletic performance can involve a vast array of emotional experiences and intensities. Emotions such as happiness, enthusiasm, excitement, fear, frustration, hope, determination, anger and anxiety (Curry, Snyder, Cook, Ruby, & Rehm, 1997; Gould et al., 2000; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Sève, Ria, Poizat, Saury, & Durand, 2007; Uphill & Jones, 2007) have been reported by athletes at all levels and are often assumed to play a role in performance quality and variability. However, with the exception of anxiety, researchers have not extensively and systematically studied this array of emotions in the context of athletic performance.

Anger is one of the most commonly experienced emotions by athletes, especially when in an actual competitive setting. For example, national-level table-tennis players reported anger as the most experienced emotion during competition (Martinent et al., 2012). In a study by Pensgaard and Duda (2003), out of 61 Olympic athletes who participated in the Sydney 2000 Olympic games, 58 reported to have experienced anger during competition (anxiety was reported by 57 athletes). All 58 athletes described anger as a negative emotion, although 40 stated that the experience of anger had enhanced their performance, and 18 athletes claimed that anger had had a debilitating effect on their performance.

Anger is generally held to be a negative emotion and commonly perceived as an unpleasant feeling, mainly because it is evoked by aversive events such as frustration; threats to autonomy, authority, or reputation; disrespect and insult; norm or rule violation; and, a sense of injustice (Potegal & Stemmler, 2010). Conversely, in the moment of anger, future reflection may often be pleasant and rewarding (Litvak et al., 2010) because anger is associated with action tendencies, a sense of control, and the belief that a situation can be improved and that obstacles can be overcome (Frijda et al., 1989). Studies across multiple domains have shown that angry people are more likely to believe that they can achieve their goal (Litvak et al., 2010).

Anger involves an active approach and may increase alertness, strength, confidence, and determination (Harmon-Jones et al., 2010; Litvak et al., 2010). Research on anger shows that this emotion is often associated with attack and approach motivations (Harmon-Jones et al., 2010) and that anger may help people to feel stronger and more energized when dealing with the cause of their anger (Frijda et al., 1989). Electroencephalogram (EEG) and imaging studies have demonstrated that anger is associated with relatively greater left-frontal cortical activity, which, in turn, has been linked to approach motivation and positive affective processes (Coan & Allen, 2003; Davidson et al., 2000). Anger may also be exhilarating when one is seeking revenge or punishment (Carlsmith et al., 2008). For example, participants who felt anger following an anger-induced manipulation reported feeling more active and stronger than control condition participants (Harmon-Jones et al., 2004).

A fruitful theoretical framework for the exploration of anger in a sport performance setting is Lazarus's cognitive-motivational-relational (CMR) theory (Lazarus, 1991, 2000a). This theory is a cognitive approach that defines emotion as a systematic, psychophysiological reaction to a social or interpersonal environment, where each emotional reaction consists of one's subjective experience, true or desired actions, and physiological responses. According to Lazarus (2000a), each emotion has its own distinctive characteristic in which the concept of appraisal plays a key role. Lazarus (1991) argued that cognitive processes are essential to the occurrence of emotion. That is to say, emotions cannot arise without some kind of thought. This cognitive appraisal process is constant, ongoing, and generates meaning.

Accordingly, people constantly evaluate events in their life. First, a person appraises a situation with respect to their well-being such as a particular risk or reward. Second, from the initial arousal stage of an emotion and throughout the emotional encounter, a coping process takes place that determines how one manages or regulates one's emotions. In other words, the role of coping is to advance our cause by means of which we think, feel, and act (Lazarus, 1999), and the coping strategy is determined by personal resources, beliefs about self and world, and environmental demands. Third, these relational meanings construct the main bases for the emotions one experiences and the actions that flow from them.

Consequently, each discrete emotion has its unique relational meaning, which is an appraisal, and reflects personal factors, environmental demands, constraints, and opportunities. To this end, Lazarus (1991) introduced the term *core relational theme,* which is a concise expression of an individual's appraisal judgments during a particular situation and combined into a single meaning for each emotion. For example, anger's core relational theme is "a demeaning offense against me and mine" (Lazarus, 2000a, p. 234).

Each core relational theme has an associated action tendency, or coping strategy, that is the result of one's cognitive appraisal (Lazarus, 1991). Anger involves an active approach and is frequently associated with approach motivational inclinations (Potegal & Stemmler, 2010). Within CMR theory, Lazarus (2000a) states that the action tendency for anger is "a powerful impulse to counterattack in order to get revenge for an affront or repair a wounded self-esteem" (p. 243).

Given the activation of the sympathetic system that is associated with the action tendency for anger, such as increased diastolic blood pressure and vascular resistance in order to support intense muscular contraction (Stemmler, 2010), anger may have a positive impact on performance when the physical skill involved requires a high-energy, physical motion of relatively short duration. In a study by Gould et al. (2000) with 211 competitive level athletes across nine sports, the only context (i.e., prior good/poor practice, during good/poor practice, prior good/poor competitive performance, during good/poor competitive performance) in which anger was reported to be good for performance was in the competitive condition. Woodman et al. (2009) showed how anger may be beneficial to performance when the required skill closely mirrors anger's associated action tendency. In this study, participants produced greater physical force when "lashing out" under anger conditions than when acting under emotion-neutral conditions. In another study by Robazza and Bortoli (2007), advanced and beginner rugby players felt that they had greater control over their anger within a competitive setting when that anger facilitated their performance.

The experience of anger has been categorized as *anger-in* and *anger-out* (Brunelle et al., 1999; Davis et al., 2010; Spielberger et al., 1983; Spielberger & Reheiser, 2009; Woodman et al., 2009). Anger-in reflects angry expression that is directed inward, towards the self (Averill, 1982; Tavris, 1989) and is not revealed openly. Anger-in may be viewed as a form of suppressed anger (Smits & De Boeck, 2007; Spielberger, Ritterband, Sydeman, Reheiser, & Unger, 1995). This manifestation of anger could potentially result in low performance quality, because the process of regulating personal anger (Smits & De Boeck, 2007) may draw resources away from the primary task at hand and interfere with concentration (Hahn, 1989). Furthermore, anger-in has been associated with attempts to supress anger's action tendency (Smits & De Boeck, 2007; Smits et al., 2004). However, anger-in could be an indication of greater self-control and hence may sometimes be beneficial to athletic performance (Brunelle et al., 1999; Robazza & Bortoli, 2007).

Anger-out is the overt manifestation of anger, the "feeling like expressing anger" (Spielberger & Reheiser, 2009, p. 286). Its direction is outward, toward persons or objects that are associated with the provoking agent and is often expressed verbally. Examples of anger-out may include profanity, criticism, threats, and/or physical attacks. Anger-out, much like anger-in, may also impact performance negatively if it consumes valuable resources or is the result of poor emotional self-regulation (Hahn, 1989). For example, frustration caused by mistakes, bad calls from referees or unfair opponents can lead to uncontrolled expression of anger. However, recent studies have revealed that anger-out can have a facilitative effect on athletic performance (Davis et al., 2010; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009).

Anger may thus have both positive and negative effects on performance. Despite these observations, little research has been done to test the effect of anger on athletic performance (Brunelle et al., 1999; Davis et al., 2010; Martinent et al., 2012; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009), particularly as anger within certain situations and conditions may result in a positive performance outcome and facilitate performance.

Anger has been linked with better performance when the performer can see a constructive way forward and has a greater sense of control (Harmon-Jones et al., 2003; Robazza & Bortoli, 2007), both of which can also affect motivational intensity (Brehm & Self, 1989). EEG and imaging studies on state-anger have demonstrated how approach motivational behaviour (reflected in the greater left-frontal activation in the brain) corresponded with coping potential or the expectation that one can take action to change a situation (Harmon-Jones et al., 2003). Participants showed increased left-frontal activation only when action was possible and the anger-induced event could be resolved (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006; Harmon-Jones et al., 2010).

In Robazza and Bortoli (2007) study, rugby players reported that anger had a facilitative influence on their performance, particularly when these feelings were under their personal control and were harnessed and channelled constructively. Robazza and Bortoli (2007) postulated that the general tendency for successful rugby players was to experience anger as a useful emotion because the players felt that they could constructively control, and possibly channel, its energising effects towards their performance goal.

One theory that addresses people’s capacities to reach their goals is Snyder’s (2002) Hope theory. This theory is a cognitive approach where *hope* is defined as “the perceived capability to derive pathways to desired goals, and motivate oneself via agency thinking to use those pathways” (Snyder, 2002, p. 249). According to Snyder (2002), when pursuing a goal, the high-hope person (as compared to a low-hope person) would be less likely to transform the initial sense of stress, that occurs upon realizing that a particular goal pursuit may be thwarted into a negative emotion. The high-hope person’s thoughts and actions may then render the impediment as being decreasingly stressful, a process that also reflects what has been called by Lazarus (1999, 2000b) as *coping*.

Snyder et al. (1996) posit that hope is a two-factor construct that consists of *pathways* thinking and *agency* thinking. Pathways thinking represents one’s level of confidence in one’s chosen route for achieving a certain goal including one’s ability to produce alternate routes if necessary. Agency thinking is the motivational component in hope theory; agency represents one’s mental energy and personal *will* to use any pathway available in order to achieve a desired goal. In other words, pathways is one’s appraisal on how capable one is of generating means to attain a certain goal. For example, a high-in-pathways mountaineer will appraise him/herself as being able to find many routes along the way to the summit, while a low-in-pathways mountaineer may become easily stuck. Agency is one’s appraisal of how capable one feels of executing the means to attain a certain goal. For example, a high-in-agency mountaineer will have the motivation and mental energy to follow through each stage in pursuit of him/her goal which, in the case of the mountaineer, is to reach the summit.

Hopeful thinking involves both pathways and agency thoughts because they feed each other over a given goal pursuit sequence (Snyder, 2002)   High-hope people have been found to be very good at finding new routes, particularly when facing difficulties (Irving et al., 1998; Snyder et al., 1996). Snyder’s approach resonates well with the notion that, in order to use anger effectively, one must perceive the situation as having a number of options for its utilization (Harmon-Jones et al., 2003; Martinent et al., 2012; Robazza & Bortoli, 2007). This may include finding new ways to channel that anger and the motivation to use it constructively.

Typically, anger has been linked with physical actions that are powerful, directed towards the cause of anger, and of short duration. Similarly, most performance-related research has focused on anger in the context of these three criteria. For example, Woodman et al. (2009) and Davis et al. (2010) measured physical force and its association with anger by having participants perform a gross muscular peak force task, kicking as fast and as hard as possible for five seconds. Robazza and Bortoli (2007) examined the perceived impact of anger amongst rugby players, a high-impact collision sport that requires players to perform powerful sprints, tackles and jumps. Other studies conducted in similar settings, such as karate (Ruiz & Hanin, 2004a, 2011) and Canadian football (Dunn, Gotwals, Dunn, & Syrotuik, 2006), focused on physical tasks that were classified as short duration (i.e., any activity that lasted less than 10 minutes) (Beedie, Terry, & Lane, 2000).

Anger involves autonomic physiological changes such as increased diastolic blood pressure, heart-rate, skin conductance response, and muscle activity (Stemmler, 2004, 2010). Increased physiological arousal and bodily energy could lead to either improved or diminished levels of performance according to the situation's characteristics (Hardy, Jones, & Gould, 1996; G. Jones, 1990). It has been reported that higher levels of physiological arousal and/or bodily energy are needed in sports that require gross motor activity (such as weightlifting) whereas less arousal is needed for sports that involve finer adjustments in motor activity (such as golf) (Hardy et al., 1996; Parfitt, Hardy, & Pates, 1995; Parfitt, Jones, & Hardy, 1990).

Overall, the existing scientific literature on anger, and more specifically its influence on performance, indicates that a player's ability to derive routes to attain his or her goal, and the motivation to use these routes, may determine whether anger will have a positive or negative effect on performance. Furthermore, the increased energy and action tendency that is associated with elevated anger may benefit gross motor tasks, while fine motor tasks may suffer because of their increased sensitivity to minor physiological changes.

The purpose of the present study is to examine the positive and negative impact that anger may have on a gross motor skill task and a fine motor skill task in highly trained performers. We hypothesised that anger would benefit the performance of a gross motor skill task regardless of the level of hope. Conversely, we hypothesized that anger would harm the performance of a fine motor skill task only in the absence of hope. Specifically, anger will have a positive effect on the performance of a gross motor skill task regardless of hope because of anger's strong bodily activation and action tendency motivation. We also hypothesised that, on the fine motor skill task, anger would have a negative effect on performance, but that this negative effect would be attenuated by hope. Higher hope would attenuate a performer's inability to cope with the debilitating effects of increased anger on the performance of a task that requires fine muscular tuning.

To this end, we conducted two cross-sectional studies. In Study 1, we explored the association between anger and hope on the performance of gross and fine motor skill tasks.

Study 1

Method

Participants. Male, Israel-based, Israel Defence Forces (IDF) paratroopers brigade recruits who were beyond their seventh month of service and in their final week of the advanced training phase participated in this study. One hundred and forty-five participants (M_{age} = 19.50 years, *SD* = 0.76 years) performed a running task (gross motor skill). Thirty-eight participants (M_{age} = 18.99 years, *SD* = 0.92 years) performed a shooting task (fine motor skill). The Paratroopers brigade is an elite infantry force. Serving in the brigade is voluntary and requires passing a one-and-a-half-day physical test. Each company has a command staff assigned for the duration of their basic and advanced training phases. The command staff consists of nine section commanders (three to each section), three platoon commanders' officers (one to each platoon), a sergeant and a company commander (i.e., lieutenant). The section commanders directly lead a section of approximately nine recruits. Whenever possible, the nine recruits and their section commander are kept together for the duration of their training. Before taking part, participants were asked to give their informed consent (see Appendix A) once all experimental conditions were explained. This study was approved by the ethics committee of the School of Sport Health and Exercise Sciences at Bangor University.

Measures[1].

State-anger. The State-Anger Inventory (Spielberger et al., 1983), which is included in the revised State-Trait Personality Inventory (STPI; Spielberger & Reheiser, 2009), is a 10-item, self-report inventory, which consists of two, five-item *state-anger* sub-scales (see Appendix B): “feeling angry” (*anger-in)* such as, "I feel irritated” and “feeling like expressing anger” (*anger-out*) such as, “I feel like banging on the table”. All items are rated on a Likert scale from 1 *(Not at all*) to 4 (*Very much so*). Spielberger et al. (1983) reported high internal consistency with a Cronbach alpha coefficient of .92. The Cronbach alphas for the current study are presented in Table 1 and 2.

State-hope. The State-Hope Scale (Snyder et al., 1996) is used to measure the level of hopeful thinking, and requires respondents to describe how they feel "right now" (see Appendix C). This measure consists of three statements that represent *pathways* thinking, such as, "If I should find myself in a jam, I could think of many ways to get out of it".

[1] Scales were translated into Hebrew, and validated by a back translation.

Another three items are the *agency* thinking, for example, “At the present time, I am energetically pursuing my goals”. Respondents indicate the degree to which each statement applies to them at the present moment on a 1 (*definitely false*) to 8 (*definitely true*) scale. Therefore, scores can range from 6 to 48, with higher scores indicating higher levels of hopeful thinking. Subscale scores are computed by adding the three even-numbered items for agency and the three odd-numbered items for pathways. Previous studies have reported Cronbach alpha coefficient of .90-.95 for overall scale, and .90 and higher for the agency and pathways factors (Snyder, Feldman, Taylor, Schroeder, & Adams, 2000; Snyder et al., 1996). All alpha coefficient for all measures are presented in Tables 1 and 2.

Performance.

Lap-time. A middle distance running test comprised the time taken to complete a 2000-metre run without carrying any equipment. Participants performed the test at the training base, on a 2000m asphalt track. Each company took the test on a different day of the same week. The test was conducted by members of the paratroopers' physical department, so that no member of the commanding staff (including the researcher) was present. A list of the final running times was given to the researcher by the physical department officer.

Hits on target. A standard, basic-training shooting test consisted of measuring the successful attempts by participants to shoot anywhere on a head-size target placed 100 metres away using a ten-round magazine. After all safety instructions were explained to participants by the combat training officer, the volunteers lined up facing their target and adopted the prone position. Participants then performed two sets of 10 single shots, using a standard M16A2 rifle at their designated target and in their own time. Once completed, the total number of successful hits was collected and recorded by the combat training staff. A list of the final scores (i.e., number of hits between 0 - 20) was given to the researcher by the combat training officer after all participants’ scores had been collected.

Commander-rated Performance. The commanders of the 24 sections were asked to assess the performance of all the recruits in their section who had taken part in the study. Each commander received a list of running-lap-times or number-of-hits on target of the recruits under his command. The commander was then asked to rate the extent to which each recruit's result was better or worse than his average performance ability on an 11-point Likert-type scale from 1 (*Very much worse than normal*), through 6 (*Same as normal*), to 11 (*Very much better than normal*). This measure was devised by the research team on the premise that section commanders were best situated to provide the most accurate assessment of their recruits (Butt, Weinberg, & Horn, 2003; Edwards & Hardy, 1996). This premise was based on the knowledge that the commanders had been following their subordinates closely for seven months. These tests are carried out once a month, and are conducted under similar conditions (i.e., time of day, nutritional considerations, stimulant consumption, no time pressure). Accordingly, it is approximated that in the current study each section commander received lap times and hits on target results six times before this specific assessment. The measure needed to be both sensitive to individual differences and ecologically valid.

Procedure. In accordance with army general regulations, and in order to meet its code of conduct and confidentiality demands, a research proposal of the current study was submitted to, and approved by, a spokesman and a legal advisor from the Army Research Department; the Army Behavioural Sciences Department; a Central command legal advisor; and the paratroopers' training base lieutenant-colonel. The study was approved by the ethics committee of the School of Sport Health and Exercise Sciences at Bangor University.

The study was scheduled with the paratroopers' physical officer several months in advance in order to be coordinated with on-going, periodical running and shooting tests. These are mandatory tests that soldiers must occasionally take in order to assess their current physical ability.

The tests were scheduled on a different day of the week for each company, so the data collection took place over six consecutive days. One day was for the test and another day was for the section commanders to rate their recruits. This rating could only start once the researcher had received the running and shooting tests results from the physical and shooting department's officers.

The research team consisted of the researcher and assistants from the training base administration staff. With each company, data was collected from participants at the company's activity site (i.e., main gym and shooting range), allowing us to minimise data collection time and fit in with the demands of training.

On the evening of the day prior to the running test, the researcher was introduced to the recruits by the company's sergeant, who did not take part in the study. Recruits were briefed on the purpose and importance of the study and the methods that would be used by the researcher. Confidentiality issues were stressed by explaining that the data provided would be held in confidence, that no military personnel would have any access to completed questionnaires, and that anonymity would be maintained in the report-writing stage of the research. These measures would thus make it impossible for anyone to identify individual recruits and/or staff members. We provided a detailed explanation of why it was necessary to collect service numbers (i.e., so that recruits' self-report data could be paired with performance outcome data). The recruits were then explicitly informed of the voluntary nature of the research and were told that they did not have to fill out the questionnaires and could withdraw at any time.

On the morning of the test day, approximately 20 minutes before the running and shooting tests began, the recruits were gathered near the 2000m asphalt track or the shooting range area, written informed consent was obtained and recruits were given questionnaires to complete (for a review of the written briefing also given to recruits, see Appendix A). When all the recruits had completed their questionnaires, they placed them in envelopes that were then sealed and placed into a box and were later collected by the researcher. The recruits were explicitly informed that the envelopes would only be opened by the researcher. The state-anger scale and state-hope scale questionnaires were both administered at the same time. Upon completion of this stage, the researcher retrieved the box and left the area, allowing recruits to carry on with their tests without his presence. The recruits were then walked to the track start area or the shooting range waiting area. In the 2000m running task the recruits started the run individually, and the physical activity instructor timed 30 seconds intervals between each runner. In the shooting task, a different group of 12 recruits was sent over by their commanders to the shooting range in each shooting round.

The following day, section commanders were presented with the final lap-time results and were asked to rate their soldiers' performance quality. This rating was held in a separate room at the company's accommodation block.

Analytic strategy. There are two independent variables: (a) state-anger scores, and (b) state-hope scores. There are three dependent variables: (a) running lap-time, (b) number of hits on target, and (c) commander-rated performance. Using linear regression analyses, we analysed separately the association between state-anger and commander-rated performance, state-anger and lap-time, and state-anger and hits on target. In addition, we analysed the association between state-hope and commander-rated performance, lap-time, and hits on target separately. Furthermore, moderated hierarchical regression analysis was conducted in order to test for a moderating influence of state-hope on state-anger and commander-rated performance relationships, state-anger and lap-time, and state-anger and hits on target. In addition, bivariate correlations were calculated across performance data, scales and sub-scales.

Results

The assumptions of regression analysis including homoscedasticity were satisfied for each analysis.

2000-metre run.

Table 1 shows the means, standard deviations, and bivariate correlations among the study variables and sub-scale constructs. All data were standardized within platoons (i.e., three companies each consisted of three platoons) before correlations were calculated.

Table 1.

Summary of Correlations, Inter-correlations, Means, and Standard Deviations for scores on the State-anger scale, State-hope scale, Lap-time, and Commander-rated running performance (N = 145).

Variable	1	2	3	4	5	6	7	8
1. State-anger	(.87)	.90***	.86***	-.21**	-.13	-.23**	.07	.26***
2. Anger-in		(.81)	.58***	-.30***	-.20**	-.31***	.07	.27***
3. Anger-out			(.85)	-.04	-.01	-.08	.02	.20**
4. State-hope				(.71)	.85***	.83***	-.22**	-.01
5. Pathways					(.69)	.43***	-.08	-.06
6. Agency						(.51)	-.32***	.09
7. Lap-time							---	-.38***
8. Commander-rated performance								---
M	13.25	7.06	6.19	37.92	18.94	18.98	07:39.98	6.56
SD	4.30	2.57	2.30	5.37	3.29	2.96	00:23.93	1.90

Note. Cronbach's alpha data in parentheses; Range of possible scores is as follows: state-anger 10 to 40, anger-in 5 to 20, anger-out 5 to 20; state-hope 6 to 48, pathways 3 to 24, agency 3 to 24; Commander-rated performance 1 to 11.
1 = state-anger, 2 = anger-in, 3 = anger-out, 4 = state-hope, 5 = pathways, 6 = agency, 7 = lap-time, 8 = commander-rated performance.
**p* < .05, ***p* < .01, ****p* < .001.

Performance. The correlations in Table 1 reveal that state-anger was a significant predictor of commander-rated performance; state-anger R^2 = .07, F (1, 143) = 10.13, p < .01, β = .26. Anger-in R^2 = .06, F (1, 143) = 9.09, p < .01, β = .25, and anger-out R^2 = .04, F

(1,143) = 5.71, $p < .01$, $\beta = .20$ were significantly related to commander-rated performance. Interestingly, state-hope $R^2 = .06$, F (1, 143) = 8.30, $p < .01$, $\beta = -.23$, and specifically agency $R^2 = .10$, F (1, 143) = 15.95, $p < .001$, $\beta = -.32$, showed a significant negative relationship with lap time (i.e., the time taken to complete the 2000-metre run). Thus, both anger and hope were significantly positively associated with performance.

In the context of potential moderating effects, we had hypothesized that anger would have a positive effect on the gross motor skill task (i.e., 2000-metre run) regardless of state-hope. We thus conducted moderated hierarchical regression analyses to test whether the positive effect of state-anger on performance was moderated by state-hope. Once state-anger and state-hope main effects had been accounted for ($R^2 = .07$, F (2, 142) = 5.24, $p < .01$), the product term (state-anger × state-hope) did not account for a further significant proportion of performance variance, $R^2_{cha} = .00$, F (1, 141) = .08, $p = .77$. This supports the hypothesis that anger will benefit gross motor skill performance regardless of state-hope.

Shooting task.

Table 2 shows the means, standard deviations, and bivariate correlations among the study variables and sub-scale constructs. Data was standardized within platoons (i.e., a company consisted of three platoons) before correlations were calculated.

Table 2.

Summary of Correlations, Inter-correlations, Means, and Standard Deviations for scores on the State-anger scale, State-hope scale, Hits on target, and Commander-rated performance (N = 38).

Variable	1	2	3	4	5	6	7	8
1. State-anger	(.91)	$.93^{***}$	$.92^{***}$	$-.33^{*}$	-.12	$-.47^{**}$	-.01	$.43^{**}$
2. Anger-in		(.90)	$.72^{***}$	$-.32^{*}$	-.12	$-.45^{**}$	-.06	$.35^{*}$
3. Anger-out			(.85)	-.26	-.04	$-.43^{**}$	.06	$.45^{**}$
4. State-hope				(.66)	$.84^{***}$	$.76^{***}$	$-.25^{+}$	-.11
5. Pathways					(.69)	$.29^{*}$	-.04	-.05
6. Agency						(.46)	$-.41^{*}$	-.18
7. Hits on target							---	$.29^{*}$
8. Commander-rated performance								---

M	14.24	7.60	6.63	35.76	18.34	17.42	14.79	6.32
SD	5.49	3.29	2.63	5.98	3.90	3.41	1.91	2.03

Note. Cronbach's alpha data in parentheses; Range of possible scores is as follows: anger 10 to 40, anger-in 5 to 20, anger-out 5 to 20; state-hope 6 to 48, pathways 3 to 24, agency 3 to 24; hits 0 to 20; commander-rated performance 1 to 11.
1 = state-anger, 2 = anger-in, 3 = anger-out, 4 = state-hope, 5 = pathways, 6 = agency, 7 = hits on target, 8 = commander-rated performance.
$^{+}p = .069$, $*p < .05$, $**p < .01$, $***p < .001$.

Performance. Our hypothesis that anger would have a negative effect on the fine motor skill task was not supported. The results suggested that anger was beneficial to commander-rated performance in the shooting task; state-anger $R^2 = .19$, F (1, 36) = 8.29 $p < .01$, $\beta = .43$, anger-in $R^2 = .12$, F (1, 36) = 5.08, $p < .05$, $\beta = .35$, anger-out $R^2 = .21$, F (1.36) = 9.26, $p < .01$, $\beta = .45$. Interestingly, agency showed a significant negative relationship with the objective measure of performance (i.e., hits on target) $R^2 = .17$, F (1, 36) = 7.14, $p = .01$, $\beta = -.41$.

We conducted moderated hierarchical regression analyses to test whether the positive effects of state-anger on performance was moderated by state-hope. Once state-anger and state-hope had been accounted for ($R^2 = .19$, F (2, 35) = 4.06, $p < .05$), the product term (state-anger × state-hope) did not account for a further significant proportion of performance variance, $R^2_{\text{cha}} = .02$, F (1, 34) = 0.95, p = .34. This does not support the hypothesis that hope will moderate the anger-performance relationship.

Discussion

The aim of Study 1 was to test the effect of anger on the performance of gross and fine motor skills tasks, and to explore the possible moderating impact of hope in the relationship between fine motor skills and performance. More specifically, we wanted to explore the potential positive relationship between anger and gross motor skills. In addition, we aimed to explore the negative relationship between anger and fine motor skills and how hope might act as a moderator of this relationship.

Our findings partially supported our hypothesis; anger was positively associated with performance in the gross motor skill task, accounting for 6.6% of performance variance. Our findings provided further evidence for the positive effect of anger on gross motor activity, a 2000m run. In addition, anger was positively associated with performance in the fine motor skill task, accounting for 18.7% of performance variance. The positive relationship on the fine motor activity was surprising as elevated anger was associated with improved shooting performance. Although the anger results were significant, the results for the moderating effect of hope in the anger-performance relationship partially supported our hypothesis. The positive effect of state-anger was not moderated by state-hope in the gross motor skill performances as expected. However, contrary to our hypothesis, state-hope did not attune the relationship between state-anger and the fine motor skill performance.

State-hope was associated with faster lap-times, showing positive association with the objective performance on the gross motor skill. This finding supports a study by Curry et al. (1997) on female cross-country runners, in which state-hope significantly predicted competitive track performance. despite this main effect, hope does not moderate the anger-performance relationship.

There were two potential limitations in Study 1. First, our sample size in the fine motor skill task was rather small. In addition, the state-hope coefficient of .25 would likely be significant with a larger sample, indicating a positive relationship between state-hope and hits on target. Furthermore, with a larger sample size, the results for the moderating effect of state-hope on the anger and fine motor performance relationship might have been significant (R^2_{cha} = .02; 2% is normally significant with ~100 participants) (Jaccard & Turrisi, 2003). Hence, we cannot know if the effect is genuinely not there or if it did not appear due to lack of power. Second, the state-hope scale may have been of limited relevance to what we wanted to test thus resulting in the lack of a moderating effect. Tong, Fredrickson, Chang, and Lim (2010) argued that agency thinking and pathways thinking are appraisals that are related to hope or are antecedents of hope, but they do not necessarily describe the nature of hope itself. Furthermore, within the items that measure agency thinking (e.g., *Right now I see myself as being pretty successful in reaching this goal*. *At this time, I see myself as reaching this goal*) no mention is made about executing specific actions toward obtaining a target goal. Instead, the items seem only to tap into a general sense that goals can somehow be attained, regardless of one’s ability in obtaining them (Aspinwall & Leaf, 2002; Tennen, Affleck, & Tennen, 2002). In Tong et al. (2010) study on the roles of agency thinking and pathways thinking in hope, only state-agency was positively related to hope while state-pathways was not related. We will revisit this idea during the general discussion.

In the following study we introduce a measure that has been proposed by many researchers in the field of emotions and performance as a moderator of this relationship, that is *self-efficacy* (Haney & Long, 1995; Hanton & Connaughton, 2002; Hardy et al., 2004;

Lazarus, 2000b; Mellalieu et al., 2006; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman, Akehurst, Hardy, & Beattie, 2010; Woodman. & Hardy, 2003). In addition, we address the small sample size limitation by conducting the shooting task with a larger sample.

Study 2

In Study 2 we aimed to redress these limitations by developing a more specific tool for examining moderating effects and by using a larger sample size. Study 1 revealed main effect for state-hope, yet it did not provide any evidence to support our hypothesis on the moderating role of state-hope in the anger-performance relationship of fine motor tasks. State-hope items did not seem to be measuring the perceived capacity for executing goal-related actions (as Snyder had proposed them to be). We conjectured that they could be measuring an expectation that desired goals could somehow be attained but not necessarily through one’s own means, similar to previous studies that suggest that hopeful people tend to think that desired goals are attainable, even if personal resources are exhausted (Bruininks & Malle, 2005; Roseman, Spindel, & Jose, 1990). Several studies have argued that hope can be felt as long as there is the belief that an important goal can be attained, even without the belief in oneself to generate the means to obtain it (Farran, Herth, & Popovich, 1995; McGeer, 2004; Pettit, 2004). Woodman et al. (2009) argued that hope is rather passive, but in reality performance requires action. As such, a more action-oriented emotion is more likely to affect performance.

Consequently, in Study 2, we added a measure of participants’ self-efficacy, which is a situation-specific form of self-confidence (Bandura, 1977, 1982, 1997). Self-confidence has been proposed by many researchers in the field of emotions (more specifically anxiety) and performance as a moderator of this relationship (Hanton & Connaughton, 2002; Hardy et al., 2004; G. Jones et al., 1993; Mellalieu et al., 2006; Raffety, Smith, & Ptacek, 1997; Skinner & Brewer, 2004; Woodman. & Hardy, 2003).

Self-efficacy may be involved in the anger-performance relationship where the relationship between anger and the performance of a fine motor skill task is dependent upon the level of self-efficacy. As described by Bandura (1997), perceived self-efficacy is concerned with people’s beliefs in their capabilities to produce given attainments. Anger may only be beneficial to performance if individuals perceive that they have the resources necessary for the task at hand. In other words, anger will be good for performance if a performer thinks he or she can do the task, but detrimental otherwise. For example, Robazza and Bortoli (2007) suggested that the general tendency of successful rugby players was to experience anger as useful because they felt they could constructively control it and possibly channel its energising effects towards their performance. In their study, self-confidence was found to act as a buffer against the debilitating effects of anger.

Bandura (1989) construed self-efficacy as specific to particular situations and differentiated between expectancies of self-efficacy (individuals’ belief in their ability to perform a specific behavior) and expectancies of outcome (individuals’ belief that a specific behavior will produce a desired outcome). Bandura characterized expectancies of efficacy, or self-efficacy, as a stronger predictor of behavior than outcome expectancies; therefore, self-efficacy may be more likely to moderate the effects of anger on performance as it may, more specifically, reflect individuals’ thoughts regarding their capability to carry out a specific task. For instance, Magaletta and Oliver (1999) showed that agency (i.e., the motivational component in hope) paralleled participants’ self-efficacy in that both pertained to expectancies about self-efficacy. However, pathways thinking (i.e., how transparent the self-created links between our present and our imagined futures are) was related to *optimism* in that both pertained to expectancies about outcomes.

To this end, we conducted a cross-sectional study in order to explore the association between anger and self-efficacy on the performance of a fine motor skill task[2]. In this study, we expanded our sample size of the fine motor skill task in order to further explore the results presented in Study 1. In the context of the potential moderating effect of self-efficacy, we hypothesised that anger would have a negative effect on a fine motor skill task, but this relationship would be attuned by self-efficacy.

Method

Participants. One hundred and eighteen (M_{age} = 19.19 years, *SD* = 1.18 years) new recruits from the Paratroopers brigade of the Israel Defence Forces (IDF) who were in their fourth week of service participated in this study. Before taking part, participants were asked to give their informed consent once all experimental conditions were explained. This study was approved by the ethics committee of the School of Sport Health and Exercise Sciences at Bangor University.

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[2] An additional running test was not possible because the soldiers had an unexpected last minute schedule change.

Measures[3].

State Anger. We used the State-Anger Inventory (Spielberger et al., 1983), which is included in the revised State-Trait Personality Inventory (STPI; Spielberger & Reheiser, 2009), as in Study 1.

State-hope. We used the State-Hope Scale (Snyder et al., 1996) as in Study 1, which requires respondents to describe how they feel "right now" on *pathways* and *agency* sub-scales.

Self-efficacy. This scale was constructed in accordance with Bandura's (1997) approach to assessing self-efficacy. Specifically, the content of the scale items reflecting participants' beliefs in their capability to perform successfully during a 10-round shooting task at a head-size target, positioned 100 metres away (appendix D). Participants rated their degree of confidence in being able to attain each of ten performance outcomes (i.e., "I have the skill and resources to hit 1 out of 10 shots"; "I have the skill and resources to hit 2 out of 10 shots"; "I have the skill and resources to hit 10 out of 10 shots") on a scale of 0% (*Cannot do at all*) - 100% (*Highly certain can do*). Perceptions of self-efficacy were calculated by totalling these certainty ratings across the scale items and then dividing by the total number of items on the measure, resulting in a single efficacy score ranging from 0 - 100.

Performance.

Hits on target. We measured performance as the number of successful strikes on a head-size target 100 metres away, using a ten-round magazine, as in Study 1. Participants performed one set of 10 single shots at their designated target.

Commander-rated Performance. The commanders of the 24 sections were asked to assess the performance of all the recruits in their section who took part in the study. As described in Study 1, each commander received a list of number-of-hits (i.e., the number of hits between 0 – 10) on target of the recruits under his command. The commander was then asked to rate the extent to which each recruit's result was better, or worse, than his average performance ability on an 11-point Likert-type scale from 1 (*Very much worse than normal*), through 6 (*Same as normal*), to 11 (*Very much better than normal*). This test is carried out once a month, and is conducted under similar conditions (i.e., time of day, nutritional considerations, stimulant consumption, no time pressure). Accordingly, it is approximated

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[3] Scales were translated into Hebrew and validated by a back translation.

that in the current study each section commander received hits on target results one time before this specific assessment.

Procedure. The study was scheduled with the paratroopers' shooting training officer several months in advance in order to be coordinated with on-going periodical shooting tests. The head target shooting test, at 100 metre distance, from a prone position is a mandatory test that soldiers must occasionally take in order to assess their current shooting skills. The study was scheduled on two days: one day was used for the test and another day was used for the section commanders to rate their recruits. This rating could only start once the researcher had received the shooting test results from the shooting training department office.

The research team consisted of the researcher and assistants from the training base administration staff. With each company, data were collected from participants at the shooting range waiting area, allowing us to minimise data collection time and to fit in with the demands of training. On the evening of the day before the shooting test, the researcher was introduced to the recruits by the company's sergeant, who did not take part in the study. The researcher briefed the recruits on the purpose and importance of the study and the methods that would be used. Confidentiality issues were stressed by explaining that the data provided would be held in confidence, that no military personnel would have any access to completed forms, and that anonymity would be maintained in the report-writing stage of the research. These measures would thus make it impossible for anyone to identify individual recruits and/or staff members. A detailed explanation was also provided on why it was necessary to collect service numbers (i.e., so that recruits' self-report data could be paired with performance outcome data). The recruits were then explicitly informed of the voluntary nature of the research and were told that they did not have to fill out the questionnaires and could withdraw at any time.

On the following morning, the researcher arrived at the shooting ranges' field classroom situated near the waiting area, where each company was sitting in a separate space according to their assigned shooting range. Safety regulations allow a maximum number of 12 soldiers in a shooting range in each shooting round. Therefore, before every round, a group of 12 participants from each company was sent over by their commanders to the field classroom. They were then given consent forms, along with questionnaires to be completed which they then placed into an envelope, sealed, and placed into a box before leaving the classroom for the shooting test. The 12 participants then entered the shooting range, after all safety instructions were explained to participants by the combat training officer, they lined up facing their target and adopted the prone position. Participants then performed a sets of 10 single shots in their own time. Once completed, the total number of successful hits was collected and recorded by the combat training staff. This process was repeated five times for approximately three hours in total.

The following day, section commanders were presented with the final shooting test results and were asked to rate their soldiers' performance quality. This rating session was held in a separate room at the company's accommodation block.

Analytic strategy. We gathered three types of independent variables data: (a) state-anger scores, (b) self-efficacy scores, and (c) state-hope scores. Two types of dependent variables were gathered: (a) number of hits on target, and (b) commander-rated performance. Using linear regression analyses, we analysed separately the association between state-anger and commander-rated performance, state-anger and hits on target. In addition, we analysed the association between self-efficacy and commander-rated performance and hits on target separately. Furthermore, moderated hierarchical regression was conducted in order to test for the moderating influence of self-efficacy on state-anger and commander-rated performance relationships, and state-anger and hits on target. In addition, bivariate correlations were calculated across performance data, scales, and sub-scales.

Results

Table 3 shows the means, standard deviations, and bivariate correlations among the study variables and sub-scale constructs. All data was standardized within platoon (i.e., three companies each consisted of three platoons) before correlations were calculated. The screening procedure showed that data was accurately entered for the analysis, missing values were not recorded. Outliers were tested. The assumptions of regression analysis including homoscedasticity were satisfied for each analysis.

Table 3.

Summary of Correlations, Inter-correlations, Means, and Standard Deviations for scores on the State-anger scale, Self-efficacy scale, Hope scale, Hits on target, and Commander-rated performance (N = 118).

Variable	1	2	3	4	5	6	7	8	9
1. State-anger	(.92)	$.96^{***}$	$.87^{***}$	$-.15^{*}$	-.11	$-.20^{*}$	-.02	.07	-.03
2. Anger-in		(.91)	$.71^{***}$	$-.16^{*}$	-.12	$-.20^{*}$	-.04	.04	-.09
3. Anger-out			(.81)	-.14	-.11	$-.20^{*}$	-.07	.12	.05
4. State-hope				(.71)	$.86^{***}$	$.82^{***}$	$.34^{***}$	$.13^{+}$	.09
5. Pathways					(.62)	$.44^{***}$	$.29^{**}$	.11	.08
6. Agency						(.66)	-.01	.12	.10
7. Self-efficacy							(.93)	$.30^{**}$	.01
8. Hits on target								---	$.65^{***}$
9. Commander-rated performance									---
M	13.06	6.93	6.13	38.13	19.29	18.84	88.61	5.02	5.60
SD	4.56	2.78	2.04	5.40	3.32	3.11	10.48	1.51	1.51

Note. Cronbach's alpha data in parentheses; Range of possible scores is as follows: anger 10 to 40, anger-in 5 to 20, anger-out 5 to 20; state-hope 6 to 48, pathways 3 to 24, agency 3 to 24; self-efficacy 0 to 100, hits on target 0 to 8, commander-rated performance 1 to 11.
1 = state-anger, 2 = anger-in, 3 = anger-out, 4 = state-hope, 5 = pathways, 6 = agency; 7 = self-efficacy, 8 = hits on target, 9 = commander-rated performance.
$^{+}p = .08$, $*p < .05$, $**p < .01$, $***p < .001$.

Performance. State-anger was not associated with commander-rated performance $R^2 = .00$, F (1, 116) = .13, $p = .72$. Neither anger-in $R^2 = .01$, F (1, 116) = .86, $p = .35$, nor anger-out $R^2 = .00$, F (1, 116) = .24, $p = .62$ were associated with commander-rated performance. State-hope was not associated with commander-rated performance $R^2 = .01$, F (1, 116) = .99, $p = .32$. Self-efficacy was not associated with commander-rated performance $R^2 = .00$, F (1, 116) = .02, $p = .90$. A significant positive relationship was found between self-efficacy and the objective measure of performance (i.e., hits on target) $R^2 = .09$, F (1, 116) = 11.29, $p < .01$, $\beta = .30$. No significant relationships were found between state-anger $R^2 = .01$, F (1, 116) = .54, $p = .46$, anger-in $R^2 = .00$, F (1, 116) = .15, $p = .70$, anger-out $R^2 = .01$, F (1, 116) =

1.59, p = .21, state-hope R^2 = .02, F (1, 116) = 2.03, p = .16, and the objective measure of performance.

We conducted moderated hierarchical regression analyses to test whether self-efficacy moderated the anger-performance relationship. Once state-anger and self-efficacy had been accounted for (R^2 = .00, F (2, 115) = .07, p = .93), the product term (state-anger × self-efficacy) did not account for a further significant proportion of performance variance, R^2_{cha} = .01, F (1, 114) = 0.89, p = .35. This does not support the hypothesis that self-efficacy will act as a moderator in the anger-performance relationship.

General discussion

The aim of the present research was to test the moderating role of state-hope in the anger-performance relationship, and to test the moderating effect of self-efficacy on a fine motor skill task. We hypothesised that state-anger would benefit performance of a gross motor activity regardless of state-hope. Furthermore, we hypothesised that state-anger would have negative relationship with a fine motor activity, where state-hope or self-efficacy moderates this relationship. Only among the high-hope or high self-efficacy performers will the negative effects of elevated state-anger upon shooting performance be reduced. In addition, we aimed to provide additional empirical support that anger could be beneficial to athletic performance during gross motor skill tasks (given anger's energising effect and action impulse) and to investigate its negative association with fine motor skills tasks.

The results supported our proposition that heightened state-anger would be associated with better performance of gross motor skills. These findings are consistent with previous research (Davis et al., 2010; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009) and support Lazarus's (1991, 2000a) suggestion that anger can be constructive when the energy stemming from anger's biologically derived action tendency or impulse is mobilised towards enhancing physical performance, particularly if a task demands a burst of energy for a relatively short duration.

Our hypothesis that increased state-anger would harm performance of a fine motor skill task was not supported. In Study 1, elevated state-anger was associated with *better* shooting performance and accounted for 18.7% of shooting performance variance [anger-in (12.4%), anger-out (20.5%)]. The result in this positive direction runs counter to earlier research with national level table-tennis players, who generally perceived anger as debilitating to their performance (Martinent et al., 2012). There is likely a contextual point worth considering here. That is, as is normal in military training, the soldiers were shooting at a cut-out of a make-believe human head and had likely been trained to imagine that head as an enemy intent on doing them harm. Hence, it could be argued that anger and the approach motivation tendency associated with anger was more beneficial during this task than would normally be expected within equivalent fine motor tasks with a more neutral target (e.g., Olympic shooting) or indeed less anger-normalised contexts (e.g., table tennis).

In Study 2, we aimed to further explore the shooting task results of Study 1 by using a larger sample size. The results neither supported our hypothesis that state-anger would harm performance during the fine motor skill task, nor did they replicate Study 1's results. No significant association between state-anger and shooting task performance was revealed in Study 2. One potential explanation may concern the commanders' short acquaintance period with the recruits under their command. Because of military constraints, the only population that was available to us for Study 2 were new recruits that were in their fourth week of military service, as opposed to seven months in Study 1. We suggest that this period of time was not sufficient, thus the section commanders could not provide accurate evaluations (i.e., commander-rated performance) on the recruits under their command. In addition, participants were still within their learning stage and their shooting skills had not yet been stabilized or fully acquired. This underdeveloped skill may be reflected in the low rate of successful strikes [(Study 1 (73.9%); Study 2 (50.2%)].

It is also worth noting that this limitation was acknowledged prior to starting Study 2; however, we were informed by the shooting department's officer that recruits spend many hours improving their shooting skills during the very first weeks of their military service. More specifically, in the first four weeks, the total amount of training time would total to approximately 120 hours of shooting training.

Both anger-in and anger-out were positively related to better performance in the running and shooting task. These results support the notion that both the suppressed and expressed forms of anger can have facilitative effect on athletic performance. Anger-in's predisposition to direct the expression of anger inward did not harm performance in both the fine and gross motor tasks, rather this result may have reflected a greater self-control by the participant (Brunelle et al., 1999; Robazza & Bortoli, 2007). Similarly, the facilitative effect of anger-out shows that this regulation style may be helpful in a wider range athletic performance (i.e., running, shooting) and is not limited to sports that are characterised by confrontational lashing out movements, such as combat sports (Davis et al., 2010; Ruiz & Hanin, 2011).

In the context of the potential moderating effect of state-hope and self-efficacy, we failed to identify any moderating influence in the anger-performance relationship. Based on previous research (Robazza & Bortoli, 2007; Ruiz & Hanin, 2004a, 2004b) our initial assumption was that state-hope, and to greater extent self-efficacy, would reflect the participants' ability to produce constructive ways to channel anger's energising manifestation and action tendency to optimize performance. It can be suggested that highly trained performers may constructively use low to moderate anger to their benefit and channel its energising effect to optimize performance; however, the effects of anger might alter as it reaches higher levels.

For example, one model that describes the conditions in which performance would suffer a sudden drop is the Cusp Catastrophe Model of anxiety and performance, originally proposed by Hardy and Fazey (1987). The Cusp Catastrophe Model describes a three-dimensional relationship between cognitive anxiety, physiological arousal and performance. Under conditions of low cognitive anxiety, changes in performance are small, and the relationship between physiological arousal and performance follows an Inverted-U shape. As the level of cognitive anxiety increases, changes in the level of physiological arousal lead to changes in performance that are more dramatic, and the relationship follows a tighter Inverted-U shape. At some point, when cognitive anxiety reaches a high level, the Inverted-U shape breaks and forms a discontinued/incomplete Inverted-U shape. Any further elevation of physiological arousal beyond this threshold point would cause a large drop in performance (Hardy, 1990).

Equally, mild anger may be good for most physically demanding tasks, as it serves as a "charger" to sub-optimal activation levels (Pensgaard & Duda, 2003). The expectation is that, as anger levels increase beyond a certain threshold, anger can no longer facilitate performance and will likely debilitate it. In fact, the highest state-anger score reported by participants in Study 1 was 30 in the 2000m running task and 31 in the shooting task, both scores corresponded with "moderately so" on the state-anger scale. In Study 2, only one participant had a score of 35 (between "moderately so" and "very much so" on the state-anger scale), and all other scores were below 29 (i.e., "moderately so"). Therefore, the moderating effect of state-hope and/or self-efficacy in the anger-performance relationship is more likely to appear under conditions of high intensity of anger, which we did not achieve in the current samples.

In terms of main effects in the anger performance relationship, state-anger accounted for 6.6% of performance variance in the 2000m running task. This finding shows that anger can benefit performance of gross muscular activity for a longer duration than a short burst of energy, as proposed by Lazarus (2000a). In addition, these results extend those of Woodman et al. (2009) and Davis et al. (2010) to an activity that exists outside the laboratory setting, is more ecologically valid, and is of longer duration.

Interestingly, state-hope in Study 1 was associated with better lap times and accounted for 5.5% of objective gross motor performance variance. This finding supports Snyder's (2002) assumption that high-hope athletes would be more successful in a stressful competitive environment than low-hope competitors. High-hope thinking helps to motivate athletes in achieving a specific goal and can enhance performers' ability to seek the best routes towards their goal. For example, athletes who frequently utilize hopeful thinking will often demonstrate significant and stable improvements in their confidence, particularly in their sport performances (Curry & Snyder, 2000).

In Study 1, agency (i.e., how capable one feels about reaching one's desired goals) had a negative (R = .41, p = .01) relationship with the objective measure performance (i.e., hits on target). Conversely, in Study 2, self-efficacy (i.e., a measure of participants' belief in their ability to perform the shooting task) had a positive relationship and accounted for 8.9% of hits on target variance. One potential explanation of these contrasting results may concern the participants' different shooting experience, which may have affected the level of effort they invested into the task. In Study 1, the participants were experienced soldiers with seven months of military service, as opposed to four weeks in Study 2. For instance, Woodman et al. (2010) revealed that some self-doubt was beneficial to rope-skipping performance. In a study by Beattie, Lief, Adamoulas, and Oliver (2011) on the reciprocal relationship between self-efficacy and performance, a participant's previous golfing performance had a strong and positive influence upon their subsequent self-efficacy beliefs; however, self-efficacy had a weak negative (albeit non-significant) relationship with subsequent performance, pointing towards the notion that high levels of self-efficacy might lead a performer to be overconfident and to invest less effort into the task at hand.

There are some limitations associated with the present study. The most obvious concerns gender, as only male recruits participated, pointing towards a lack of external validity regarding female performers. Unfortunately, we did not have access to female combat fighters as the paratroopers' brigade only recruits males. We would like to note that, in the context of gender, there is ample evidence that men and women are similar in the frequency and intensity of their angry feelings (see Fischer & Evers, 2010). According to research, expressions of anger are also often dictated by social construct, expectation and culture. Gender differences were apparent only in the way anger was expressed: women seem to prefer indirect expressions of anger while within a social context (Bettencourt & Miller, 1996; Eagly & Steffen, 1986; Fischer & Roseman, 2007). With further development of the findings from this research, one could examine the link between different expression styles of anger and enhanced performance (Spielberger & Reheiser, 2009).

A second criticism that could be levelled at this study concerns the use of a cross-sectional study. The cross-sectional study is a type of observational study that is time specific and more descriptive. Since it does not involve manipulating variables any inferences on causality should be made with caution. Furthermore, it should be noted that the study did not allow us to investigate performance under higher levels of anger. Rather, this study provides valuable clues for future research into the anger-performance relationship. However, in future research, a repeated measure experimental design would allow to investigate over time the situational contexts in which anger improves and/or harms performance. In addition, a case-control study could be created if a mechanism for inducing a stronger state-anger effect were to be devised.

A third limitation is that the measure for quality of performance (i.e., commander-rated performance) was determined by subjective assessment; section commanders rated the extent to which the recruits under their command performed better, or worse, than their average performance ability. This method is subjective in nature and therefore might be more sensitive to judgmental biases. Another alternative was to ask participants rate their own performance, which could also account for reasons beyond the "performer's control", such as a cold or a niggling injury. However, research have shown that when people are asked to evaluate their own abilities, capacities, and performances within a specific domain, they tend to rate themselves above average (Dunning, Meyerowitz, & Holzberg, 1989).

Another limitation in regards to the use of commander-rated performance measure concerns its dependency on the number of times a commander had received previous tests scores. Commander-rated performance assessment might be confounded by the number of tests a participant performed, where the accuracy of an assessment improves as the number of tests increase. Moreover, although the tests were scheduled to be conducted under similar conditions, it is acknowledged that factors such as weather conditions, hydration status and number of sleeping hours were not assessed by the experimenter. Any subtle changes in these variables might confound the results by affecting participants' emotional state and/or other physiological activities such as concentration and physical resources. For example, Thun, Bjorvatn, Flo, Harris, and Pallesen (2015) showed that sleep deprivation was negatively associated with better athletic performance whereas sleep extension seemed to improve performance.

Alternatively, objective measures, such as lap-time during a specific point in time, often will not account for individual differences and intra-individual fluctuations in performance across time. These discrepancies may then confound the sensitive emotion-performance relationship. Hence, longitudinal studies may help address this issue by measuring performance as an ongoing process across time. For instance, SGI (successful game involvement) for basketball is an example for overall objective measure, as it includes shot percentage, total points, personal fouls, and turnovers, and can account for performance variations across time (Uphill, Groom, & Jones, 2014).

In conclusion, our initial theoretical position for this study – that there would be a positive association between anger and the performance in gross motor skill tasks – was supported. We found that state-anger had a positive relationship with the 2000m run. Additionally, we revealed that moderate anger could have a positive effect on the performance of a fine motor skill. We also provided further support for the positive association between performers' state-hope, self-efficacy, lap-time, and hits on target performance.

Future research, such as longitudinal studies could be used to examine this relationship for longer periods by using objective performance assessments. For example, laboratory studies on ongoing performance of fine motor skill such as fencing, golf, and table-tennis could investigate the quality of performance under anger and no-anger emotional conditions, including investigate into the mechanism associated with this relationship.

In the following project, as described in Chapter 3, we conducted a laboratory based experiment in order to address some of the limitations illustrated above. This experiment enabled us to control for participants' emotional state (i.e., anger and no-anger), and via a repeated measure design to infer causality between anger and performance. Moreover, by collecting objective psychophysiological measures associated with anger, as well as muscle tension, we were able to take a glimpse into the mechanism(s) associated with elevated anger and sport performance.

Chapter 3

Anger is an intrinsic emotional state within competitive environments, because it is mainly evoked by stress (Isberg, 2000), frustration, disrespect, threats to reputation, rule violation, and an overall sense of injustice (Potegal & Stemmler, 2010). Consequently, anger is frequently experienced across all levels of athletic performance and competitive sports (Brunelle et al., 1999; Davis et al., 2010; Dunn et al., 2006; Gould et al., 2000; Isberg, 2000; Martinent et al., 2012; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011). For example, John McEnroe, seven-time Grand Slam winner, was notorious for his angry outbursts during games. More recently, Valentino Rossi, an Italian professional motorcycle racer, multiple MotoGP World Champion, and one of the most successful motorcycle racers of all time, was penalised for kicking his rival Marc Marquez off his bike in the 2015 Malaysian Grand Prix. Another example is Zinedine Zidane, UEFA Champions league winner, World Cup champion, and one of the greatest French players in the history of football, who was infamously red carded for head butting an Italian player who had insulted him in the 2006 World Cup final.

Theories on emotions indicate that changes in the environment will lead to discrete emotion, which serve as an evolutionary adaptive function by organizing our cognitive, experiential, behavioural and physiological responses (Lench et al., 2011). For instance, a change in cognition might include focusing on a real or imagined threat, while a former experience, such as an intense vs mild negative memory, may determine one’s level of fear response. People’s behaviour may be characterized by their tendency towards flight/fight, and one’s physiological reaction may result in an elevated heart rate and respiration (Lench et al., 2011).

Attack is often associated with angry behavioural responses, as noted by Lazarus (2000a), if the physical skill requires a “lashing out” motion or a short burst of energy performance may be facilitated due to its close association with anger’s action tendency. Attack initiates strong activation of sympathetic systems in order to motivate and support individuals in regaining their superiority following physically and socially caused harm (Stemmler, 2010). Traditional coaching approaches believe that exhorting athletes into anger will benefit performance by energizing the athlete and helping them to hit harder, jump further, or run faster (Brunelle et al., 1999). Indeed, anger involves an active approach and is often associated with attack and approach motivations (Harmon-Jones et al., 2010). Anger may increase alertness, strength, confidence, determination (Harmon-Jones et al., 2010;

Litvak et al., 2010), and may help people feel stronger and more energized (Frijda et al., 1989).

In general, scientific research shows that performance in anaerobic and strength tasks are positively associated with physiological arousal (Parfitt et al., 1995; Perkins, Wilson, & Kerr, 2001), whereas performance of fine motor control tasks may suffer from elevated arousal (Noteboom, Fleshner, & Enoka, 2001; Parfitt et al., 1990). Similar to anxiety, anger involves autonomic physiological changes such as increased diastolic blood pressure, heart-rate, skin conductance response, and muscle activity (Stemmler, 2004, 2010).

Equally, within certain sports and under certain conditions, scientific evidence points toward a beneficial effect of anger upon athletic performance. This effect largely include sports that are characterised by gross motor activity and require players to perform powerful tackles, jumps, and attacks such as rugby (Robazza & Bortoli, 2007), karate (Ruiz & Hanin, 2011), and Canadian football (Dunn et al., 2006). At the same time, other researchers within the field of sport psychology reject the notion that anger is an effective means for inducing improved athletic performance. This rejection is due to its detrimental effects on concentration, attentional focus (Hahn, 1989), and systematic reasoning (Tiedens & Linton, 2001). Furthermore, in sports that involve fine adjustments in motor activity, the extra energy associated with anger may not result in a better outcome (Martinent et al., 2012).

As noted above, anger can have both positive and negative effects on performance. Woodman et al. (2009) showed how anger may be beneficial to performance when the required skill closely mirrors anger’s associated action tendency and is characterized by gross motor components. In this study, participants produced greater physical force when “lashing out” (i.e., kicking as fast and as hard as possible for five seconds) under anger conditions than when acting under emotion-neutral conditions. Conversely, when fine motor components are involved, anger may be detrimental to performance. In a study by Martinent et al. (2012), professional national-level table-tennis players reported anger as almost always detrimental to their performance, but a few instances in which a performer felt confident regarding their ability to control and constructively use that extra energy derived from elevated anger toward better performance.

There is currently limited evidence in regards to the potential negative and positive influence of anger on fine motor activity in relation to environmental context, such as the type of sport or performance situational demand (Martinent et al., 2012). Although anger is one of the most commonly experienced emotions by athletes (Martinent et al., 2012;

Martinent & Ferrand, 2009; Pensgaard & Duda, 2003), the majority of research examining emotions within the context of athletic performance has focused on anxiety and has largely disregarded anger (Hanin, 2007; Hardy et al., 1996; Woodman. & Hardy, 2003).

In many sports, such as golf, Olympic shooting, fencing and basketball, good performance is determined largely by how well the performer exhibits fine motor control, whereas the augmented physiological arousal elicited by anger can be detrimental to performances of this kind (Martinent et al., 2012; Noteboom et al., 2001). Anger may be debilitative to fine muscular tasks because, within that family of sports, the performer is required to be physiologically relaxed and mentally calm. For example, table-tennis players predominately associated serenity, hope, and joy with better performance (Martinent et al., 2012). On the other hand, within these sports, there may be situations in which anger’s approach inclination and action tendency could be constructive. This usefulness might be seen when a task demands quick response-time and/or powerful reaction for relatively short duration. For instance, in Martinent et al. (2012) study with table-tennis players only the “single-point anger” (i.e., player experiences anger with a duration of one point on the scoreboard) was sometimes facilitative to performance. In contrast multiple-point anger (i.e., player experiences anger with a duration of two or more consecutive points on the scoreboard) was almost always debilitative to performance.

Competitive fencing is an Olympic sport that involves fast and powerful bursts of energy, such as the *attack* (i.e., flèche). At the same time, when attacking, a fencer is required to hit a target with accuracy (Singer, 1968; Tsolakis & Vagenas, 2010). Accordingly, fencing is an attractive vehicle to explore the manner in which the psychophysiological and motivational aspects of anger may be reflected during a typical fencing task, such as an attack. Likewise, researchers from a range of sub-disciplines within the field of sport sciences (e.g., biomechanics, physical education, bioenergetics, kinesiology, physiology) have used fencing as their chosen task because it provides a suitable platform for measuring fine motor components (e.g., reaction time, strength-power, precision and kinematics) within a controlled laboratory-based setting (Aquili et al., 2013; Frère et al., 2011; Guilhem, Giroux, Couturier, Chollet, & Rabita, 2014; Tsolakis & Vagenas, 2010; L. Williams & Walmsley, 2000).

Current scientific research on the anger-performance relationship comprises studies that have used subjective tools as measures of broad-spectrum performance quality such as retrospective self-reports (Ruiz & Hanin, 2011), questionnaires (Robazza & Bortoli, 2007) and qualitative data via video recordings (Martinent et al., 2012). Additional studies have looked into other specific aspects of performance (i.e., extension of the right leg), used objective measures of performance (i.e., Kin Com Muscle Testing adjustable dynamometer), and focused on physical motion in a gross motor activity (Davis et al., 2010; Woodman et al., 2009).

Furthermore, much of the literature has focused on performance outcome, which is the number of wins/losses, successful/unsuccessful competitions, subjective assessments on overall performance quality, gross muscular peak force tasks, and final game results (Davis et al., 2010; Martinent et al., 2012; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009). Such an approach to performance is rather crude and an investigation in a controlled environment into the anger-performance process could clarify the underlying mechanisms that cause variability in performance outcome.

For instance, the greater muscular force that is said to be summoned when anger could facilitate the power of a fencing attack. To clarify, motor units are multiple muscle fibres that are bundled together and are recruited by the central nervous system in order of smallest to largest based on the size of the load. After receiving the signal from the brain, the motor unit contracts muscle fibres within the group thus creating movement. The majority of the time, the real limit to athletes' performance is the number of motor units their nervous system can recruit in the short period of time and the amount of forces provided by these motor units. The nervous system determines the degree of motor units activated during an athletic activity. People can considerably increase their strength without increasing the size of their muscle, because of greater muscle recruitment (P. S. Williams, Hoffman, & Clark, 2013).

Furthermore, reaction time refers to the time between stimulus presentation and the onset of the response. Movement time is the time it takes to complete a movement. Response time is the sum of the reaction time plus movement time. Consequently, the increased alertness and action tendency that is associated with anger may facilitate the speed of a fencing attack. For example, increased alertness has been found to be positively associated with a faster reaction time (Wright, Hull, & Czeisler, 2002). In addition, movement time may be quicker due to the anger’s action tendency and approach motivation. Conversely, increased muscular tension due to elevated anger could compromise the accuracy of a fencing attack. Activation of the arousal response, and elevated muscular tension can impair the performance of motor tasks that require fine motor control and precision (Noteboom et al., 2001).

In the previous chapter, the cross-sectional nature of our studies limited our ability to infer causality between participants' emotional state and their performance. Thus, in the current study we adopted a within-subject design (i.e., single-case multiple-baseline design), which allows better examination of causality. To this end, we conducted a laboratory-based study in order to test athletes' fine motor task performance (i.e., a fencing flèche attack) under two emotional states: anger and neutral. Each emotional state was induced within the participants via an imagery script. This "non-provocative" imagery induction of anger was performed in many studies (Levenson, Ekman, & Friesen, 1990; Sinha et al., 1992; Stemmler et al., 2001), and has been found to have quite strong effect on somatovisceral responses (Stemmler, 2010).

The purpose of the present laboratory study was to explore, within a controlled environment, three aspects of a fencing flèche attacks under anger and emotion-neutral conditions: *precision*, *response-time*, and *peak muscle activity*. We hypothesised that anger would have a negative effect on precision because this skill requires fine muscular tuning. We also hypothesised that, because of the increased alertness and action tendency that is associated with anger, when athletes are angry their response-time would be faster and their peak-muscle activity would be greater.

Method

Participants

The recruiting process involved advertising in fencing clubs located within the New York metropolitan area. The advertisement called for experienced male and female fencers over 18 years old to participate in a unique study on the effects of different mental states on the quality of fencing performance using a biofeedback system and response time analysis (see Appendix E).

Participants were four, right-handed fencers from the New York metropolitan area, ranging in age from 19 to 35 years (three females, one male; M_{age} = 25.00; SD = 6.98). The participants were:

1. *Fencer A*: a 22-year-old world bronze medallist female fencer from the US team with 13 years of experience including the 2012 London and 2016 Rio Olympics.

2. *Fencer B*: a 19-year-old world top 100 junior female fencer with 10 years of competitive experience at the international level.
3. *Fencer C*: a 24-year-old female fencer with six years of experience and performed at a regional level.
4. *Fencer D*: a 35-year-old male fencer with eight years of training experience and little competitive experience.

All participants were reported as healthy as indexed by the absence of any self-reported illnesses, injuries, and/or prescribed medications at the time of the experiment. The ethics committee of the School of Sport Health and Exercise Sciences at Bangor University approved this study.

Experimental design

A withdrawal, multiple-baseline single-subject design (Barker, McCarthy, Jones, & Moran, 2011a), also referred to as an *A-B-A* or a reversal single-case design (SCD), was employed within this study to assess the impact of state-anger on fencers' precision, response-time, and peak-muscle activity. When following this type of single-case research method, data are collected separately from a small number of participants while an intervention is introduced to each participant at different points in time. No control group is required because participants act as their own control; if changes are observed when the intervention is applied, and are reversed when the intervention is removed then the change in performance can be attributed to the intervention (Barker et al., 2011a). We determine that the effects occur if, and only if, intervention is applied (Bryan, 1987).

In applied research the withdrawal, multiple-baseline single-subject design, is regarded as a powerful and robust procedure for assessing the effects of an independent variable on target variables (Barker, McCarthy, Jones, & Moran, 2011b). The procedure begins with an *observation phase* (A_1) that provides a stable and representative picture of the independent variables and indicates a participant's baseline state before intervention. Then follows the second phase, titled the *intervention phase* (B) that manipulates the independent variables and takes place at equivalent intervals as in the observation phase. Finally, there is the *reversal phase* (A_2) where the intervention is removed. If the dependent variable returns to the same level as in phase A_1 we can determine that a change is linked to the intervention and not to some other variable (Barker et al., 2011b).

Accordingly, by first introducing the intervention and then removing this intervention, we can make a judgment regarding causal inference. The structure of the A_1-B-A_2 design helps us in ruling out extraneous variables as an alternative explanation for changes in dependent variables, which in turn strengthens the study's internal validity. Furthermore, single-subject designs offer greater in-depth understanding of the information gathered from participants and greater control over a participant's experiences during the intervention (Barker et al., 2011b).

Task

The task was to hit a target, using a fencing foil, as quickly and as accurately as possible while seated, in response to a *Go/No Go* sign, which appeared on a screen (Figure 1). Specific detail concerning the target design and dependent measures are provided in the Measures section below.

Measures

Performance.

Precision. As shown in Figure 1, one HD C525 Logitech webcam located on the top edge of the target's frame facing downwards (1) and another on the target's side edge facing sideways (2), captured the weapon's tip at the moment of impact. A 35 cm metal ruler (3) was attached to the target's bottom edge facing upwards and another on the side edge facing sideways (4), enabled us to measure the exact hitting point on both the x axis (right to left) and y axis (top to bottom). Precision is the distance between the 37 cm wide square target's centre point and the weapon's strike on the target, and was measured by video recording the moment of impact.

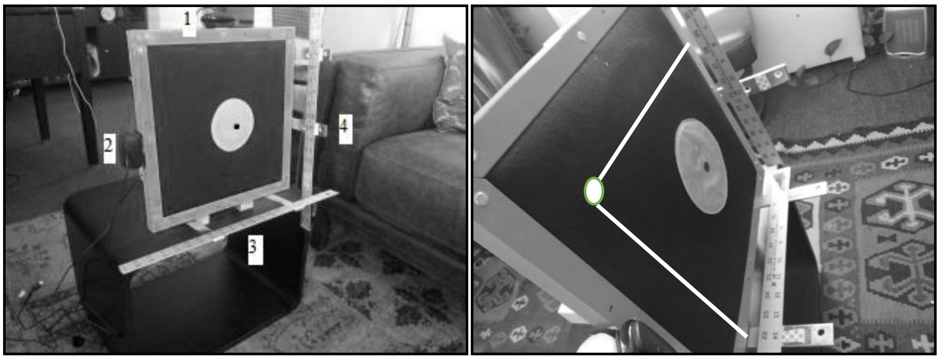

Figure 1. (1) x-axis webcam, (2) y-axis webcam, (3) x-axis ruler, (4) y-axis ruler.

The distance (i.e., radial error) was calculated by using the Pythagorean equation. As can be seen in Figure 1, radial error was calculated by measuring the length of the error horizontally (x = 0 at target's centre point) then square the value, measure the length of the error vertically (y = 0 at target's centre point) then square the value, add the squared x and y values and then square root the total.

Response-time. The time recorder using a bespoke push-button with TT-AV Sync device connected to a ProComp Infinity data acquisition system (Thought Technology Ltd. Canada) and computer running BioGraph Infinity software V6.0.4. Specifically, response-time was calculated as the duration in milliseconds between the presentation of the "GO" stimulus and the foil-target contact, as captured by the push-button switch (3).

Figure 2. (1) x-axis webcam, (2) y-axis webcam, (3) push-button switch.

Peak muscle activity. Electromyogram (EMG) electrodes (MyoScan-Z^{TM} Sensor-T9503Z, Thought Technology Ltd. Canada) placed on the triceps brachii muscle of the weapon arm recorded muscle activity. This location was chosen based on previous fencing research implicating it in the fencing attack (Frère et al., 2011). Specifically, the triceps brachii muscle is the primary agonist of the elbow extension in the flèche attack in fencing and highly active until the hit of the target. We recorded EMG activity with a sensitivity setting of 2000µV and a frequency range between 100Hz and 200Hz. Signals were acquired through a ProComp Infinity data acquisition system (Thought Technology Ltd. Canada) and computer running BioGraph Infinity software V6.0.4. Peak muscle activity was analysed by opening up the review mode in the BioGraph Infinity software and manually marking each trial, that is the area between stimulus presentation marker and end of muscle response marker, and then identifying the muscle activity peak, and extracting the Root-mean-squared (RMS) value in microvolts by selecting the "show segment statistics" option.

Emotional state.

Self-Report measures.

State-anger. The State-Anger Inventory (Spielberger et al., 1983), which was included in the revised State-Trait Personality Inventory (STPI; Spielberger & Reheiser, 2009), is a 10-item, self-reported inventory, which consists of two, five-item, state-anger sub-scales: “feeling angry” (anger-in) such as, “I feel irritated”, and “feeling like expressing anger” (*anger-out*) such as, “I feel like banging on the table”. All items are rated on a Likert scale from 1 (Not at all) to 4 (Very much so). Similar to Hardy’s procedure (1996a; Hardy et al., 2004) participants were taught to self-report single-integer scores on a Likert scale, ranging from 0 to 15, for the anger-in and anger-out. This method (see Procedure for details) minimizes the time needed for recording a participant’s anger.

Imagery ability. It has been shown that the physiological activity that occurs in response to emotional imagery varies dependent on the function of the participant’s imagery ability (Miller et al., 1987). Good imagers showed greater emotion-specific physiological activity than poor imagers. Imagery ability mediates the efficacy of imagery interventions; that is, the greater the performer's imagery ability, the more effective are their imagery interventions (Goss, Hall, Buckolz, & Fishburne, 1986). Because no imagery ability level has been established in the research literature, Callow, Hardy, and Hall (2001) suggest that participants should score a mean of 16 for both the visual and kinaesthetic subscales on the MIQ-R (Hall & Martin, 1997) in order for the imagery intervention to be effective.

In order to check that the participants could visualise the emotional scripts used in this study, their imagery ability was measured using the Vividness of Movement Imagery Questionnaire-2 (appendix F) (VMIQ-2; Roberts, Callow, Hardy, Markland, and Bringer (2008). The VMIQ-2 examines an individual’s ability to imagine specified, basic body movements and any movements that require great precision and control. The VMIQ-2 contains 12 items to measure (e.g., *running upstairs, jumping sideways*) internal visual imagery (i.e., watching yourself performing the movement), external visual imagery (i.e., looking through your own eyes whilst performing the movement), and kinaesthetic imagery (i.e., feeling yourself do the movement). The items were responded to a 5-point Likert scale, which ranged from 1 (perfectly clear and vivid as normal vision) to 5 (no image at all; you only know that you are thinking of the skill).

Psychophysiological indices.

In order to obtain physiological measurements to corroborate our self-reported measurements of state-anger, heart rate, skin conductance, and facial temperature were recorded continuously during each block of trials. In his meta-analysis of anger, based on 15 studies which reported anger and fear contrasts in at least two somatovisceral responses, Stemmler (2004) revealed that, compared to control, anger elicited greater increases in heart rate, skin conductance, and facial skin temperature. All signals were acquired using a ProComp Infinity data acquisition system (Thought Technology Ltd. Canada) and computer running BioGraph Infinity software V6.0.4. Signals were analysed by opening up the review mode in the BioGraph Infinity software and by manually marking each trial block (eight consecutive GO trials) and then extracting the average score by selecting the “show segment statistics” option.

Skin conductance. Two skin conductance sensors (SA9309M, Thought Technology Ltd. Canada), with two UniGel electrodes, were attached to the inner palm of the non-weapon arm in order to monitor skin conductivity in MicroMho (0 – 30 MΩ). An increase/decrease in MicroMho indicates an increase/decrease in anger-related arousal (Stemmler, 2004).

Skin surface temperature. Measured in Celsius, we used a single sensor (SA9310M, Thought Technology Ltd. Canada) to measure the skin surface temperature of the forehead. On average, the skin temperature range was 28ºC - 34ºC. In order to maintain a good reading and to standardize the temperature of the laboratory across testing sessions, the room temperature was set to a steady 22ºC.

Heart rate. Measured in number of heart beats per minute. The experimenter attached a blood volume pulse (BVP) sensor (SA9308M, Thought Technology Ltd. Canada) to the thumb on the non-weapon arm. This is a non-invasive sensor that uses an infrared finger photoplethysmograph to measure inter-beat intervals in the pulse rate.

Procedure

Imagery scripts. We composed two imagery scripts for inducing an emotion-neutral affect (appendix G) and anger (appendix H). The anger emotion script was based on Lazarus’s (1991, 2000a) core relational themes of anger and contained vivid details regarding stimuli, response, and meaning propositions to elicit physiological and cognitive activation consistent with the tested emotional state (Cumming, Olphin, & Law, 2007). The emotion-neutral script outlined the process of brushing one’s teeth (see Kavanagh & Hausfeld, 1986).

By recording the scripts into an audio file, we standardized the delivery of the imagery scripts.

Preparation stage. We recruited six volunteers for this study, and excluded data from two participants, a pilot participant and another participant because of poor single-integer scores correlation (as described in the following section). We scheduled each participant for a different day and provided him or her with information about the study in advance. The length of the study (i.e., intake forms and questionnaires: 20 minutes; visual-imagery training: 25 minutes; experimental task training: 15 minutes; single-integer learning: 30 minutes; experimental stage: nine sessions, 4 minutes each; total of 126 minutes) was discussed in order to stress the importance of their commitment throughout the study. I ensured participants agreed with the terms of the monetary reward stating that they would be paid $80 only upon full completion of the study.

On the day of the experiment, participants received a detailed explanation of the experiment schedule, terms, and conditions. We also provided them a full explanation of the measurements involved and informed of the purpose of the study. Each participant was encouraged to ask any questions that he or she may have in order to ensure they fully understood what was required of them. Then we asked the participant to complete a consent form (appendix I), and an intake form (appendix J) that included personal information and fencing experience before moving on to the next stage.

Imagery training stage. Visualization – vividly imagining scenes and events – was part of the current study's experimental procedure and was used as a way to induce neutral and/or anger emotional states in the participants. Studies have shown that anger responses, even in a laboratory "non-provocative" setting, can be quite strong (Stemmler, 2010). To this end, participants practiced visualization (internal visual, external visual, and kinaesthetic) on three commonplace scenes (see appendix K). The participants were informed that a vivid image is one where feel as if it were real, actual experience. Before each scene was presented, the experimenter provided them with imagery training in order to improve the participant's imagery ability.

During the next stage, the experimenter asked the participant to complete the VMIQ-2. The imagery induction technique that was used for this study required participants to identify specific emotional situations from their own lives and visualize them according to the standardized emotion script. All participants reached the criterion imagery ability level of l6 on the MIQR questionnaire (Callow et al., 2001).

Anger learning stage. Following the imagery training stage, the experimenter taught the participants how to self-report single-integer scores of the state-anger subscales (Spielberger et al., 1983; Spielberger & Reheiser, 2009), enabling a quick measurement of participants' anger-in and anger-out levels right before the beginning of each experimental fencing task. We administered the state-anger terminology of anger-in and anger-out in order to familiarize them with these concepts, then explained to the participant how to report the intensity of each of the subcomponents of the state-anger scale by stating a single number, ranging from 0 to 15, for the anger-in and anger-out subscales. This scale enabled the same range of scores to be kept for each of the state-anger subcomponents (minimum subscale score equals 5, minimum single-integer score equals 0) (Hardy, 1996a; Hardy et al., 2004).

The learning procedure went as follows: the participant completed a modified version of the state-anger scale in which the items for anger-in and anger-out were separated out. Then the participant referred his or her scores to the following two hypothetical scenarios: "How do you feel when someone cuts in front of you in line?" and "How do you feel when a customer service representative keeps you waiting too long?". For each scenario, immediately after completing the two subscales of the state-anger scale, a participant was presented with a Likert scale ranging from 0 to 15 for each subscale. These Likert scales were termed "Feeling angry" and "Feeling like expressing anger". We then asked the participant to report a single score for each subscale. Finally, we provided them with both sets of scores for each scenario so they could compare their single-integer scores to the state-anger adjusted[4]scores and see the accuracy of their single-integer scores.

The same comparison between the two measurements was repeated after each of the three following processes. First, we asked each participant to complete the original state-anger scale version (subscales are integrated) and then report a single number on a Likert scale for each of the subcomponents with respect to the hypothetical scenario "How do you feel when you make a foolish mistake in fencing?". During the next two processes, the original state-anger scale was used with respect to two scenarios: "How do you feel when you're behind a slow walker and there's no way around them?" and "How do you feel when someone other than your coach gives you negative feedback on your fencing skills?". For these two scenarios, a participant first reported a single number for each of the

[4] State-anger scores were adjusted by subtracting the number 5 from each of the anger-in and anger-out subscale scores.

subcomponents and then completed the state-anger scale. During the learning stage, the experimenter encouraged the participant to ask any questions that might aid his or her understanding.

We calculated correlation coefficients between the single-integer scores and the state-anger subscale scores across the five scenarios, in order to assess the reliability of the single-integer measures of anger-in and anger-out. The experimenter standardized the data collected during the anger learning stage within participants in order to control for individual differences in response sensitivity (Hardy, 1996a), and then pooled the data across participants. In order to detect those participants who did not achieve satisfactory correlations between the state-anger scale and the single-integer scores, we performed a linear regression analysis. One participant's single-integer scores correlated poorly with the state-anger subscale scores showing standard residual greater than 3. This participant's data had to be removed from the data set because the reliability of the self-reported measurements was analysed only after the data collection had been completed, so no additional training was possible. Hence, the correlations were calculated using 20 observations (5 scenarios × 4 participants) rather than 30. The resulting Pearson correlation coefficient were $r = 0.78$ for anger-in and $r = 0.88$ for anger-out (all $p < 0.001$). We considered these correlation coefficients high enough to justify further analysis of the single-integer scores.

Experimental procedure. Upon completion of the above described preparation stage, the participant put on his or her fencing glove and sat on a cube bench situated 44 cm above the floor in a testing room while holding his or her weapon. Performing the task from a sitting position enabled us to isolate the EMG and physiological recorded data from artefacts (e.g., bodily balance, legs movement, excessive body movement) that could stem from performing the task from a standing position. The experimenter then attached the equipment for measuring skin surface temperature, heart rate, and skin conductance. The experimenter abraded and degreased all recording sites using skin preparation gel (NuPrep) and alcohol wipes (BD) prior to affixing electrodes. For EMG recording the experimenter rubbed Ten-20 conductive paste onto the EMG electrode, and attached it to the weapon arm parallel to the muscle fibres in the belly of the triceps brachii muscle. The experimenter then performed an impedance check for measuring proper electrodes contact; all impedances were below 15 kOhms. The experimenter attached two skin-conductance electrodes to the palm of the passive arm (the arm not holding the weapon), a BVP sensor to the passive arm's thumb, a facial temperature sensor to the participants' forehead using adhesive tape, and placed noise-cancelling headphones on participants' ears.

The experimenter then instructed the participant to remain seated while his or her body aligned sideways with the weapon hand out front, to place the tip of the fencing foil on a mark and look at the target and computer screen. The experimenter asked a participant to sit comfortably and quietly during a *rest period* of two minutes, and to refrain from talking, moving, and falling asleep, or engaging in any specific technique or practice. An audio recording imagery script followed the rest period. During this script, the participant listened to the following instructions through the headphones:

You will soon hear a situation being described to you. Your task is to close your eyes and imagine yourself in the situation being described, as if it were happening right now. Allow yourself to become completely involved in the situation, by involving your mind and body in actually doing what is being described. Continue imagining until you are asked to stop.

The corresponding imagery script (appendices G & H) was then presented through the headphones. When the imagery script had finished, the experimenter asked the participant to report anger-in and anger-out levels by stating a single number for each of the subcomponents.

The format for script presentation and measurements was as follows: A two-minute rest period, a visualization period during which the script was played over the headphones to the participant within a 30-second image period. At the end of each imagery session, a participant stated a single number for each of the state-anger subcomponents. Then the experimenter stated, "Please hit the centre point of the target as accurately and quickly as possible". While still seated, the participant then performed a set of eight attacks at the target in response to the Go/NoGo stimulus appearing on the screen in front of them (as shown in Figure 3). Similar to a protocol used in a similar fencing study (Frère et al., 2011), after each attack a participant returned the tip of the weapon to the exact same resting point, 37 cm above the floor and between 18 and 22.7 cm from the target so that the distance from the target remained the same before each attack. Specifically, the measure was derived by having a participant extend his or her weapon arm so they can reach the target and then place the tip on the resting mark. The distance depended on the participant's reach: Fencer A: 18 cm, Fencer B: 22.7 cm, Fencer C: 20 cm, and Fencer D: 22.5 cm.

Figure 3. Full extension of the weapon arm.

The task[5] consisted of nine *sessions*; each included 8 *trials* (in order to use average values of the response-times, hitting points and the peak muscle activity). To help avoid anticipation effects, catch trials (i.e., a red *NoGo* stimulus) were randomly employed at a ratio of one to four; 8 GO (i.e., *Trial block*) and 2 NoGo.

The same experimental task format (i.e., two-minute rest, visualization period, and eight attacks) was repeated nine times. Upon completion of the nine experimental sessions, eight attacks toward the target during each session, the experimenter removed all recording electrodes and gave the participant ten minutes to rest. The experimenter then conducted a short one-on-one interview in order to collect qualitative data on their experience of the study.

[5] We gave each participant 15 minutes to practice, allowing him or her to become familiar with the experimental task.

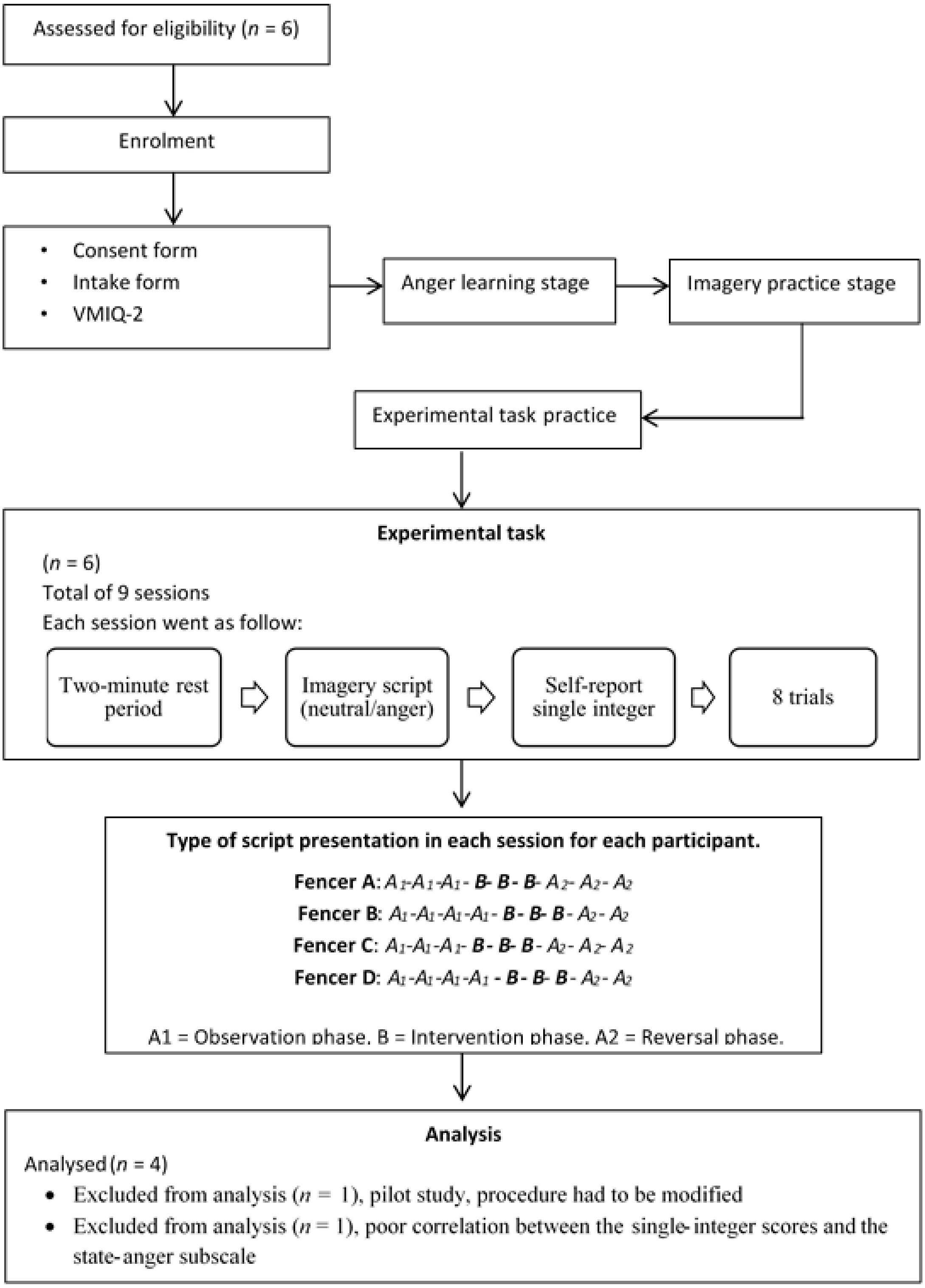

Figure 4. Flowchart of the experiment.

Data Analysis

The current laboratory-based experiment consisted of a lengthy post inspection process of the data collected. The process included going through each participant's physiological recordings and manually marking the trials to compute EMG activity on a trial by trial basis. It also involved frame-by-frame analyses of the webcam footage to detect the hitting points on the x and y axes, and then coding it as a *Radial error*.

Due to the large amount of data collected (5184 data points), we averaged the psychophysiological indices, performance (i.e., response-time and precision) and trial-by-trial EMG peaks for each block of trials. We then calculated means for each experimental phase (i.e., phases $A_{1,}$ B and A_2) according to the experimental procedure. Next, we calculated linear best-fit trend-line, mean-line, and slope for each data block and created graphs of the above-described data for visual inspection. To assess the effects within single-case designs six features are used to examine between-phase data patterns, these are: *level*, *trend*, *variability*, *immediacy* of the effect, *overlap*, and *consistency* of data patterns across similar phases (Gast, Ledford, & Ledford, 2008; Kazdin, 2011; Morgan & Morgan, 2008).

Constructing a trend-line enables change in slope across phases to be calculated (see Kazdin, 2011 for details of slope calculations). The slope of trend-lines is expressed in a ratio with a plus sign (+) to indicate a positive slope or a minus sign (-) to signify a negative slope. Once the trend lines have been determined, a Binomial test can be used to assess significance of change between the phases.

In order to determine whether changes in the physiological, performance and muscle activity data resulted from experimental effect, we conducted visual examination of the data (including a Binomial test). This method of analysis is standard in single-case research and allows manageable and self-explanatory analysis via pictorial illustration of the data (Bloom, Fischer, & Orme, 2006; Kinugasa, Cerin, & Hooper, 2004).

Consistency of data in similar phases involves looking at data patterns from all phases within the same condition, the greater the consistency, the more likely the data represent a causal relation (Hrycaiko & Martin, 1996; Kratochwill et al., 2010). Level refers to the mean score for the data within a phase. Trend refers to the slope of the best-fitting straight line for the data within a phase, a zero-celeration trend or in an opposite direction to those predicted by the effect of the intervention increases our confidence that an effect has been observed. Variability refers to the fluctuation of the data (as reflected by the data's range or standard deviation) around the mean. Immediacy of the effect refers to the change in level between the last data point in one phase and the first data point of the next, the more immediate the effect, the more convincing the inference that change in the outcome measure was due to the intervention. Overlap refers to the proportion of data from one phase that overlaps with data from the previous phase. The greater the percentage of non-overlapping data points (*PND*), the more compelling the demonstration of an effect.

These features are assessed individually and collectively to determine whether the results demonstrate a causal relation between an independent variable and an outcome variable. Visual analysis is used to assess whether the data demonstrate at least three indications, as featured above, of an effect at different points in time. If this criterion is met, the data are deemed to document a causal relation, and an inference may be made that change in the outcome variable is causally related to manipulation of the independent variable.

Results

State-anger emotional state and bodily activity

We expected state-anger to increase at the intervention phase (Performers A and C: Trial-blocks 4, 5 and 6; Performers B and D: Trial-blocks 5, 6, and 7), following the imagery anger-induced intervention, and to return to baseline levels at the reversal phase (Performers A and C: Trial-blocks 7, 8 and 9; Performers B and D: Trial-blocks 8 and 9). Furthermore, we expected to see elevations in the physiological indices in order to support the self-report measures and to illuminate underlying physiological reactions that are associated with increased anger and its relationship with performance.

As can be seen in Figure 5, self-report scores in the intervention phase (B) differed from the observation phase (A_1) and the reversal phase (A_2) for both anger-in and anger-out, and across all participants. A visual inspection of the physiological indices data revealed increases in the B phase in skin surface temperature for Fencer A and in heart-rate for Fencer B. The mean skin surface temperature for Fencer A increased from 33.84 ºC in the observation phase (A_1) to 34.52 ºC in the intervention phase (B), and to 34.61 ºC in the reversal phase (A_2). This represents a temperature increase of 2% across the A_1 and B phases and a subsequent zero-percent change from the B phase to the A_2 phase. The positive trend in the observation phase (A_1) was accelerated in the intervention phase (B) by a ratio of +1.01, and was reversed by a ratio of -1.03 in the reversal phase (A_2). The mean heart rate for Fencer B increased from 86.13 beats per-minute in the observation phase (A_1) to 89.83 beats per-minutes in the intervention phase (B), and decreased to 85.87 beats per-minute in the reversal phase (A_2). This represents a heart rate increase of 4% across the A_1 and B phases and a subsequent decrease of 4% from the B phase to the A_2 phase. The negative trend in the observation phase (A1) was reversed to a positive trend in the intervention phase (B) by a ratio of +1.10, and was decreased to a zero-celeration trend by a ratio of -1.02 in the reversal phase (A2). The immediacy of the effect was reflected by a ratio change of +1.06 phases (+ denoting a step up) immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}}$ = 83.97; $M_{\text{Trial-block 5}}$ 89.27). When the reversal condition was reintroduced (A_2), the immediacy of the effect was reflected by a ratio change of -1.07 phases (- indicating a step down) ($M_{\text{Trial-block 7}}$ = 91.50; $M_{\text{Trial-block 8}}$ = 85.82).

Summary. All four participants (i.e., Fencer A, Fencer B, Fencer C, and Fencer D) self-reported greater state-anger levels in the intervention phases than in the observation and reversal phases. Visual inspection of the graphs (Figure 5), and the data analysis as illustrated above, suggests that the introduction of the intervention led to an increase in the skin surface temperature of Fencer A, hence providing additional support to Fencer A’s self-report measure. In addition, the data analysis revealed an elevation in the heart rate for Fencer B in the intervention phase, which corroborates Fencer B’s self-report measure. In the follow up interview, Fencer B said: “I definitely don’t think I was as angry as in the bouts… but it definitely worked”.

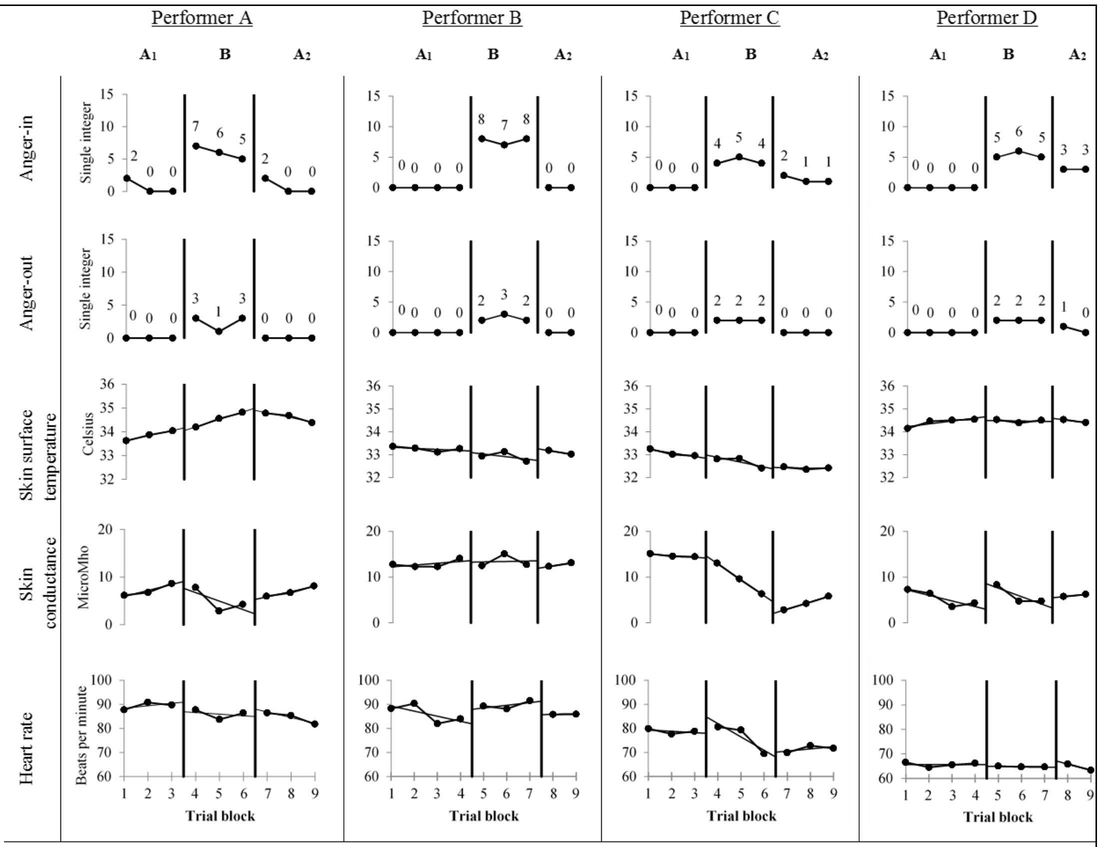

Figure 5. Anger-in and anger-out self-report, and psychophysiological indices.
A_1 = observation phase, B = intervention phase, A_2 = reversal phase.

Performance

Precision. The radial-error in centimetres between the foil's striking point and the target's centre point, as presented in Table 1.

Table 1.

Mean, Standard deviation, and slope for each participant for the observation, intervention, and reversal phases.

Fencer	Observation phase (A_1)			Intervention phase (B)			Reversal phase (A_2)		
	M	*SD*	*Slope*	*M*	*SD*	*Slope*	*M*	*SD*	*Slope*
A	5.23	3.13	-1.43	7.38	4.99	+1.07	5.39	2.85	+1.12
B	7.45	4.03	-1.07	7.58	3.30	1	6.71	3.71	-1.21
C	5.39	3.32	-1.60	5.56	3.87	+1.03	7.00	3.53	+1.28
D	5.26	3.61	-1.17	5.85	2.45	+1.15	5.85	4.86	-1.21

Note. *M* = mean; *SD* = standard deviation; A_1 = emotion-neutral condition; *B* = anger condition; A_2 = emotion-neutral condition.

Fencer A. As shown in Table 1, the mean radial-error scores for Fencer A increased from 5.23 in the pre-experimental observation phase (A_1) to 7.38 in the intervention phase (B), and decreased back to 5.39 in the reversal phase (A_2). This represents a precision decrease of 41% across the A_1 and B phases and a subsequent increase of 27% from the B phase to the A_2 phase. As shown in Figure 6, the deceleration trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of +1.5, and was increased by +1.05 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of +1.60 phases (+ denoting a step up) immediately upon the introduction of the intervention ($M_{\text{Trial-block 3}} = 4.31$, $SD_{\text{Trial-block 3}} = 2.53$; $M_{\text{Trial-block 4}} = 6.91$, $SD_{\text{Trial-block 4}} = 5.14$). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of -1.54 phases (- indicating a step down) ($M_{\text{Trial-block 6}} = 7.14$, $SD_{\text{Trial-block 6}} = 6.20$; $M_{\text{Trial-block 7}} = 4.64$, $SD_{\text{Trial-block 7}} = 1.97$). All three data points in the B phase were greater than the largest data point in the A_1 and the A_2 phases (PND = 100%). The completion of a Binomial test demonstrated that the precision performance scores decreased significantly ($p < 0.001$) following the introduction of the intervention.

Fencer B. The mean radial-error scores for Fencer B increased from 7.45 in the observation phase (A_1) to 7.58 in the intervention phase (B), and decreased to 6.71 in the reversal phase (A_2). This represents a precision decrease of 2% across the A_1 and B phases and a subsequent increase of 11% from the B phase to the A_2 phase. As shown in Figure 6, the deceleration trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of +1.07, and was reversed back to a decelerating trend by a ratio of -1.21 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of 1.00 phases, indicating a zero change immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}} = 7.37$, $SD_{\text{Trial-block 4}} = 4.12$; $M_{\text{Trial-block 5}} = 7.32$, $SD_{\text{Trial-block 5}} = 3.96$). When the reversal condition was reintroduced (A_2), the immediacy of the effect was reflected by a ratio change of +1.04 ($M_{\text{Trial-block 7}} = 7.28$, $SD_{\text{Trial-block 7}} = 3.82$; $M_{\text{Trial-block 8}} = 7.59$, $SD_{\text{Trial-block 8}} = 3.35$). None of the data points in the B phase were greater than the greatest data point in the A_1 phase. One data point in the B phase was greater than the greatest data point in the A_2 phase. The completion of a Binomial test demonstrated that the precision scores decreased significantly ($p < 0.001$) following the introduction of the intervention.

Fencer C. The mean radial-error scores for Fencer C increased from 5.39 in the A_1 phase to 5.56 in the B phase, and increased to 7.00 in the reversal phase (A_2). This represents a precision decrease of 3% across the A_1 and B phases and a decrease of 26% from the B phase to the A_2 phase. As shown in Figure 6, the deceleration trend in the observation phase (A_1) was reversed to an acceleration trend in the intervention phase (B) by a ratio of +1.65, and was increased by +1.24 in the reversal phase (A_2). The immediacy of the effect is reflected by a ratio change of +1.45 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 3}} = 4.05$, $SD_{\text{Trial-block 3}} = 2.25$; $M_{\text{Trial-block 4}} = 5.86$, $SD_{\text{Trial-block 4}} = 3.74$). The level changed by a ratio of +1.11immediately upon the reintroduction on the reversal condition (A_2). None of the data points in the B phase were greater than the greatest data point in either the A_1 or the A_2 phases. The completion of a Binomial test demonstrated that the precision scores decreased significantly ($p < 0.001$) following the introduction of the intervention.

Fencer D. The mean radial-error scores for Fencer A increased from 5.26 in the observation phase (A_1) to 5.85 in the intervention phase (B), and remained the same in the reversal phase (A_2). This represents a precision decrease of 11% across the A_1 and B phases and a zero change from the B phase to the A_2 phase. A shown in Figure 6, the deceleration trend in the A_1 phase was reversed in the B phase by a ratio of +1.34, and was reversed back to a deceleration trend by a ratio of -1.39 in the A_2 phase. Upon the introduction of the intervention, the level changed by a ratio of +1.11 ($M_{\text{Trial-block 4}} = 4.57$, $SD_{\text{Trial-block 4}} = 2.91$; $M_{\text{Trial-block 5}} = 5.09$, $SD_{\text{Trial-block 5}} = 2.24$), and was changed by a ratio of +1.15 when the intervention was withdrawn ($M_{\text{Trial-block 7}} = 5.71$, $SD_{\text{Trial-block 7}} = 3.23$; $M_{\text{Trial-block 8}} = 6.56$, $SD_{\text{Trial-block 8}} = 4.71$). A single data point in the B phase was greater than the data points in the A_1 and A_2 phases. The completion of a Binomial test demonstrated that the decrease in precision scores was non-significant ($p = 0.92$), following the introduction of the intervention.

Summary. Visual inspection of the graphs (Figure 6), and the data analysis as illustrated above suggests that the introduction of the intervention led to a performance decline in precision performance. The change in performance following the introduction of the intervention suggests a debilitating impact on the performance of Fencer A, Fencer B, Fencer C, and Fencer D. However, Fencer C's precision scores did not return to baseline in the reversal phase, while Fencer D's Binomial test was non-significant.

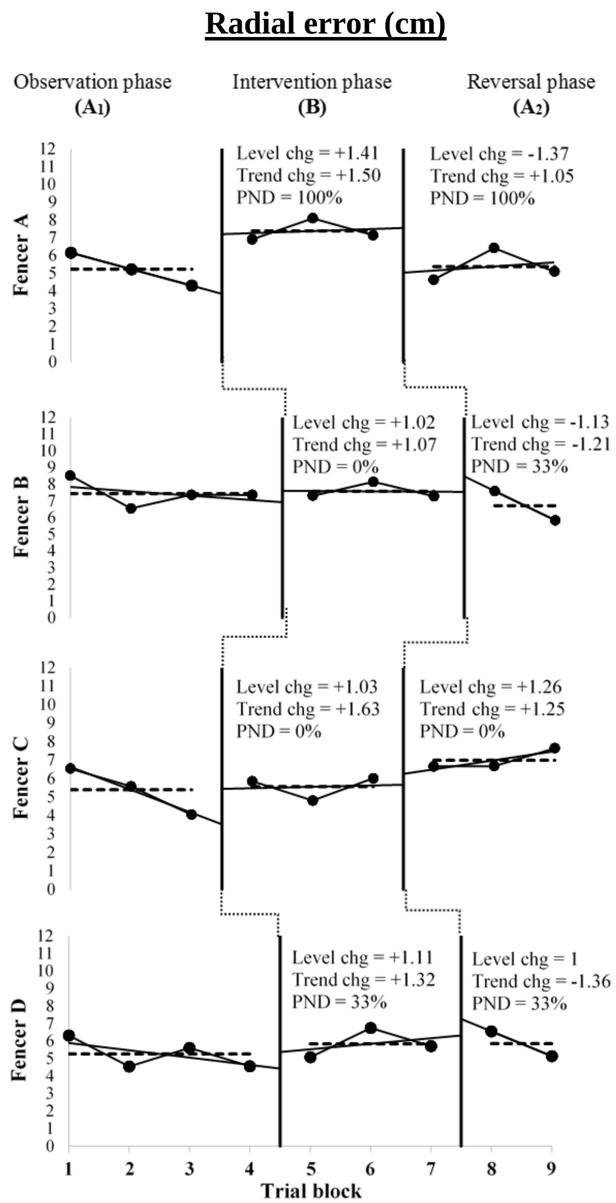

Figure 6. Results for Radial error in centimetres using the least-squares regression method for data analysis.
In all performance figures, solid vertical line shows the point of phase change. Solid lines represent trend lines. Dashed lines indicate mean scores for successive Trial Blocks within a phase. Level change, trend change, and Percentage of Non-Overlapping Data (PND) are shown for each Trial Block.

Response time. The time in milliseconds between the appearance of the GO stimuli and the moment the fencing foil hits the target is presented in Table 2.

Table 2.

Mean, Standard deviation, and slope for each participant for the observation, intervention, and reversal phases.

Fencer	Observation phase (A_1)			Intervention phase (B)			Reversal phase (A_2)		
	M	*SD*	*Slope*	*M*	*SD*	*Slope*	*M*	*SD*	*Slope*
A	507.46	38.11	1	500.04	42.81	-1.04	492.38	34.80	1
B	486.34	41.15	+1.02	462.71	47.32	-1.08	481.00	31.47	+1.24
C	581.50	53.32	+1.04	584.21	55.59	-1.06	609.63	29.30	-1.02
D	778.75	84.86	-1.10	633.42	45.86	+1.01	637.38	57.69	+1.23

Note. M = mean; SD = standard deviation; A_1 = emotion-neutral condition; B = anger condition; A_2 = emotion-neutral condition.

Fencer A. The mean response-time for Fencer A decreased from 507.46 in the observation phase (A_1) phase to 500.04 in the intervention phase (B). The mean response-time decreased to 492.38 in the A_2 phase when the intervention was withdrawn, this indicates a 1.5% reduction in response-time across the observation and intervention phases, and across the intervention and reversal phases. As shown in Figure 7, the zero-celerating trend in the A_1 phase was changed to a decelerating trend by a ratio of -1.04 when the intervention was introduced (B). This trend was reversed by a ratio of +1.04 when the intervention was withdrawn A_2. The immediacy of the effect of the intervention was reflected by a ratio change of -1.01 in response-time ($M_{\text{Trial-block 3}}$ = 513.13, $SD_{\text{Trial-block 3}}$ = 31.68; $M_{\text{Trial-block 4}}$ = 512.25, $SD_{\text{Trial-block 4}}$ = 29.08). When the intervention was removed, the immediacy of the effect was reflected by a ratio change of 1, indicating a zero change ($M_{\text{Trial-block 6}}$ = 488.75, $SD_{\text{Trial-block 6}}$ = 49.13, $M_{\text{Trial-block 7}}$ = 489.88 $SD_{\text{Trial-block 7}}$ = 39.78). One data point in the B phase was below the lowest data point in the A_1 phase (PND = 33%). None of the data points in the B phase was below the lowest data points in the A_2 phase (PND = 0%). The completion of a Binomial test demonstrated that the response-time performance did not improve significantly (p = .99) following the introduction of the intervention. In the follow-up interview, Fencer A stated that she was focusing on precision and not much on response-time.

Fencer B. The mean response-time for Fencer B decreased from 486.34 in the observation phase (A_1) to 462.71 in the intervention phase (B), and increased to 481.00 in the reversal phase (A_2). This represents a response-time decrease of 5% across the A_1 and B phases and a subsequent increase of 4% from the B phase to the A_2 phase. As shown in Figure 7, the accelerating trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of -1.10, and was reversed to an acceleration trend by a ratio of +1.34 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of -1.01 immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}} = 484.38$, $SD_{\text{Trial-block 4}} = 28.65$; $M_{\text{Trial-block 5}} = 479.00$, $SD_{\text{Trial-block 5}} = 65.44$). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of +1.06 ($M_{\text{Trial-block 7}} = 438.88$, $SD_{\text{Trial-block 7}} = 31.05$; $M_{\text{Trial-block 8}} = 465.88$, $SD_{\text{Trial-block 8}} = 32.85$). One data point in the B phase was below the lowest data point in the A_1 and in the A_2 phases. The completion of a Binomial test demonstrated that the response-time performance improved significantly ($p < 0.001$) following the introduction of the intervention.

Fencer C. The mean response-time for Fencer C increased from 581.50 in the A_1 phase to 584.21 in the B phase, and increased to 609.63 in the subsequent A_2 phase. This represents a zero response-time increase across the A_1 and B phases and a subsequent increase of 4% from the B phase to the A_2 phase. As shown in Figure 7, the accelerating trend in the A_1 phase was reversed in the B phase by a ratio of -1.10, and was decreased by +1.04 in the A_2 phase. The immediacy of the effect was reflected by a zero change immediately upon the introduction of the intervention ($M_{\text{Trial-block 3}} = 591.75$, $SD_{\text{Trial-block 3}} = 55.26$; $M_{\text{Trial-block 4}} = 591.13$, $SD_{\text{Trial-block 4}} = 67.58$). When the intervention condition was withdrawn the immediacy of the effect was reflected by a ratio change of +1.12 ($M_{\text{Trial-block 6}} = 554.13$, $SD_{\text{Trial-block 6}} = 37.79$; $M_{\text{Trial-block 7}} = 620.00$, $SD_{\text{Trial-block 7}} = 26.05$). A single data point in the B phase was lower than the lowest data point in the A_1 phase. Two data points in the B phase were lower than the lowest data point in the A_2 phase. The completion of a Binomial test demonstrated that the response-time performance did not improve significantly ($p = 0.99$) following the introduction of the intervention.

Fencer D. The mean response-time for Fencer D decreased from 778.75 in the observation phase (A_1) to 633.42 in the intervention phase (B), and increased to 637.38 in the reversal phase (A_2). This represents a response-time decrease of 19% across the A_1 and B phases and a subsequent increase of 1% from the B phase to the A_2 phase. As shown in Figure 7, the decelerating trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of +1.11, and was increased by +1.22 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of -1.23 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}} = 761.75$, $SD_{\text{Trial-block 4}} = 69.89$; $M_{\text{Trial-block 5}} =$

620.50, $SD_{\text{Trial-block 5}} = 38.64$). When the intervention condition was withdrawn (A_2) the immediacy of the effect was reflected by a ratio change of +1.01 ($M_{\text{Trial-block 7}} = 626.50$, $SD_{\text{Trial-block 7}} = 47.08$; $M_{\text{Trial-block 8}} = 617.50$, $SD_{\text{Trial-block 8}} = 65.32$). All three data points in the B phase were below the lowest data point in the A_1 phase. None of the data points in the B phase were below the lowest data point in the A_2 phase. The completion of a Binomial test demonstrated that the response-time performance did not improve significantly ($p = 0.99$) following the introduction of the intervention.

Summary. Visual inspection of the graphs (Figure 7), and the data analysis as illustrated above, shows a decrease in means from the A_1 to the B phase for Fencer A, Fencer B, and Fencer D, implying that the introduction of the intervention led to faster response-times, with the exception of Fencer C. However, only Fencer B demonstrated a statistically significant change in response-time between the anger phase and the pre and post emotion-neutral phases. Fencer A’s and Fencer D’s response-time did not return to the base-line level when the intervention was withdrawn.

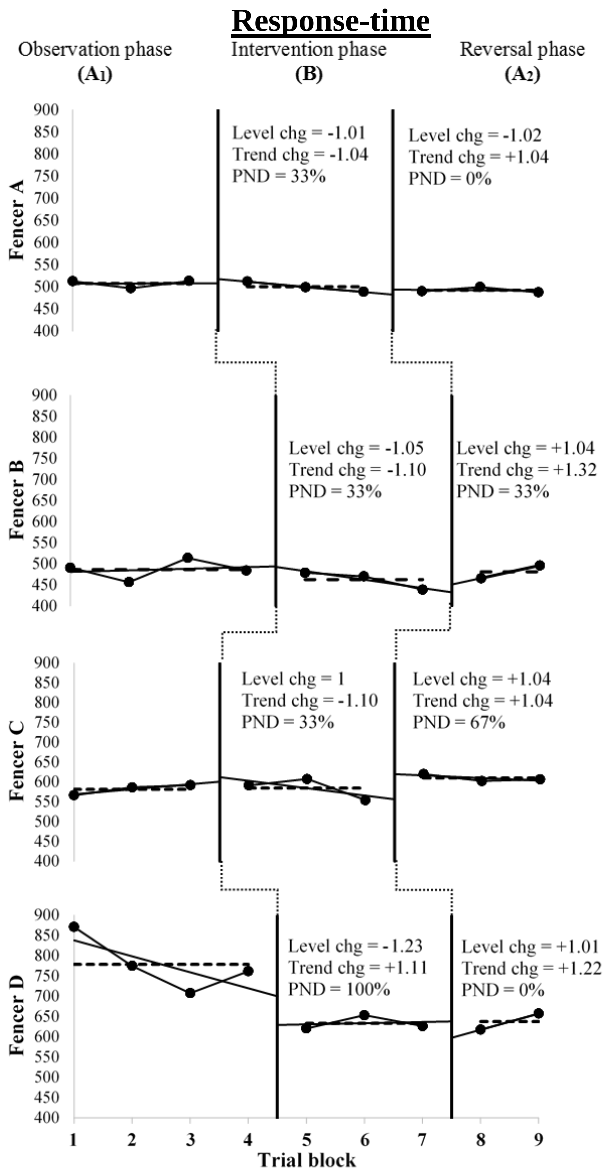

Figure 7. Results for Response time in milliseconds using the least-squares regression method for data analysis.
In all performance figures, solid vertical line shows the point of phase change. Solid lines represent trend lines. Dashed lines indicate mean scores for successive Trial Blocks within a phase. Level change, trend change, and Percentage of Non-Overlapping Data (PND) are shown for each Trial Block.

Peak muscle activity. The peak muscle activity in microvolts of the triceps of the weapon arm, as presented in Table 3.

Table 3.

Mean, Standard deviation, and slope for each participant for the observation, intervention, and reversal phases.

Fencer	Observation phase (A_1)			Intervention phase (B)			Reversal phase (A_2)		
	M	*SD*	*Slope*	*M*	*SD*	*Slope*	*M*	*SD*	*Slope*
A	346.17	80.24	+1.09	289.02	51.64	-1.05	146.47	32.24	-1.19
B	372.22	102.17	-1.20	397.39	93.53	-1.04	356.13	66.65	-1.17
C	172.53	49.11	-1.09	203.59	59.03	+1.19	203.33	44.99	-1.09
D	90.39	32.22	+1.54	127.69	43.99	-1.13	116.88	31.36	-1.13

***Note*.** *M* = mean; *SD* = standard deviation; A_1 = emotion-neutral condition; *B* = anger condition; A_2 = emotion-neutral condition.

Fencer A. As shown in Table 3, the mean peak-muscle activity scores for Fencer A decreased by 17% across the observation (A_1) and intervention phases (B), and decreased by 49% across the intervention (B) and reversal (A_2) phases. As shown in Figure 8, the acceleration trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of -1.14, and was increased by -1.13 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of -1.12 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 3}}$ = 340.75, $SD_{\text{Trial-block 3}}$ = 52.72; $M_{\text{Trial-block 4}}$ = 304.77, $SD_{\text{Trial-block 4}}$ = 36.51). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of -1.66 ($M_{\text{Trial-block 6}}$ = 288.86, $SD_{\text{Trial-block 6}}$ = 54.83; $M_{\text{Trial-block 7}}$ = 173.84, $SD_{\text{Trial-block 7}}$ = 16.32). None of the data points in the B phase were greater than the highest data point in the A1 phase (PND = 100%). All data points in the B phase were greater than the highest data point in the A2 phase (PND = 100%). The completion of a Binomial test demonstrated that the peak-muscle activity did not increase significantly (p = 0.92) following the introduction of the intervention.

Fencer B. The mean peak-muscle activity scores for Fencer B increased by 7% across the observation (A_1) and intervention phases (B), and decreased by 10% across the intervention (B) and reversal (A_2) phases. The deceleration trend in the observation phase (A_1) was reduced in the intervention phase (B) by a ratio of +1.15, and was increased by a ratio of -1.13 in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of +1.22 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}}$ =

333.87, $SD_{\text{Trial-block 4}} = 79.04$; $M_{\text{Trial-block 5}} = 408.94$, $SD_{\text{Trial-block 5}} = 132.98$). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of -1.06 ($M_{\text{Trial-block 7}} = 393.16$, $SD_{\text{Trial-block 7}} = 69.91$; $M_{\text{Trial-block 8}} = 371.37$, $SD_{\text{Trial-block 8}} = 85.37$). None of the data points in the B phase was greater than the greatest data point in the A_1 phase. In the B phase, all data points were greater than the greatest data point in the A_2 phase. The completion of a Binomial test demonstrated that the peak-muscle activity increased significantly ($p < 0.01$) following the introduction of the intervention.

Fencer C. The mean peak-muscle activity scores for Fencer C increased by 18% across the observation (A_1) and intervention phases (B), and remained the same across the intervention (B) and reversal (A_2) phases. As shown in Figure 8, the deceleration trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of +1.30, and was reversed back in the reversal phase (A_2) by a similar ratio of -1.30. The immediacy of the effect was reflected by a ratio change of +1.34 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 3}} = 157.37$, $SD_{\text{Trial-block 3}} = 37.70$; $M_{\text{Trial-block 4}} = 211.32$, $SD_{\text{Trial-block 4}} = 58.11$). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of -1.10 ($M_{\text{Trial-block 6}} = 239.59$, $SD_{\text{Trial-block 6}} = 57.13$; $M_{\text{Trial-block 7}} = 217.46$, $SD_{\text{Trial-block 7}} = 56.20$). Two data points in the B phase (PND = 67%) were greater than the greatest data point in the A_1 phase, and one data point in the B phase was greater (PND = 33%) than the greatest data point in the A_2 phase. The completion of a Binomial test demonstrated that the peak-muscle activity increased significantly ($p = 0.01$) following the introduction of the intervention.

Fencer D. The mean peak-muscle activity scores for Fencer D increased by 41% across the observation (A_1) and intervention phases (B), and decreased by 8% across the intervention (B) and reversal (A_2) phases. The acceleration trend in the observation phase (A_1) was reversed in the intervention phase (B) by a ratio of -1.74, and was not changed in the reversal phase (A_2). The immediacy of the effect was reflected by a ratio change of +1.17 phases immediately upon the introduction of the intervention ($M_{\text{Trial-block 4}} = 117.86$, $SD_{\text{Trial-block 4}} = 37.98$; $M_{\text{Trial-block 5}} = 138.31$, $SD_{\text{Trial-block 5}} = 59.87$). When the reversal condition was reintroduced (A_2) the immediacy of the effect was reflected by a ratio change of +1.03 ($M_{\text{Trial-block 7}} = 118.56$, $SD_{\text{Trial-block 7}} = 29.46$; $M_{\text{Trial-block 8}} = 122.51$, $SD_{\text{Trial-block 8}} = 39.28$). All three data points in the B phase were larger than the largest data point in the A_1 phase (PND = 100%). Two data points in the B phase were larger than the largest data point in the A_2 phase

(PND = 67%). The completion of a Binomial test demonstrated that the peak-muscle activity did not increase significantly ($p = 0.85$) following the introduction of the intervention.

Summary. The increase in means from the A_1 to the B phase for Fencer B, Fencer C and Fencer D, suggests that the introduction of the intervention led to higher peak muscle activity. The change in performance following introduction of the intervention suggests an immediate impact on performance. Fencer A demonstrated a gradual reduction in peak-muscle activity across the phases. Fencer D's Binomial test was not significant, hence only Fencer B and Fencer C showed more powerful attacks in the anger condition.

Peak-muscle activity

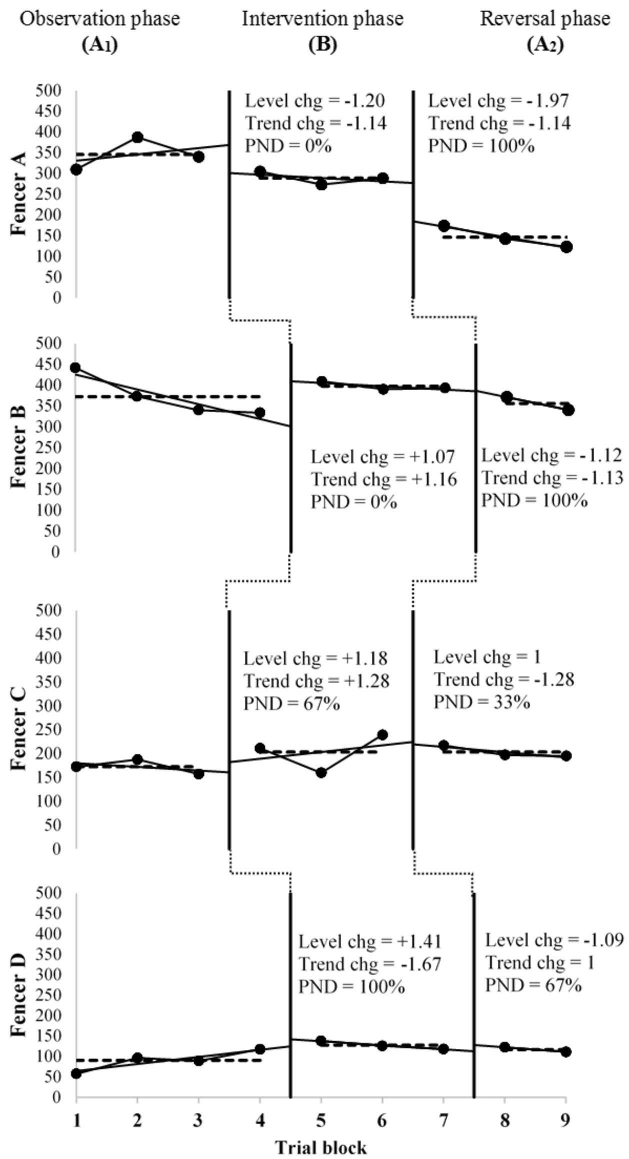

Figure 8. Results for Peak-muscle activity using the least-squares regression method for data analysis.

In all performance figures, solid vertical line shows the point of phase change. Solid lines represent trend lines. Dashed lines indicate mean scores for successive Trial Blocks within a phase. Level change, trend change, and Percentage of Non-Overlapping Data (PND) are shown for each Trial Block.

Discussion

The purpose of the current research study was to conduct a repeated measures experiment for anger-performance investigations. Many questions need to be explored in order to extend the breadth of available knowledge of anger in relation to athletic performance. Three of these questions have been examined in the present research study. First, the relationships between anger and performance of fine motor skill tasks. Second, the use of a laboratory-based experiments in order to reveal an underlying kinematics mechanism when performing under anger. Third, the investigation of anger over a longer period of time through repeated, non-traditional experimental designs, that includes a multiple-baseline single-case study design.

Participants experienced higher levels of anger in the intervention phase, and participants reported greater single-integer scores in the B phase than in the pre and post intervention phases. Thus, in terms of the self-report data, the manipulation was successful. However, according to the physiological indices data the intervention seemed more effective for Fencer A and Fencer B (i.e., the more experienced fencers) than for Fencer C and Fencer D (i.e., the intermediate level fencers). In the intervention phase, the physiological data revealed a slight rise (i.e., positive increase in trend) in skin-surface temperature for Fencer A, and a significant increase in heart rate for Fencer B. As has been demonstrated in a meta-analysis of somatovisceral anger, when compared to control, anger was positively associated with changes in heart rate and facial skin-surface temperature (Stemmler, 2004). The change in skin-surface temperature results may be an indication of a more suppressive form of anger ("hot liquid under pressure"), and the elevated heart rate data may indicate a more expressive form of anger ("feeling like expressing anger"). According to the self-reported anger scores, all participants apart from Fencer B experienced a carryover effect for anger-in from the intervention phase to the second emotion-neutral phase (A_2). This effect is likely an artefact of the intervention. That is, participants might struggle to return to baseline levels after being exposed to emotion-laden interventions such as the one that we used in the present study.

The impact of state-anger on precision, response-time, and peak-muscle activity of fencing performance on the four individual performers was tested repeatedly over three phases. The observation phase ($A_{1)}$ represented the baseline stage of the study, followed by the B phase in which the intervention was introduced, which was then followed by the final phase (second phase A) and consisted of the withdrawal of the intervention and the reintroduction of the emotion-neutral imagery script (i.e., return to the baseline level).

Fencer A and Fencer B demonstrated a decrease in precision during the anger condition, thus supporting the contention that increased state-anger is harmful to the performance of a fine motor skill task. These results were consistent with findings by Martinent et al. (2012); Martinent and Ferrand (2009) who found that the experience of anger during a table-tennis competition was detrimental to performance. Fencer C and Fencer D also demonstrated a decrease in their precision during the anger condition. However, the precision of their performance did not recover to base-line levels in the second emotion-neutral phase. One possible explanation for these results can be explained by the fact that both fencers were of intermediate experience and, consequently, might not have had the stamina and skills required to sustain a consistent level of performance for longer periods of time. Support for this argument can be drawn from Fencer C's sudden drop in heart rate and skin conductance beginning at trial-block 5 and onward. Heart rate can be associated with effort and skin conductance with physiological arousal hence these factors may indicate a decrease in level of alertness (Ito et al., 2011; M. Jones et al., 2009).

The results for the response-time scores indicated that Fencer B produced faster response-times during the anger condition than in the emotion-neutral condition. Visual inspection, including a significant Binomial test result, showed a significant improvement in response-time for Fencer B, indicating a positive effect for the anger intervention on speeding up the time taken to hit the target.

Regarding Fencer A's response-time results, we suggest that the fencer might have adopted a precision strategy that emphasized attacking as accurately as possible. Therefore, the changes in response-time were not apparent. In the follow-up interview, Fencer A said, "I was focusing on precision, not much on response-time". This statement may provide an explanation for why Fencer A's response-time did not change throughout the experimental phases. Furthermore, due to Fencers A's high proficiency level (i.e., Olympic) it is possible that there was a floor effect in the response-time for this fencer. Specifically, her response time was likely so proficient at baseline that it was not possible for her to improve. An explanation for Fencer C's unchanged response times may be due to her fatigue, as described earlier. Fencer D produced faster response-times when in the anger condition than in the first emotion-neutral condition; however, Fencer D's times were at least 1.5 times slower during the pre-intervention phase (A_1) than those of the other participants. For example, elite level fencers tend to show considerably faster response-times than novice fencers and demonstrate efficient timing patterns that result from well-coordinated limb movements (L. Williams &

Walmsley, 2000). In addition, the Binomial test for Fencer D did not yield significant results. Hence, these results largely reflected a learning curve effect along the A_1 and B phases rather than the anger-performance influences.

The results for the peak-muscle activity suggest a facilitative effect for anger on the peak force during an attack (i.e., flèche) of an experienced fencer. Fencer B demonstrated more powerful attacks in the anger condition than in the pre and post emotion-neutral conditions. She said, “In the anger scenarios, I cycled through sort of spots in my history…I definitely don’t think I was as angry as in the bouts…but it definitely worked.” The Binomial test showed a significant elevation in peak muscle activity in the anger phase. These results are consistent with previous findings by Davis et al. (2010); Woodman et al. (2009). In their studies, anger resulted in significantly improved performance during gross motor peak-force tasks, which was consistent with Fencer B’s elevated heart rate in the anger phase. The results for Fencer A provided another support for our earlier argument, which was based largely on her report in the follow-up interview. This report stated that she had invested energy in precision performance only. Fencer A demonstrated a gradual decreased in power-strength throughout the phases. A visual examination revealed a positive effect of anger on peak-muscle activity for Fencer C, the Binomial test was significant. Interestingly, these results challenge our argument that Fencer C experienced fatigue at trial block 6 and onward. It can be suggested that Fencer C experienced a decrease in cognitive effort and ability to maintain high alertness (Woodman et al., 2010). This suggestion, reflected in the sudden drop in skin conductance levels, whereas the results indicate an increase in motivational effort. This argument is also supported by Fencer C’s unchanged response-time in the anger condition. As noted by Eysenck and Calvo (1992); Eysenck, Derakshan, Santos, and Calvo (2007), when effort is more motivational than cognitive, a reaction time task would be less effective at detecting changes in effort. Consequently, Fencer C performed more powerful attacks while in the anger condition, and her response-time and precision performance reduced gradually across the phases. A visual inspection of the results also showed a substantial elevation in power-strength for Fencer D pointing toward a positive relationship between anger and peak-muscle activity performance.

The findings largely support Lazarus’s (2000a) theoretical framework. Lazarus’s (1991, 2000a) cognitive-motivational-relational theory proposes that the associated action tendency with anger will influence performance depending on the complex relationship between the athlete and the situation. If the emotion experienced is aligned with what the task demands, then that emotion seems to facilitate performance. Anger was positively associated with powerful fencing attacks and increased muscle activity, among both skilled and intermediate level participants. Faster response-times were associated with elevated anger only when the participant was skilled and attentive to the task. Otherwise, anger may negatively affect response-time performance by drawing resources away from the primary task. Furthermore, when the task requires greater fine motor tuning and less explosive motion (such as in a table-tennis serve), increased anger may be detrimental to performance outcome, specifically when a performer is skilled.

The results of the present study have an intriguing applied implication. The results provide evidence to suggest that anger could be helpful to athletic performance in certain situations, specifically when the task demands a powerful exertion of energy. Hence, athletes and reactionaries in the field of sport and performance could develop mental preparation processes that address the different situations an athlete might face within the same sport. One example may be seen during a fencing bout, when a performer would be required to regulate their anger or utilise that anger.

One implication for future research arising from this study is the importance of the participants' expertise level when investigating the emotion-performance relationship. Because the emotional effects on performance are subtle, the participants are required to be highly skilled so that "noise" (i.e., error variance) in the data (such as fatigue, consistency and learning curve) is reduced to a minimum. Another implication is the use of single-case research designs for experimenting causal relationships using a small number of highly skilled participants. To date, most studies in sport psychology have used this methodology in order to show effectiveness of behavioural interventions (Callow et al., 2001; Neil et al., 2013). The current research study offers a novel approach for examining cause and effect relationships within the field of performance psychology.

The present study has a number of methodological weaknesses that should be considered when interpreting the results. One methodological limitation was that participants could have experienced anger desensitization during the B phase as a result of receiving the anger imagery script manipulation three times. This desensitization might have contributed to the performance regression towards baseline levels when within the intervention phase. In view of this limitation, a multiple-baseline design was employed within the study in order to reduce this effect by introducing, and then removing, the anger intervention at different points in time.

Another concern lies in the use of imagery script as a method for inducing emotional states (i.e., anger and emotion-neutral). As stated by Fencer B in the follow-up interview, visualizing an angry event did make her as angry as if she were in the actual situation. This did not allow for investigation into the effects of very high anger on performance. However, we were getting performance effects with some fairly clear, albeit moderate, anger self-report responses, despite less clear effects on the physiological data. Still, there is likely an emotional threshold beyond which anger no longer facilitates any type of performance (e.g., precision vs. power) and instead debilitates it, sometimes, perhaps in a catastrophic manner similar to anxiety (see Hardy, 1990).

A third criticism that could be levelled at this study concerns the use of physiological indices as an indication for the type of emotional state (i.e., anger vs neutral). After all, autonomic responding in emotion has been an active research topic over the past century (Kreibig, 2010), and there is still no scientific consensus on whether there exists a relation between emotion and the organization of autonomic nervous system (ANS) activity. Then again, since research does show that anger has a distinct somatovisceral physiology that, at its core, is an alpha-adrenergic activation that increases heart rate activity and facial skin surface temperature (Stemmler, 2010), the physiological data serves as a complementary tool to the participants' self-reports.

Indeed, a large body of literature reports on feeling changes in the absence of the effects of autonomic responding. However, anger is associated with specific motivational functioning (Kreibig, 2010). For example, in some models, anger is associated with approach motivation whereas anxiety is associated with avoidance motivation (Bodenhausen, Sheppard, & Kramer, 1994; Carver & Harmon-Jones, 2009; Harmon-Jones, 2003) and, in fact, studies have found that approach and avoidance motivations strongly determine responses to situations (Bechara, Damasio, Tranel, & Damasio, 1997; Carver, 2004; Davis et al., 2010). Accordingly, one would expect emotions of approach motivational direction, such as anger, to have different effects on outcome than the emotions of different motivational directions, such as anxiety.

A fourth limitation concerns the use of heart rate as a psychophysiological indication of anger during a fencing activity. Although we tried to minimize fencers' physical activity to what was required, by having them sit while performing the experimental task, physical activity (i.e., movement of the weapon arm) independently elevates heart rate. Even though participants acted as their own controls, increased heart rate caused by physical movement may mask any anger-induced changes in heart rate that may occur under resting conditions following anger manipulation. Hence, anger derived from heart rate may be more difficult to detect when simultaneously performing a physical activity.

Another point for consideration is the high sensitivity of physiological activity to environmental factors such as, room temperature, nutrition, stimulant consumption, and hours of sleep. We did attempt to control some of these factors, such as regulating room temperature, and asking participants to refrain from ingesting food and caffeinated beverages during the hour preceding participation. However, we did not monitor factors such as sleep or perceived fatigue. As a result, the same experiment conducted on another day might reveal different results than in this study. Hence, it is necessary to repeat the current study in order to confirm the findings.

In conclusion, our initial assumption in this study – that fine motor performance may suffer under elevated anger – was supported. In addition, this study provided deeper insight into the mechanisms associated with increased anger, where anger activates stronger bodily and physical activity when a performer is skilled. Moreover, the different effects on performers in relation to their skill level strengthens our chosen methodology (i.e., single-case design) in which performers can be assessed individually and allows greater understanding of inter-individual differences. This research design enables us, for example, to identify how anger can interfere when a performer requires cognitive resources in order to sustain high levels of attention, as postulated by Eysenck et al. (2007).

There is, therefore, a need for future research to examine the effect of anger on the cognitive aspects of performance, such as attention, focus and mental effort, similar to Woodman et al. (2009) study on the influence of anger on a cognitive task. Nevertheless, the present study has provided further evidence that anger needs to be investigated in relation to the situation and the task at hand.

Chapter 4

General Discussion

The current research project aimed to test the anger-performance relationship of athletic performance. More specifically, the goal was to study anger within the performance of gross and fine motor skill tasks. In addition, the study explored anger in the context of mixed emotions by investigating state-hope and self-efficacy as moderators of the anger-performance relationship. Furthermore, the current research project extended the test of the effect of anger on fine motor skill tasks in a laboratory setting (i.e., fencing) via a withdrawal, multiple-baseline, single-case research design.

The first cross-sectional study in this research project consisted of a 2000m running task (i.e., gross motor skill) and a rifle-shooting task (i.e., fine motor skill). Similar to previous studies (Davis et al., 2010; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009) the results in the 2000m running task supported the proposition that elevated anger is beneficial to the athletic performance of a gross motor skill. The findings in the rifle-shooting task contradicted the hypothesis that anger would harm the performance of a fine motor skill task, as results indicated a positive correlation between state-anger and rifle-shooting performance.

The data showed that the highest level of state-anger among participants was moderate (i.e., “moderately so” on the STAI). This finding might explain why the rifle-shooting, fine motor skill task benefited from increased anger. We propose that anger served as an activator that shifted participants’ mental state closer to an optimal level of alertness and bodily arousal, hence helping participants to demonstrate better rifle-shooting performance (Harmon-Jones et al., 2010; Litvak et al., 2010). In addition, we suggest that the rifle-shooting task used in this study does not require such muscular tuning that it might be negatively affected by a moderate increase in anger from baseline. Moreover, because the participants were aiming at a fake head target, we propose that anger’s approach motivation and action tendency was more strongly reflected in the rifle-shooting task than would normally be expected with a neutral target (e.g., Olympic shooting). This suggestion draws from the fact that soldiers are usually trained to imagine the fake head target as an enemy intent on doing them harm. In other words, anger in this task quite literally has a target for effective expression.

Our central interest in this investigation was to explore the moderating effect of state-hope in the anger-performance relationship. Anger may be facilitative to gross motor performance, regardless of state-hope. Conversely, anger would benefit fine motor performance as long as the individual's attainable expectancies of being able to cope and achieve his or her goal are high. If athletes become hopeless and/or lose confidence in their capability to reach his or her goal, then anger will become debilitative to performance. To this end, we included a measurement for participants' state-hope as conceptualized by Snyder (2002); Snyder et al. (1996). The results revealed a moderating role for hope in the anger-performance relationship for neither the gross motor task (as we expected) nor the shooting task (contrary to our expectations). Interestingly, state hope was associated with better running lap times. This finding supports Snyder's (2002) assumption that high-hope athletes would be more successful in a competitive environment than low-hope competitors.

Tong et al. (2010) conducted a series of studies on the role of agency thinking and pathways thinking in Snyder (2002); Snyder et al. (1996) hope theory that may explain the lack of moderating effect of state-hope in our findings; they found that only state-agency was positively related to hope, whereas state-pathways were not related to hope. In fact, even when the researchers introduced participants with very concrete goals, the lack of relationship between pathways thinking and hope remained robust. Consequently, the researchers concluded that the extent to which people tend to believe that they can generate means to desired goals does not predict hope. At the state level, "as long as people feel that a specific and concrete goal can somehow be attained, regardless of whether they see themselves as able to generate ways to achieve that goal, they are likely to feel more hopeful" (Tong et al., 2010, p. 1213). In support of Tong et al. (2010) argument on the role of agency thinking in hope, our results indicated that only agency was significantly related to performance (i.e., running lap time and hits on target). However, due to the low internal consistency of agency in the current study, these findings must be considered with caution.

This led us to propose self-efficacy as a moderating variable in the anger-performance relationship in the context of athletic activity. Similar to Lazarus's (2000a, p. 234) core relational theme of hope "fearing the worst but yearning for better, and believing the improvement is possible", we suggest that hope is passive (e.g. "I hope it doesn't rain tomorrow"). Conversely, self-efficacy is more about the person as an agent of their world (e.g., "there is a chance it will rain tomorrow, so I will put in place a number of actions to ensure that I can do what I planned to do"), and therefore might more likely affect the anger-performance relationship than state-hope. As described by Bandura (1997), perceived self-efficacy is concerned with people's beliefs in their capabilities to produce given attainments.

The second cross-sectional study in the current research project aimed to further explore the fine motor skill task findings of the first study. In the second study, we conducted a second rifle-shooting task examination with a larger sample size and added a measurement for participants' self-efficacy. The results neither supported our hypothesis that state-anger would harm performance during the fine motor skill task, nor do they replicate Study 1's results. No significant association between state-anger and the shooting task performance was revealed in the second cross-sectional study. Similar to previous research in sport (Moritz, Feltz, Fahrbach, & Mack, 2000), self-efficacy had a positive relationship with the rifle-shooting task performance outcome and accounted for 8.9% of performance variance. In the context of the potential moderating effect of self-efficacy, we failed to identify any moderating influence in the anger-performance relationship. One plausible explanation may concern the commanders' short acquaintance period with the recruits under their command. We suggest that this period of time was insufficient, thus the section commanders could not provide accurate evaluations (i.e., commander-rated performance) on the recruits under their command. In addition, participants were still within their learning stage and their shooting skills had not yet been fully acquired or stabilized.

In the following laboratory-based single-case experiment, we addressed some of the limitations associated with the cross-sectional studies. First, anger was examined repeatedly over a longer period. Second, objective measures were used for assessing performance quality. Third, the causal relationship between anger and performance was explored, as cross-sectional studies are a type of observational study, are descriptive, and do not involve manipulating variables. Fourth, we focused on recruiting highly skilled athletes in order to minimize artefacts such as the level of proficiency. The findings in the single-case design study are consistent with the initial hypothesis that anger can be detrimental to the performance of fine motor skill tasks. However, anger was beneficial in increasing the participants' alertness and response-time, particularly when the action was aligned with anger's action tendency (i.e., lashing out). When the action was aligned, then anger increased the power invested within that action.

Although fencing precision performance decreased across all participants in the anger condition, as noted above, in order to suggest a causal effect, precision performance must return to baseline levels when the intervention is removed. Only the elite fencers (i.e., Fencer

A and B) demonstrated such an effect; therefore, we could only infer that the experience of anger harms the performance of a task that requires fine muscular control when the performers are skilled. Then again, there is an argument that participants might struggle to return to the initial phase after being 'polluted' with the intervention. Indeed, Fencer C and D (i.e., intermediate level fencers) reported some heightened anger-in during the second emotion-neutral phase, which serves to strengthen the latter argument. Moreover, less skilled performers are more likely to show "noise" (i.e., error variance) in the data (such as fatigue, consistency and learning curve). From an A-B perspective, in which a causality can be made based on the introduction of the intervention at different points in time (i.e., multiple baseline design), all four fencers' precision performance suffered from the increased anger.

Our hypothesis that the response-time would benefit from the increased anger, because it reflects anger's associated bodily reaction and action tendency, was partially met. One participant (Fencer B) struck faster under anger than under emotion-neutral condition. Fencer A and Fencer B (both expert fencers) demonstrated fast, consistent, stable and relatively minor response-time changes. It is possible that there was a floor effect in the response times of these fencers. Because based on our pre-experimental tests it is difficult to cover that distance in less than 450-500ms, it is likely that Fencers A and B were simply such experts that it was not possible for them to improve further. Both Fencer C and D demonstrated response-time behaviours that mostly reflected an intermediate level of fencing ability. Fencer C's response-times slowed down gradually across the experimental phases, and Fencer D's response-time changes reflected a learning curve. These results (i.e., precision performance and response-time) showed that highly skilled participants allow for a better experimental investigation due to the reduced noise in the data and the more consistent levels of performance outcome.

As hypothesised and observed in previous studies (Davis et al., 2010; Woodman et al., 2009), all fencers' (i.e., B, C, and D) peak-muscle activity, with the exception of Fencer A (focused solely on accuracy), increased in the anger condition. This finding enhances our understanding of the mechanisms that underlie the anger-performance relationship. The results clearly indicate that, when angry, performers produce greater muscle contraction and consequently generate additional force during performance.

The results of the present project, taken together with those of previous studies (Davis et al., 2010; Gould et al., 2000; Martinent et al., 2012; Martinent & Ferrand, 2009; Pensgaard & Duda, 2003; Robazza & Bortoli, 2007; Ruiz & Hanin, 2011; Woodman et al., 2009), strongly support the notion that anger increases the level of strength-force a performer is investing during a physical task. More specifically, anger is shown to have a positive relationship with action tendency and motivational effort. Furthermore, the increased alertness that is associated with anger improves the performance of skills that require some level of muscle coordination (i.e., response-time, rifle-shooting); however, when the task is characterized by fine muscular tuning (i.e., precision) anger tends to harm performance outcome.

To date, most research in the field of sport psychology has focused on measuring anger retrospectively (Martinent & Ferrand, 2009; Ruiz & Hanin, 2011), on a single motor skill (Davis et al., 2010; Woodman et al., 2009), or via field studies and questionnaires (Pensgaard & Duda, 2003; Robazza et al., 2006; Robazza & Bortoli, 2007). The current series of studies offer a longitudinal and in-depth investigation into the relationship between anger and athletic performance by using large samples, ecologically valid performance tasks, on-site measures, and experienced participants.

The current research project also clearly demonstrates that Lazarus (1982, 2000a) cognitive-motivational-relational model is a fruitful model for studying the anger-performance relationship in the context of athletic performance. The study further provides support for Lazarus's (2000a) argument that anger benefits performance when the activity is aligned with anger's action tendency and approach motivation. Both the rifle-shooting task and, to a larger extent, the fencing task were activities that involved direct engagement with a target and required the performer to act and express his/her energy outward toward an actual object for a short duration.

The running task was different in the sense that there was no actual target, and, although the running task may be relatively short, it was much longer than previous studies. Consequently, the results may indicate that anger can be helpful in tasks that are of longer duration and not only in sports that are characterised by confrontational lashing out movements, such as combat sports. Accordingly, there are likely instances where the "angry burst" or the "angry brew" may be beneficial. If one needs to clean jerk a heavy weight in weightlifting, then an angry well-directed burst might be beneficial. Conversely, allowing one's anger to brew inside for a longer duration while slowly releasing it into useful bursts of energy, as in tennis or squash for example, means that one can be angry and remain in control of that anger in order to gain dominance over a task or a competitor. Much like the anger-in anger-out concepts of anger.

In this study we adopted a multi-measure approach (Cooke, Kavussanu, McIntyre, & Ring, 2013) by supplementing self-reporting measure of anger anxiety with measures of heart rate, skin-conductance, and skin surface temperature. Although there is still no scientific consensus on whether there exists a relation between discrete emotions and the organization of autonomic nervous system activity, the physiological data serves as a complementary tool to the participants' self-reports, and are used to corroborate changes in self-reported anger across the experimental sessions. Any inconsistencies between self-report and psychophysiological data could indicate that the manipulation is not as effective for those participants with fewer physiological effects. However, measuring both is a recommended (Mauss & Robinson, 2009) and appears to be the optimum approach since we cannot have full confidence in either effect when used as standalone indices.

Davis et al. (2010); Woodman et al. (2009) studies were the closest attempt in the scientific literature in sport psychology to offer a psychophysiological explanation to the effects of anger on muscle activity by showing how anger increases kicking performance. The current study extends their approach by including a measure for muscle activity (i.e., EMG). The findings imply an underlying mechanism associated with physical performance when one is angry. We showed that, under anger, the relevant muscle for the task (i.e., triceps brachii) produced increased muscle activity, which was reflected by greater muscle force measured in microvolts.

There is a methodological challenge when trying to investigate anger and its effects on human behaviour and, more specifically, on athletic performance. The experience of anger can be a cause for emotional distress for many people. When people reflect backwards on angry situations, they generally perceive anger as a negative emotion and as an unpleasant feeling, mainly because it is evoked by aversive events (Potegal & Stemmler, 2010). Therefore, the ability to induce high levels of anger in an experimental setting without causing participants emotional distress is limited. Researchers in the field of anger have long struggled to find an appropriate, yet effective, experimental intervention strategy for provoking anger within participants in laboratory setting (see Potegal, Stemmler, & Spielberger, 2010). A few decades ago, when ethical requirements were less strict, anger was induced by creating a "real-life" situation where the participant was manipulated in the laboratory by exposing them to acute emotional stimulation procedures, and injecting them with emotion-inducing drugs such as adrenaline (J. Schachter, 1957; S. Schachter & Singer, 1962). Another example is an anger induction technique where participants perform a frustrating number of tasks while being criticized whenever they made errors (Funkenstein, King, & Drolette, 1954). A somewhat more recent example, that better adheres to current ethics requirements, is Levenson et al. (1990) study where they asked participants to make angry facial expressions, assuming that the associated facial muscles would enable the corresponding affect program in the brain. In the current research program, in order to meet ethical standards and avoid having participants undergo a disturbing experience, in the first two cross-sectional studies, participants were observed within their natural environment without any type of intervention. In Study 3, when the intervention was necessary, the chosen intervention method (i.e., imagery) was selected based on three thoughtful and effective studies (Sinha et al., 1992; Stemmler et al., 2001; Woodman et al., 2009) that showed how imagery could be used to induce anger in a laboratory setting.

Another limitation in this study concerns the use of subjective rating (i.e., commander-rated performance) to assess quality of performance. Normally, self-ratings would be used so that performers could evaluate their own performance and, thus, account for “reasons beyond the performer’s control” such as niggling injury or headache, for example. Our chosen method (i.e., evaluation was made by section commanders), did not allow us to take into consideration such aspects that we might be unaware of and could influence the participants’ performance quality. Furthermore, the way that the assessment item was phrased, a comparison to how they performed “normally”, also did not allow for accounting these reasons (he/she normally performs well but he/she has an injury so he/she performed badly, so I scored him/her at a 1). However, research have shown that when people are asked to evaluate their own abilities, capacities, and performances within a specific domain, they tend to rate themselves above average (Dunning et al., 1989).

A third limitation in the current study concerns Study 1’s rather low sample (rifle-shooting task, N=38). It is possible that, with a larger sample size, the results for the moderating effect of state-hope on the state-anger and rifle-shooting performance would have been significant (R^2_{cha} = .02; 2% is normally significant with ~100 participants). Alternatively, it may be that other, so called, ‘positive’ emotions such as “excited” and “happy” would be better candidate moderators.

Another approach would be to focus on the role of coping rather than on other emotions as moderators. As implied by Lazarus (2000a), coping influences the emotions we experience and is an essential feature of the emotional process. For example, when facing an obstruction, the anger experienced may soften if one thinks that one can overcome the obstruction or intensify if the obstruction is perceived as impossible to cope with.

A fourth limitation in the current study concerns the similarity between anger and anxiety. For example, both anger and anxiety can lie in the same space on Russell's circumplex model of affect (Posner et al., 2005); that is, a high arousal of unpleasant feelings. For example, a series of studies found that anger and anxiety are frequently experienced during test-taking situations. In the context of sport, Robazza and Bortoli (2007) observed that cognitive anxiety is a significant predictor of anger-in and anger-out, negative reactions to criticism, and an angry temperament. Therefore, based on this model alone, one would not be able to differentiate between anger and anxiety. However, the physiological data was an adjunct to the anger questionnaire data, and we deemed this method appropriate for gathering additional discriminatory information about the success of our emotional manipulation.

The results of the present study also have two applied implications. The results provide evidence to suggest that, in discussing the consequences of anger on athletic performance, a multi-dimensional approach should be considered. As such, anger's functional effects include not only intrapersonal factors, such as intensity level, but also situational factors, such as the actual movement that an athlete is required to perform (e.g., blocking vs striking). Intervention strategies should take into consideration scenarios in which a performer would be required to utilise an angry feeling towards gaining a better skilled execution. For example, a judoka might be better off preparing differently depending on whether he/she intends to take an offensive or defensive approach. Therefore, emotional regulation strategies should be more specifically tailored to the performer, type of sport, and specific situational demands.

Another applied implication concerns the notion of negative and positive emotional states. Anger can be both helpful and harmful to athletic performance. When devising an intervention strategy for an athlete, as long as anger serves its regulatory function (for example, giving the performer a boost of energy), or alternately signals to an athlete that his or her achievement is at risk, anger should be regarded as a useful and effective human phenomenon. If future research were to provide concrete evidence for the existence of a negative relationship between state-anger and fine motor skills, cognitive interventions that focus on changing the way performers perceive their anger may prove beneficial in reducing the assumed reaction. For example, a cognitive intervention that was designed to help swimmers to perceive anxiety symptoms as facilitative rather than debilitative, showed that an athlete's perceptions of anxiety could be modified so as to view it as facilitative (Hanton & Jones, 1999a, 1999b). Indeed, among skilled performers, anger may be used constructively in the context of athletic performance of gross, as well as fine, motor skills. Therefore, interventions aimed at reducing anger should be applied with caution as mild anger could help some athletes to perform better.

In conclusion, this research project provides evidence that, within the context of athletic performance, the experience of anger can be constructive. This evidence is particularly true for skilled performers who are required to exert a high volume of energy. Moreover, anger can serve as an activator for cognitive alertness when a performer is experienced and the task is not characterised by great muscular tuning. With regard to athletic skills of fine motor tuning, anger harms performance of such kind even when performed by highly skilled individuals.

A number of research directions were implicated by the present study, the most obvious being the need to explore the effects of anger on sport performance under conditions of high anger intensity. Future research will have to overcome the methodological challenge for meeting ethical standards and having participants experience higher levels of anger. One possibility would be to follow athletes in their daily routines and explore how true anger experiences affected their performance outcomes and overall performance quality.

Another useful research direction would be to explore other moderators in the anger-performance relationship, such as other positive emotion as moderators. Perhaps coping would be the moderator, as anger is beneficial so long as it is accompanied by a challenge appraisal (i.e., coping resources exceed demands) as suggested by M. Jones et al. (2009) psychophysiological Theory of Challenge and Threat States in Athletes (TCTSA), which considers the perceived demands weighed against coping resources.

Future research can investigate the effect of anger on the muscle activity of co-contracting muscles in order to measure any offset effect. For example, during a fencing attack, an agonist muscle can be measured against its antagonist pair. If anger increases the amount of force generated in the muscles, an exploration of agonist and antagonist muscles could reveal interesting interactions between them that can have consequences on physical activity and athletic performance (Weinberg & Hunt, 1976).

Another interesting psychophysiological future direction would be to explore the relationship between anger and the two components of response time: these are reaction time (i.e., mental chronometry), which indicates how fast the individual can execute the mental operations needed by the task at hand; and movement-time, which indicates the time it takes to complete the movement. This would provide insight into the relative influence of anger on central processing (i.e., brain), indexed by reaction time, or peripheral processing (i.e., muscles), indexed by movement time. Overall, the present research project illuminates several central aspects of the complex anger–performance relationship.

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Appendices

Appendix A – Consent form

Involvement in this study is voluntary and you are free to withdraw at any time. Please read the information sheet and sign the consent form before completing these questionnaires.

What is this study about?

The aim of the current study is to understand the way that different mental states may affect performance quality in training and on the battlefield. Important implications may stem from this study, and it will help the IDF to better understand with the methods that are needed to prepare soldiers for special operations where ideal mental states are required.

Because of its importance in the modern battlefield, the IDF regards this study highly and has approved it out of the ordinary. Your participation is not mandatory, and you are free to withdraw at any time. Any information you provide remains completely confidential.

What are these questionnaires?

The questionnaires you are being asked to complete are designed to gain better understanding of the mental factors influencing the performance of soldiers in training and battlefield.

This is **NOT** a test. There are no right or wrong answers. There are no good or bad answers. The questionnaires simply present you with statements which people have used to describe themselves. All you are asked to do is to read each statement carefully and circle the appropriate number to the left of the statement to indicate how you feel right now, that is, at this moment.

Who will see my answers?

Completed questionnaires remain totally confidential. **There will be no attempt to identify you, or to pass this information to any other party**. The researcher, **Itzhak Zur**, is the only person who can access your completed questionnaire, and he is not authorised to pass on any information either inside or outside the IDF. The report on the findings of this survey will be presented in such a way that it will not be possible for anyone to identify you.

The reason your service number is asked for is not in an attempt to identify you, but in order to cross-reference your running and shooting scores with your answers in the questionnaires. Once data has been analysed, your service number will be completely erased from questionnaire forms, data will be analysed in groups and identifying you will become impossible.

Any information provided by you is subject to IDF confidentiality rules and regulations which oblige the researcher to maintain full anonymity.

Once you have completed both questionnaires, please place them in the envelope provided, seal the envelope and hand it to the researcher.

- I hereby confirm that I have read the consent form carefully, and I give my approval to take part in this study.

Service number____________________ Signature________________

Appendix B – State Anger Scale

Company: __________ Platoon: __________

Service number: __________

Directions:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel ***right* now**, that is, ***at this moment.*** There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to **best** describe your **present feelings**.

	NOT AT ALL	**SOMEWHAT**	**MODERATELY SO**	**VERY MUCH SO**
I am furious	1	2	3	4
I feel like banging on the table	1	2	3	4
I feel angry	1	2	3	4
I feel like kicking somebody	1	2	3	4
I feel like breaking things	1	2	3	4
I am mad	1	2	3	4
I feel irritated	1	2	3	4
I feel like hitting someone	1	2	3	4
I feel annoyed	1	2	3	4
I feel like swearing	1	2	3	4

Appendix C – State Hope Scale

Company: __________ Platoon: __________
Service number: __________
Directions:

Read each item carefully.

_____1. If I should find myself in a jam, I could think of many ways to get out of it.

_____2. At the present time, I am energetically pursuing my goals.

_____3. There are lots of ways around any problem that I am facing now.

_____4. Right now, I see myself as being pretty successful.

_____5. I can think of many ways to reach my current goals.

_____6. At this time, I am meeting the goals that I have set for myself.

Using the scale shown below, please select the number that best describes how you think about yourself right now and put that number in the blank before each sentence.

Please take a few moments to focus on yourself and what is going on in your life at this moment. Once you have this "here and now" set, go ahead and answer each item according to the following scale:

1. = Definitely False
2. = Mostly False
3. = Somewhat False
4. = Slightly False
5. = Slightly True
6. = Somewhat True
7. = Mostly True
8. = Definitely True

Appendix D – Self efficacy Questionnaire

Company: ___________ Platoon: ___________

Service number: ___________ Age: _____

Please write down how confident you are in achieving the following performance level.
Please state your degree of confidence you have in obtaining that level

Confidence (0% - 100%)

0 10 20 30 40 50 60 70 80 90 100

No confidence at all	Moderate amount of confidence	Completely confident

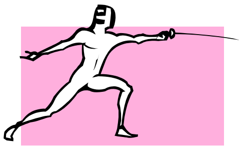
100m shooting task (10 rounds)	Confidence % (0 – 100)
I have the skills and resources to hit 1 shot	
I have the skills and resources to hit 2 shots	
I have the skills and resources to hit 3 shots	
I have the skills and resources to hit 4 shots	
I have the skills and resources to hit 5 shots	
I have the skills and resources to hit 6 shots	
I have the skills and resources to hit 7 shots	
I have the skills and resources to hit 8 shots	
I have the skills and resources to hit 9 shots	
I have the skills and resources to hit 10 shots	

How certain are you of performing your best? _______%

How certain are you of being among the three best? ________%

How certain are you of being among the eight best? _______%

Appendix E - Recruitment flyer



Volunteers needed for research study

We are currently looking for participants (fencers) for a study on the effect of different mental states on fencing performance.

The aim of the current study is to understand the way that different mental states may affect performance quality in training and competitions. Important implications may stem from this study, and it will help fencers and coaches to discover ideal methods that are needed to best prepare fencers for tournaments and competitions.

Your participation is not mandatory, and you are free to withdraw at any time. Any information you provide remains completely confidential.

What's in it for you?

- **Learn** more about yourself as an athlete - Find out what mind set you have to be in for your highest chance of success.
- **Improve** your reaction time and reflexes using our biofeedback technology.
- **Understand** what happens in your body through different stages of competition - measuring heart rate, breathing patterns, and skin temperature, you'll be able to know exactly what's happening to your body while you fence.

We are looking for committed participants who are interested in **improving** as athletes and fencers.

Selected participants will receive a **$80 monetary reward** upon completion of the study.

To learn more, call Itzhak Zur 917-455-7800, or email izur75@gmail.com

Appendix F - Vividness of Movement Imagery Questionnaire-2

Name: Age: Gender: Sport:
Level at which sport is played at (e.g., Recreational, Club, University, National, International, Professional)

Years spent participating in this sport competitively:

Movement imagery refers to the ability to imagine a movement. The aim of this questionnaire is to determine the vividness of your movement imagery. The items of the questionnaire are designed to bring certain images to your mind. You are asked to rate the vividness of each item by reference to the 5-point scale. After each item, circle the appropriate number in the boxes provided. The first column is for an image obtained watching yourself performing the movement from an external point of view (External Visual Imagery), and the second column is for an image obtained from an internal point of view, as if you were looking out through your own eyes whilst performing the movement (Internal Visual Imagery). The third column is for an image obtained by feeling yourself do the movement (Kinaesthetic imagery). Try to do each item separately, independently of how you may have done other items. Complete all items from an external visual perspective and then return to the beginning of the questionnaire and complete all of the items from an internal visual perspective, and finally return to the beginning of the questionnaire and complete the items while feeling the movement. The three ratings for a given item may not in all cases be the same. For all items please have your eyes CLOSED.

Think of each of the following acts that appear on the next page, and classify the images according to the degree of clearness and vividness as shown on the RATING SCALE.

RATING SCALE. The image aroused by each item might be:

Perfectly clear and as vivid (as normal vision or feel of movement)	……………	RATING 1
Clear and reasonably vivid	……………	RATING 2
Moderately clear and vivid	……………	RATING 3
Vague and dim	……………	RATING 4
No image at all, you only “know” that you are thinking of the skill.	……………	RATING 5

	Watching yourself performing the movement (External Visual Imagery)					Looking through your own eyes whilst performing the movement (Internal Visual Imagery)					Feeling yourself do the movement (Kinaesthetic Imagery)				
Item	Perfectly clear and vivid as normal vision	Clear and reasonably vivid	Moderately clear and vivid	Vague and dim	No image at all, you only know that you are thinking of the skill	Perfectly clear and vivid as normal vision	Clear and reasonably vivid	Moderately clear and vivid	Vague and dim	No image at all, you only know that you are thinking of the skill	Perfectly clear and vivid as normal feel of movement	Clear and reasonably vivid	Moderately clear and vivid	Vague and dim	No image at all, you only know that you are thinking of the skill
1.Walking	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2.Running	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3.Kicking a stone	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4.Bending to pick up a coin	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5.Running up stairs	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
6.Jumping sideways	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7.Throwing a stone into water	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
8.Kicking a ball in the air	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9.Running downhill	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10.Riding a bike	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11.Swinging on a rope	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
12.Jumping off a high wall	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

Appendix G – Emotion-neutral script

Sit and make yourself comfortable, close your eyes, focus all of your attention on my voice. Let yourself become completely absorbed in the things I am telling you. In a moment, I want you to use your imagination. I want you to think about brushing your teeth, to picture it so vividly that it might feel like you are brushing your teeth right now… To feel the same inside now. Think about the situation now. Imagine it as vividly as you can. Make the picture come alive. See all the details. Picture the surroundings as clearly as possible. See yourself, see your toothbrush. Hear the sounds, experiencing the event exactly as it's happening to you… Thinking the same thoughts… feeling the same feelings… letting yourself react as if you were actually there.

As you imagine that you are brushing your teeth you realize you are feeling incredibly calm. Your mind is clear of any emotions… You are feeling completely unemotional about everything. As you continue to focus all of your attention on the experience, feel even more unperturbed about surrounding events… You are feeling completely unemotional… When you are ready and while you continue to imagine the situation of brushing your teeth, open your eyes and look at the target in front of you.

Appendix H – Anger emotion script

Sit and make yourself comfortable, close your eyes, focus all of your attention on my voice. Let yourself become completely absorbed in the things I am telling you. In a moment, I want you to use your imagination. I want you to think about the angry situation I asked you to think about earlier… To picture it so vividly that you actually feel angry right now… To feel the same inside now. Think about the situation now; imagine it as vividly as you can. Make the picture come alive, see all the details, picture the surroundings as clearly as possible. See the people, the objects. Hear the sounds, experiencing the event exactly as it was happening to you. Thinking the same thoughts, feeling the same feelings, let yourself react as if you were actually there now.

As you imagine the situation, you realize you are feeling angry… You want to lash out… Your muscles are tense and blood rushes to your face as you focus all your attention on the experience… Deepen this feeling even more, feeling incredibly angry… When you are ready, while continuing to imagine the situation and holding on to the angry feeling, open your eyes and look at the target in front of you.

Appendix I – Informed Consent

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT OR EXPERIMENT

Title of Research Project: ____

The researcher conducting this project subscribes to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of participants. This form and the information sheet have been given to you for your own protection and full understanding of the procedures**.** Your signature on this form will signify that you have received information which describes the procedures, possible risks, and benefits of this research project, that you have received an adequate opportunity to consider the information, and that you voluntarily agree to participate in the project.

Having been asked by **Itzhak Zur** of the School of Sport, Health and Exercise Sciences at the University of Wales, Bangor, to participate in a research project experiment, I have received information regarding the procedures of the experiment.

I understand the procedures to be used in this experiment and any possible personal risks to me in taking part.

- I understand that I may withdraw my participation in this experiment at any time.
- I also understand that I may register any complaint I might have about this experiment to Itzhak's supervisor, Professor Tim Woodman, and that I will be offered the opportunity of providing feedback on the experiment using standard report forms.
- I may obtain copies of the results of this study, upon its completion, by contacting: Itzhak Zur, E-mail: pepa31@bangor.ac.uk

I confirm that I have been given adequate opportunity to ask any questions and that these have been answered to my satisfaction.

I have been informed that the research material will be held confidential by the researcher.

I agree to participate in the study

NAME (please type or print legibly): ___________________________________

ADDRESS: (Optional)_____________________________

PARTICIPANT'S SIGNATURE: __________________ **DATE**: ___________

RESEARCHER'S SIGNATURE: __________________ **DATE**: ___________

Two sheets should be completed - one for the participant and one for the researcher.

Appendix J – Intake form

INTAKE FORM

Please provide the following information and answer the questions below. Please note: information you provide here is protected as confidential information.

Name: ____

(Last) (First) (Middle Initial)

Birth Date: _____/______/______ Age: _____________ Gender:_________________________

Cell/Other Phone: ( ) _____________

E-mail: ____________________________

Have you ever experienced any of the following health problems?

Cardiovascular abnormalities: No Yes

Hormonal and endocrine problems: No Yes

Are you currently taking any prescription medication?

No

Yes

Please list: ____

How would you rate your current physical health? (Please circle)

Poor Unsatisfactory Satisfactory Good Very good

How many times per week do you generally exercise? _________

How many times per week do you practice fencing? ___________

Please list your fencing experience (style, years, tournaments, awards, etc.…):

____

____

____

____

Appendix K – Imagery training commonplace scenes

1. You are sitting in a chair reading a popular magazine. Your eyes go from word to word and from line to line down the page as you make rapid progress through the text. You shift to a full page illustration of the muscles of the arm, and you look up and down all over the page, noting first the hand on the upper right corner of the page, then inspecting the elbow in the centre, and finally the upper arm muscles in the lower left part of the page. You turn the page, and your eyes follow the text into the next chapter.

2. You are standing at the base of an observation tower or lighthouse as some of your friends climb up the stairs. Your eyes follow their hands, gliding upwards on the handrails, as they slowly climb the metal staircase. You tense the muscles of your face, squinting to avoid the sun, which glints through the metalwork of the tower. Craning your neck, you continue to watch closely, following your eyes as they move upward toward the observation deck. They reach the top, and you look up as someone drops a hat. You follow the hat with your eyes while it sails gently down to the ground at your feet.

3. You are doing sit-ups in a gym class. The instructor insists that everyone do as many as possible. You glance to either side and notice the other students working hard at doing their sit-ups it is a warm day and you begin to sweat. You face is flushed as your muscles strain to continue the pace. You take a deep, rapid breaths. Several others have had to quit, but you try to do a few more. Your heart pounds as you try to lift yourself one last time.

Appendix L – Welcome letter

Dear Participant,

Thank you for taking part in this study.

The purpose of the current study is to test the potential for modifying mental states to improve fencing performance using biofeedback and visual imagery.

Part one consists of the following activities:

1. Filling out forms (i.e., consent and intake forms) and questionnaires (i.e., VMIQ-2, and STAS) (30 minutes).
2. Visual-imagery training (30 minutes).
3. Training stage – learning how to perform the required experimental task (20 minutes),

Part two consists of the following activities:

1. Single-integer learning stage (30 minutes).
2. Introducing participants to the biofeedback and reaction-time equipment (10 minutes).
3. Imagery script development (15 minutes).
4. Experimental stage – comprising nine sessions with two 15-minute breaks in between (90-120 minutes).

You will be compensated $80 for your time and effort upon full completion of the study.

Please ask any question at any time to aid your understanding.

* The information you give is totally confidential. There will be no attempt to identify your personal information. Only Itzhak Zur will have access to information completed by individuals. The report on the findings of this study will be presented in such a way that it will not be possible for any one individual to be identified. All information you provide will be treated in accordance with the ethics code of conduct.13