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Preliminary evidence for a neuro-cognitive model of mental toughness

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**Preliminary evidence for a neuro-cognitive model of mental
toughness**

Ph.D. Thesis

James John Bell

**Thesis submitted to Bangor University in fulfilment of the
requirements for the degree of Doctor of Philosophy at the
School of Sport, Health and Exercise Sciences.**

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Thesis Summary

The thesis contains four chapters which attempt to extend our understanding of mental toughness. The thesis focuses predominantly on sporting environments, which can be very stressful and often require athletes to perform under intense pressure; as such it provides a useful context to examine mental toughness. Using Reinforcement Sensitivity Theory (RST; McNaughton & Gray, 2000) as a theoretical framework, the thesis contains five empirical studies (organised into two chapters for the purpose of publication), which attempt to apply the principles of RST to understand how cricketers maintain or enhance their performance under pressure. The thesis is *not* a test of Reinforcement Sensitivity but an application of its principles in a novel environment.

Chapter 1 critically reviews the research on mental toughness and highlights a number of theoretical and empirical limitations which need to be resolved. Most notably, these include: (i) circuitous and somewhat confusing definitions; (ii) only modest attempts to draw upon relevant theory to inform a priori hypothesis testing; (iii) a lack of valid measurement tools; and (iv) limited experimental studies that focus on the development of mental toughness. The chapter finishes by proposing a neuro-cognitive explanation of mentally tough behaviour based on the tenets of the revised Reinforcement Sensitivity Theory (McNaughton & Gray, 2000).

Chapter 2 contains four separate studies. The first two studies were concerned with the development of a valid, informant-rated, questionnaire to measure mental toughness. The final two studies explored the interactive relationship between reinforcement sensitivities and mental toughness. The findings of the studies suggested that the relationship between RST and mental toughness is a somewhat complex one in that cricketers rated as mentally tough by their coaches tended to be sensitive to punishment cues and insensitive to reward cues. In contrast, cricketers

rated as low in mental toughness by their coaches tended to be sensitive to punishment cues *and* reward cues. These results are discussed and explained in terms of threat detection, behavioural inhibition and decision making accuracy.

Chapter 3 depicts a quasi-experimental, longitudinal intervention study. The study reports on the design, delivery and evaluation of a theoretically grounded mental toughness training program for youth aged Academy cricketers. The intervention was designed to expose cricketers to punishment conditioned stimuli in the training environment and to equip them with effective coping skills to manage threat. The results are discussed in terms of the theoretical and applied implications of using punishment to alter behaviour.

Chapter 4 concludes the thesis. More specifically, the chapter provides a summary and integrated discussion of the thesis findings, implications from both theoretical and applied perspectives, methodological and conceptual limitations and avenues for future research.

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I've got to be honest, when I first came to Bangor in 2005 to embark on an MSc, I did not predict that I would be here 7 years later, on the verge of submitting a PhD. My first impressions of Bangor were not particularly positive, not least because it was way too far away from London. However, after 7 years, I can safely say that the SHES department and the people affiliated with it have had an enormously positive influence on me, and I will always look back on my time here fondly. There are of course many people who I would like to thank for their help and support throughout my PhD. First, thanks to my parents for their continued support and encouragement. There were many times that it would have been more sensible for them to discourage me from pursuing a PhD and to get a 'real' job instead. In reality they have always been incredibly supportive and I doubt very much I would be in this situation if it wasn't for them. Second, I'd like to thank Em. The girl who stayed in the George Computer room until the early hours the night before I interviewed for this PhD and the girl who has managed to put up with me for 4 years since then, which is an achievement in itself. She is expecting to get a whole paragraph dedicated to her, which is definitely not happening, but I am incredibly grateful to her, especially for the way she has persistently ripped me for my 10-year student career! Third, to all of the SHES PhD students I have shared this experience with. I have shared offices, conferences, road-trips and numerous nights out with many a PhD student over the past 5 years, however special thanks go to Poynor, Mawny, Barney, and (even) Kirk for making this experience particularly entertaining. Fourth, I'd like to thank the staff at SHES who have made this a stimulating and enjoyable place to conduct research. I have collaborated with many of the staff at various times across my 7 years but particular mention must go to Tim, Ross, and Cal, whose doors have always been open, and to Junior, who is the most dedicated and selfless bloke I could ever wish

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Author's Declaration

This work has not been previously accepted in substance for any degree and is not being currently submitted in candidature for any degree.

Signed (Candidate)

Date

Statement 1

This thesis is the result my own investigations, except where otherwise stated. Other sources are explicitly acknowledged in the references

Signed (Candidate)

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Statement 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Chapter 1

General Introduction

Mental Toughness has often been described as one of the most used but least understood phrases in sport psychology (Jones, Hanton, & Connaughton, 2002). The term has been used frequently amongst applied practitioners and within the sport psychology literature to describe the attributes that enable some people to perform or behave exceptionally well in psychological circumstances where others are unable to cope and “choke” or “fall by the wayside”. It has relevance in a wide range of performance contexts including business settings, military, performing arts, and high level sport (Jones, 2004). Originally, Gould, Hodge, Peterson, and Pelitchkoff (1987), surveyed 126 collegiate wrestling coaches who rated mental toughness as the most important psychological characteristic in determining competitive success. However, this study highlights the disparity which often exists between the importance attributed to mental toughness by applied practitioners and the understanding of what mental toughness actually is in the research community (Clough, Earle, & Sewell, 2005). Recent attempts (e.g., Jones, Hanton, & Connaughton, 2002) to improve our understanding of mental toughness have served to offer a more comprehensive picture of what mental toughness means to athletes and applied practitioners (Crust, 2007). Nevertheless, despite the considerable volume of published research on mental toughness, there remain a number of enduring criticisms that need to be addressed in order to improve our understanding of this somewhat elusive construct.

Definitions

For researchers attempting to further our understanding of mental toughness a major concern is the circuitous definitions that have often been provided in the literature (Crust, 2008). Some of the definitions are ambiguous and confusing, for example: “Mentally tough individuals tend to be sociable and outgoing; as they are able to remain calm and relaxed, they are competitive in many situations and have lower anxiety levels than others. With a high sense of

self-belief and an unshakeable faith that they control their own destiny, these individuals can remain relatively unaffected by competition or adversity” (Clough et al., 2002, p.38). There are numerous problems with this definition. Firstly, it appears unlikely that all mentally tough athletes experience “lower levels of anxiety than others”, not least because there is plenty of evidence that moderate levels of anxiety can have facilitative effects upon performance (e.g., Woodman & Hardy, 2003). A second problem with this definition concerns the emphasis on “self belief and unshakeable faith”. This component appears to be related to self-efficacy beliefs (Bandura, 1997). The thesis would question the centrality of self-efficacy beliefs in a conceptualisation of mental toughness because often it is in the most desperate situations (i.e., dealing with terminal illness, facing death in military action) that mental toughness is most clearly demonstrated. It seems fairly unlikely that patients or soldiers in these circumstances would report high levels of self efficacy. It would be more reasonable to suggest that *robust* self efficacy beliefs are cyclically correlated to mental toughness, because they could be described as a likely cause or consequence of mentally tough behaviour, but they are almost certainly not central.

Possibly the most widely used definition in the literature was proposed by Jones and colleagues: “a natural or developed psychological edge that enables you to: (a) generally cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; (b) specifically be more consistent and better than your opponents in remaining determined, focused, confident and in control under pressure” (Jones et al., 2002, p.292). The first part of this definition which focuses on coping with adversity is in line with the general view of mental toughness as outlined by numerous other researchers (e.g., Middleton, Marsh, Martin, Richards, & Perry, 2004, Crust, 2008). However, the second part appears to be a

description of more generic psychological characteristics related to elite performance rather than the central components of mental toughness (see, for example, Hardy, Jones, & Gould, 1996).

To add to the conceptual confusion, the definition provided by Jones et al. (2002) is accompanied by an extensive list of psychological attributes that are proposed to characterize the mentally tough performer. The list of attributes includes motivation; self efficacy; concentration; resilience; anxiety control; and competitiveness (Jones, Hanton, & Connaughton, 2007). There are numerous problems with this line of thinking. By identifying multiple attributes associated with mental toughness it remains unclear exactly which of the attributes are crucial. Some researchers (e.g., Crust, 2008) have argued that the attributes listed in the research describe all of the desirable psychological characteristics related to elite performance rather than the key components of mental toughness. In the present author's view, it is inconceivable that all of these attributes are necessary components of mental toughness and it is highly likely that some of them are more accurately described as correlates (e.g., self efficacy).

The problem regarding multiple attributes seems to have been accentuated by an almost exclusive reliance on qualitative methodologies. Typically, researchers (e.g., Connaughton, Wadey, Hanton, & Jones, 2008) have interviewed samples of elite athletes, coaches, or parents to report on their perceptions of what mental toughness is and how it develops. This approach assumes that all elite athletes are mentally tough and are able to define mental toughness, which appears at best naïve. Qualitative designs are inherently flawed because athletes and coaches have repeatedly cited difficulties in articulating exactly what mental toughness is (Crust, 2008). Furthermore, the sampling of elite athletes and coaches is problematic given the likelihood that they have read widely on the topic of sport psychology and are therefore likely to have been influenced by popular conceptions of mental toughness and mental skills training (Gucciardi,

Gordon, & Dimmock, 2008). To add to the problem some of the interview frameworks used to elicit information appear better suited to an analysis of the psychology of elite performance rather than an analysis of mental toughness. This is best illustrated by Bull, Shambrook, James, & Brooks (2005: p. 214) who asked a panel of international cricketers for their personal views about the “*winning mind*” during interviews that were supposedly devoted to mental toughness. Given the above limitations in research design, it is not surprising that mental toughness has been mislabelled as an array of psychological attributes that are more commonly associated with expert performance. Furthermore, the reliance on qualitative methodologies has impaired the operationalisation of mental toughness and the development of reliable measurement tools.

Measurement Issues

There are a number of measurement tools purporting to measure mental toughness that have been published in the literature: (i) The Psychological Performance Inventory (PPI: Loehr, 1986), (ii) The Mental Toughness Questionnaire – 48 (MTQ-48: Clough et al., 2002), (iii) The Australian football Mental Toughness Inventory (AfMTI: Gucciardi, Gordon, & Dimmock, 2009a), (iv) The Sports Mental Toughness Questionnaire (SMTQ: Sheard, Golby, & van Wersch 2009), (v) The Cricket Mental Toughness Inventory (CMTI: Gucciardi & Gordon, 2009). However, there are three major criticisms of the instruments which currently exist in the literature. Firstly, none of the instruments were developed within the context of a sound theoretical framework, or with a clear conceptualization of mental toughness in mind (Crust, 2008). Secondly, many of the instruments published in the literature have failed to demonstrate adequate psychometric properties under rigorous statistical testing procedures (Gucciardi, Hanton, & Mallett, 2012). This is most likely due to a lack of clarity around the conceptualizations that underpin the proposed measures. Thirdly, all of the measures available in

the literature were originally designed as self-report questionnaires, which is highly problematic given that mental toughness questionnaires are inherently vulnerable to socially desirable responses (Crust, 2007). Recently, researchers have begun to ask other informants (e.g., parents and coaches) to complete mental toughness assessments (e.g., Gucciardi, Gordon, & Dimmock, 2009b). However, to put this criticism into context, of the 95 peer-reviewed studies that have been published on mental toughness since 2002, only two have used a non self-reported, assessment of mentally tough behaviour obtained from a relatively independent source.

Experimental Studies

Given the problems with defining and measuring mental toughness it is unsurprising that there are very few empirical studies that have focused on the development of mental toughness. This is alarming because the original interest in mental toughness came from applied practitioners who felt it was a crucial predictor of competitive performance (e.g., Gould et al., 1987). Coaches often request that sports psychologists enhance mental toughness in teams and individuals and it is often considered a central part of their role (cf., Gucciardi et al., 2009b). Given the interest expressed by applied practitioners in mental toughness, it is somewhat surprising that there are so few examples of effective mental toughness interventions in the literature. Perhaps the reason is the difficulty in distinguishing mental toughness from the psychological characteristics of elite performance (cf., Anderson, 2010). As things currently stand, it is difficult to know how a mental toughness intervention would differ from a typical psychological skills training package (e.g., Thelwell, Greenlees, & Weston, 2006). Recently, Gucciardi et al. (2009b) failed to find any differences in self, parent or coach ratings of mental toughness between a psychological skills training program and a specially designed mental toughness intervention. By their own admission, a large majority of the material delivered in the

mental skills program was also delivered in the mental toughness program (i.e., self efficacy, arousal regulation, and mental rehearsal). As a result it is unsurprising that the authors concluded that the common components of the programs were probably responsible for the similar observed effects. This study further illustrates the need to identify the distinctive elements of a mental toughness intervention that are not contained within a typical psychological skills training package.

Theoretical Rigour

A further criticism of the mental toughness research is the very modest attempts that have been made to draw upon any relevant theory (Middleton et al., 2004). Although researchers (e.g., Jones et al., 2002, 2007) have studied mental toughness within the guiding framework of personal construct theory (Kelly, 1955), there is very little evidence of researchers using existing theory to develop and test a priori hypotheses. Generally speaking, mental toughness is considered a relatively stable trait-like construct (Crust, 2007), that allows individuals to deal with stress and adversity in a wide range of circumstances (Middleton et al., 2004). It is common for mental toughness to be placed within the theoretical foundations of personality dispositions like hardiness (Kobasa, 1979) and tough-mindedness (Cattell, 1957; cf., Clough et al., 2002), and researchers appear to agree that the observable behaviours which characterise mental toughness centre on the ability to cope with difficulties, pressures, and adversity. For example, Clough et al. (2002, p. 38) referred to mental toughness as an ability to remain “relatively unaffected by competition or adversity”; and Loehr (1995, p. 293) described mental toughness as an “ability to perform toward the upper range of one’s talents and skills, regardless of competitive circumstances”. With these definitions in mind, the present author defined mental toughness as “a relatively stable disposition that enables one to maintain or enhance performance under

pressure from a wide range of different stressors”. It is worth noting at this point that such a conceptualization has relevance to a wide variety of different performance contexts, not just sport.

Reinforcement Sensitivity Theory

Having defined mental toughness as “a relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide range of different stressors”, there is a need to provide a theoretically driven account of the mechanisms that might underpin individual differences in performance under pressure. One theory which could explain such individual differences is Gray’s (1970) neuro-psychological theory of personality, now known as Reinforcement Sensitivity Theory (RST). RST emerged as an alternative psycho-physiological theory to Eysenck’s (1967) theory of personality which called for biologically based causal theories to account for the two major dimensions of personality, extraversion–introversion (E) and stability–neuroticism (N). Gray (1970) proposed that Eysenck’s E and N dimensions should be rotated by approximately 30° to form the more causally efficient axes: Reward Sensitivity, reflecting impulsivity and Punishment Sensitivity, reflecting anxiety. Gray (1970) went on to describe a conceptual nervous system which could account for these personality dimensions. According to RST, reward sensitivity is underpinned by a neurological system known as the Behavioural Activation System (BAS) comprising the dopaminergic reward circuitry, involving projections from the substantia nigra and the ventral tegmental area to the dorsal and ventral striatum, and also their corresponding cortical projections to the prefrontal cortex (McNaughton & Corr, 2004). By responding to rewarding stimuli in the environment, this system was thought to be responsible for all approach behaviour and peoples’ movements towards their goals (Carver & White, 1994). In the original theory, the neurological substrate of punishment sensitivity was

the Behavioural Inhibition System (BIS). The BIS was thought to be sensitive to signals of punishment, non-reward, and novelty and had the effect of inhibiting movement towards goals. Gray (1970) also held that BIS functioning was responsible for increases in physiological arousal as well as the experience of negative emotions such as fear, anxiety and frustration.

In 2000, Gray and McNaughton substantially revised RST to include a more elaborate neuro-physiology along with new predictions regarding the elicitation of fear and anxiety. In the new theory, the BAS remained largely unaltered, however there was a sharp (functional, behavioural, and pharmacological) distinction between fear and anxiety. Fear, which is underpinned by the flight-fight-freeze system (FFFS), has the function of moving an individual *away* from danger. The FFFS is thought to be responsible for mediating all reactions to aversive stimuli (unconditioned, conditioned and innate) resulting in active avoidance behaviour and is *insensitive* to anxiolytic drugs. The Behavioural Inhibition System (BIS), which underpins anxiety, has the function of resolving goal conflict. Typically conflict occurs between the BAS (approach) and the FFFS (avoidance), although conflict can also occur in approach-approach or avoidance-avoidance situations. Faced with an approach-avoidance conflict, anxiety is experienced when moving *towards* danger. Although the BIS is now thought to be engaged during approach to aversive stimuli, the approach-avoidance conflict still elicits similar outcomes to those stated in the original theory, namely, the inhibition of all pre-potent behaviour, an increase in physiological arousal and where appropriate the initiation of risk assessment behaviours. All these manifestations of the core state of anxiety are *sensitive* to anxiolytic drugs.

In the evolution of this theory since 2000, the core assumption about the neural basis of fear and anxiety has remained the same but the superstructure of the theory has been elaborated to encompass new data. In its simplest terms, the neural structures involved in the approach

towards (BIS) or away (FFFS) from threat depend on defensive distance. When there is a small defensive distance between an individual and a source of danger more caudal, sub-cortical structures are involved. When the defensive distances are larger more rostral, cortical structures are activated (see McNaughton & Corr, 2004 for further details). In total, the FFFS and the BIS make shared use of the periaqueductal grey, medial hypothalamus and amygdala at short defensive distances. When defensive distances are greatest, the FFFS involves the anterior cingulate, and prefrontal ventral stream, while the BIS involves the septo-hippocampal system, posterior cingulate, and prefrontal dorsal stream (McNaughton & Corr, 2008).

Reward Sensitivity

In the context of mental toughness it is possible to argue that all of the neural networks described in RST might be implicated in an examination of performance under pressure. In fact, it is possible to argue that multiple combinations of reinforcement sensitivities might be able to explain how individuals are able to maintain or even enhance performance under pressure from a wide range of stressors. For example, reward sensitivity or BAS functioning underpins all goal-directed behaviour (Gray, 1970). In order to perform optimally under pressure there is almost certainly a need to consistently engage in approach behavior in the pursuit of important goals. Encouragingly, there is plenty of empirical evidence which suggests that BAS functioning underpins the ability to consciously shift attention to goal-relevant information (Avila & Parcet, 2002) and to disengage from aversive, peripheral information that might act as a distraction (Avila & Torrubia, 2008). As such it appears reasonable to predict a positive relationship between reward sensitivity and mental toughness. However, heightened sensitivity to reward also underpins impulsive and dis-inhibited behavior (Gorenstein & Newman, 1980), which is unlikely to be optimal in pressurized circumstances. More specifically, heightened sensitivity to reward

impairs reflection of environmental contingencies and leads to a failure to learn from punishment (Patterson & Newman, 1993). In order to perform optimally under pressure, there is a need to learn from past mistakes and identify important changes to the environment, especially those that indicate threat. Based on this argument, it appears unlikely that reward sensitivity would always be positively related to mental toughness, and there may well be occasions where a negative relationship exists.

Punishment Sensitivity

The relationship between mental toughness and the neural networks that underpin punishment sensitivity, the FFFS and the BIS, is highly complex. One might argue for a negative relationship between mental toughness and punishment sensitivity because persistent avoidance behaviour (FFFS) or behavioural inhibition (BIS) is unlikely to lead to high levels of performance under pressure. Punishment sensitivity is related to the excessive detection and elaboration of negative material (Poy, Eixarch & Avila, 2004). Individuals who are sensitive to punishment process threat related stimuli more deeply and can become distracted by peripheral aversive information (Derryberry & Reed, 1994). Punishment sensitivity also predisposes individual to emotional distress in stressful situations (Heponiemi, Keltikangas-Järvinen, Puttonen, & Ravaja, 2003). These are not qualities one would normally associate with mental toughness. However, the BIS and the FFFS also have an adaptive evolutionary function, to help animals escape and/or approach dangerous situations. Corr (2004) has argued persuasively that punishment sensitivity can be associated with positive outcomes in threatening environments where there is a need to identify aversive stimuli and modify behaviour accordingly. The benefits of punishment sensitivity seem to revolve around the propensity to detect, process, and learn from aversive cues in the environment, retain them in memory for longer, and accurately predict

when they might re-occur (Avila & Torrubia, 2008). Given the inherently aversive nature of pressurized performance environments, these findings suggest that punishment sensitivity might be positively related to mental toughness in some circumstances.

RST and Performance

Generally speaking, RST studies have produced equivocal results in terms of performance (Corr, 2004). This should not come as a surprise given the research outlined above which implies a complex relationship between reinforcement sensitivities and the cognitions and behaviours which underpin performance. In addition, the empirical evidence from RST is difficult to interpret because there is tremendous variability in both experimental paradigms and the measures used to assess punishment and reward sensitivity (Avila & Torrubia, 2008). This is particularly pertinent in the case of punishment sensitivity because Gray's (1970) original theorizing related punishment sensitivity to BIS functioning and the personality trait anxiety. However, in the revised theory it is the FFFS which now responds to punishment and this is said to give rise to the emotion of fear (Gray & McNaughton, 2000). As it stands, there appears to be no clear resolution to this problem as Corr (2004, p. 324) relates punishment sensitivity to "combined FFFS/BIS functioning". Much of the empirical evidence since Gray and McNaughton's (2000) revisions has not taken into account the differentiation of BIS/FFFS functioning (cf. Smilie, Pickering, & Jackson, 2006). This is particularly problematic when interpreting data from studies that measured BIS with instruments devised before revisions were made to the theory (e.g. Carver & White, 1994).

Having acknowledged the revisions to RST (Gray & McNaughton, 2000) and the problems surrounding the measurement of BIS functioning (Smilie et al., 2006), the relationship between performance and punishment sensitivity remains complex. Some studies find very clear

negative relationships between punishment sensitivity and performance across a range of tasks, including letter recognition (Cavanagh & Allen, 2001), mental arithmetic (Boddy, Carver, & Rowley, 1986), air traffic control simulations (Koy & Yeo, 2008), gambling scenarios (van Honk, Hermans, Putman, Montagne, & Schutter, 2002), and multiple-choice examinations (Avila & Torrubia, 2004). Often, studies which find negative relationships between punishment sensitivity and performance find the opposite relationship between reward sensitivity and performance (Avila & Torrubia, 2008). Perkins, Kemp and Corr (2007), demonstrated that BAS sensitivity was a strong positive predictor of performance and BIS sensitivity was a strong negative predictor of performance in a peer-evaluated combat military scenario. However, there are other studies which find positive effects associated with punishment sensitivity and negative effects associated with reward sensitivity (e.g., Dennis & Chen, 2007). In fact, some of the studies outlined above found opposite effects when the balance of reward and punishment within the environment was amended. Avila and Torrubia (2004) found that punishment sensitivity was positively related to performance in multiple-choice examinations, but only when incorrect answers were penalised. When there was no penalty for choosing an incorrect response, reward sensitivity was a stronger predictor of performance. McCord and Wakefield (1981) similarly demonstrated that the relative balance of reward and punishment used by teachers was related to classroom attainment in a manner consistent with RST. Punishment sensitivity was related to academic achievement in classrooms where teachers frequently punished errors, whereas reward sensitivity was related to academic achievement when teachers praised correct responses without punishing errors. The sum total of this research suggests that the relationship between reinforcement sensitivities and performance might depend on the motivational context in which performance is assessed (Avila & Torrubia, 2008). In highly threatening environments,

punishment sensitivity is likely to be related to performance, whereas in environments which contain relatively greater opportunities for glory and positive re-enforcement, reward sensitivity is likely to be related to performance. In environments containing mixed appetitive and aversive stimuli it remains unclear how reinforcement sensitivities may be related to performance.

Interactive Relationships

Given the different predictions derived from RST and the equivocal empirical data, an investigation of the relationship between reinforcement sensitivities and mental toughness appears warranted. It is possible that RST may provide an explanation for individual differences in mentally tough behaviour. Corr (2001) has argued that equivocal data from RST may exist because of a failure to examine the interactive relationship between reinforcement sensitivities. The vast majority of research cited above examined main effects where punishment and/or reward sensitivity exerted an independent relationship on an outcome variable. Until now, interactions between punishment and reward systems have been largely ignored by reinforcement sensitivity theorists (Corr, 2004). The Joint Subsystems Hypothesis (Corr, 2001) postulates that under certain experimental conditions reward and punishment systems exert interactive, or joint effects. The systems underpinning punishment sensitivity and reward sensitivity are neutrally independent, but their outputs are expected to interact when they are concurrently activated. Effects consistent with the Joint Subsystems Hypothesis are predicted to occur in environments containing mixed appetitive and aversive stimuli, and where rapid attentional and behavioral shifts between reinforcing stimuli are required (Corr, 2001). It could be argued that these are the exact conditions which characterize pressurized performance environments where mental toughness is most clearly demonstrated. Often, when athletes are performing in pressurized contexts they are faced with opportunities for reward and

simultaneously are exposed to the possibility of punishment. The evidence compiled above suggests that extreme levels of either punishment or reward sensitivity are unlikely to be helpful in these circumstances. To perform optimally, athletes almost certainly need to be able to detect and manage threat (punishment sensitive) and simultaneously remain steadfast in the pursuit of their goals (reward sensitive). As such, complex interactive relationships may exist between reinforcement sensitivities and mental toughness, the exact nature of which is difficult to predict.

Purpose of the Thesis

In light of the limitations of the mental toughness literature the present research attempted to develop an alternative conceptualisation of mental toughness and endeavoured to establish construct validity for the new conceptualisation using established theory (RST) from the cognitive neuroscience literature. More specifically, the thesis has four main objectives: (i) to conceptualize and operationalise mental toughness in a way that overcame the limitations of previous definitions; (ii) to develop a valid and reliable informant-rated measure of mentally tough behaviour; (iii) to apply relevant personality theory to the examination of between-person differences in mentally tough behaviour, with a specific focus on cognitive neuroscience literature; (iv) to design a theoretically grounded mental toughness intervention and evaluate its effectiveness as a development program.

Thesis Format

The remainder of the thesis is composed of two empirical chapters comprising five separate studies designed to meet the objectives laid out above and one theoretical chapter that concludes the thesis. The structure of the thesis is as follows:

1. Chapter 2 presents a four study paper that defines mental toughness as “relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide range of different stressors”. The first two studies are concerned with the development of a valid, informant-rated questionnaire and the final two studies explore the interactive relationship between reinforcement sensitivities and mental toughness.
2. Chapter 3 presents a quasi-experimental longitudinal intervention study in which the design and delivery of a theoretically grounded mental toughness training program for a group of youth aged Academy cricketers is evaluated.
3. Chapter 4 summarises the findings from the thesis and presents an integrated discussion which includes applied and theoretical issues that have arisen along with some recommended avenues for future research.

The thesis was structured in such a condensed manner to meet the dual needs of completing a thesis and learning how to write empirical papers for publication. As such, some of the detailed content that is included in the general introduction (Chapter 1) is repeated in the introductions of the empirical chapters in an abbreviated format so they were compatible with publication standards. This approach helped to train the candidate to engage with the research process at an early stage with a view to producing multi-study research papers suitable for publication in high quality journals.

Chapter 2

Preliminary evidence for a neuro-cognitive model of mental toughness¹

¹ This chapter is submitted for publication as;

Hardy, L., Bell, J. J., & Beattie, S. J. (under review). Preliminary evidence for a neuro-cognitive model of mental toughness. *Journal of Personality*.

Abstract

The mental toughness literature is often criticized for being overly descriptive, atheoretical, and overly reliant on qualitative methodologies. In order to address these criticisms four studies were conducted with three main objectives: (i) to conceptualize and operationalize mental toughness in a way that overcame the limitations of previous definitions; (ii) to develop a valid and reliable measure of mentally tough behavior; and (iii) to apply relevant personality theory to the examination of between-person differences in mentally tough behavior. Studies 1 and 2 focused on the development of an informant-rated mental toughness questionnaire that assessed individual differences in the ability to maintain or enhance performance under pressure from a wide range of stressors. Studies 3 and 4 examined the relationship between reinforcement sensitivities and mentally tough behavior. In both studies, the highest level of mental toughness reported by coaches occurred when individuals were sensitive to punishment and insensitive to reward. Follow up work in Study 4 suggested that mentally tough cricketers are predisposed to identify threatening stimuli early which gives them the best possible opportunity to plan an effective response for the pressurized environments they encounter. Implications and directions for future research are discussed.

KEYWORDS: mental toughness, reinforcement sensitivity theory

Mental Toughness is a term used to describe the attributes that enable some people to perform or behave exceptionally well in psychological circumstances where others are unable to cope and “choke” or “fall by the wayside”. It has relevance in a wide range of performance contexts including business settings, military, performing arts, and high level sport (Jones, 2004). Nevertheless, although there is a considerable volume of published research on mental toughness, the construct is not well-understood or even well-defined within the research community (cf., Anderson, 2010).

Mental toughness is generally considered to be a relatively stable trait-like construct that allows individuals to deal with stress and adversity in a wide range of circumstances (Crust, 2007; Middleton, Marsh, Martin, Richards & Perry, 2004). It is common for mental toughness to be placed within the theoretical foundations of personality dispositions like hardiness (Kobasa, 1979) and tough-mindedness (Cattell, 1957; cf., Clough, Earle & Sewell, 2002), and researchers appear to agree that the observable behaviors which characterize mental toughness centre on the ability to cope with difficulties, pressures, and adversities. For example, Clough et al. (2002, p. 38) referred to mental toughness as an ability to remain “relatively unaffected by competition or adversity”; and Loehr (1995, p. 293) described mental toughness as an “ability to perform toward the upper range of one’s talents and skills, regardless of competitive circumstances”.

Although there is general consensus around the trait-like qualities associated with mental toughness, the circuitous definitions that have often been often provided in the literature are somewhat confusing. For example, Jones, Hanton and Connaughton (2002: p.292) defined mental toughness as “a natural or developed psychological edge that enables you to: (a) generally cope better than your opponents with the many demands (competition, training, lifestyle) that sport places on a performer; (b) specifically be more consistent and better than your opponents in

remaining determined focused, confident and in control under pressure”. The first part of this definition which focuses on coping with adversity is clearly in line with the definitions provided by other researchers outlined above. However, the second part appears to be a description of more generic psychological characteristics related to elite performance rather than the central components of mental toughness (see, for example, Hardy, Jones & Gould, 1996). To add to the confusion, the definition provided by Jones et al. (2002) is accompanied by an extensive list of psychological attributes that are proposed to characterize the mentally tough performer. The list of attributes includes motivation; self efficacy; concentration; resilience; anxiety control; and competitiveness (Jones, Hanton, & Connaughton, 2007). In the view of the present thesis, it is inconceivable that all of these attributes are necessary components of mental toughness and it seems highly likely that at least some of them would be more accurately described as correlates of mental toughness.

One reason why so many problems have arisen in the conceptualization of mental toughness may be an over-reliance on qualitative methodologies in the extant literature (Crust, 2007). Typically, this literature asks high level performers and coaches what the term mental toughness means to them and how they developed it. The researchers then report the findings as though they have some theoretical significance (e.g., Jones et al., 2002, 2007). However, such designs assume that elite performers and coaches have declarative knowledge of the psychological characteristics possessed by elite performers, and are able to differentiate between the psychological attributes of an elite performer and those of a mentally tough performer. Furthermore, both athletes and coaches have repeatedly cited difficulties articulating exactly what mental toughness is (Clough et al., 2002). Critics of mental toughness research, such as

Anderson (2010), have argued that relying on athletes' retrospective opinions has contributed to the circuitous and confusing conceptualizations that abound in the literature.

These methodological problems are magnified by the relatively modest attempts that have been made to draw upon relevant theory when investigating mental toughness (Crust, 2008). Often studied within a guiding framework of personal construct theory (e.g., Jones et al., 2002, 2007), there is almost no evidence of researchers using theoretical constructs to develop and test a priori hypotheses. There is clearly a need to develop a conceptualization of mental toughness that: 1) utilizes existing theories of personality and performance under stress; 2) isolates the central components of mental toughness from its correlates; and 3) differentiates between correlates that could be causal influences upon mental toughness, correlates that are likely outcomes of mental toughness, and correlates that could be involved in a circuitous relationship with mental toughness. With this in mind, the present thesis proposes that mental toughness might best be conceptualized in terms of the observable behaviors underpinning the disposition. Given the general consensus around the behaviors which characterize mental toughness (e.g., Clough et al., 2002), and the problems inherent in Jones et al.'s (2002) original definition, the present thesis chose a simple if relatively narrow definition of mental toughness: *a relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide range of different stressors*. It is worth noting at this point that such a conceptualization has relevance to a wide variety of different performance contexts, not just sport.

A number of measures of mental toughness have been developed in the literature (for a review see Connaughton, Hanton, Jones, & Wadey, 2008). However, there are two major criticisms of all the instruments that currently exist. Firstly, none of the instruments was

developed within the context of a sound theoretical framework, or with a clear conceptualization of mental toughness in mind (Crust, 2008). Secondly, all of the instruments are self-report in nature which is highly problematic given that mental toughness questionnaires are inherently vulnerable to socially desirable responses (Crust, 2007). To put this second criticism in context, of the 87 studies that have been published on mental toughness since 2002, none has used a reasonable, objective, assessment of mentally tough behavior obtained from a relatively independent source. As such, the initial purpose of the current investigation (studies 1 and 2) was to construct a measurement tool to be completed by an informant (e.g., a coach) that could be used to assess mental toughness in sports performers. Sport was considered an appropriate context in which to examine mental toughness because the competitive sports environment can be very stressful and often requires athletes to perform under intense pressure. Although the demands placed upon a performer can emerge from a number of sources including competition, training, injury, general life events, and everyday occurrences (cf. Hardy et al., 1996), the present set of studies will focus exclusively on competitive pressures because these seem to be particularly salient to high level athletes (Gould, Diefenbach, & Moffet, 2002). The development of another version of this instrument, focused upon mental toughness in training, will be reported elsewhere.

The second and primary aim of the investigation is to examine relevant personality theories that are capable of accounting for mentally tough behaviour. Of particular interest is the cognitive neuroscience literature (cf. Gray & McNaughton, 2000) which might help to identify the neural architecture that underpins mental toughness. This theory will be discussed after studies 1 and 2.

Study 1

Method

Participants

246 University students (133 male; 113 female) from the UK aged between 18 and 31 ($M_{age} = 20.5$, $SD = 2.1$) were recruited to take part in the first stage of data collection. All participants were members of University sports teams and/or local sports clubs from the following sports: Netball (26), Hockey (87), Rugby Union (34), Rugby League (30), Soccer (51), and Athletics (18). In order to take part in the study, participants were required to have been actively involved in university or club sport for at least 12 months. They also had to be able to make informed judgments about the performance of other athletes who competed on the same team as themselves.

Measures

Mental Toughness was assessed using an “informant” rated scale designed specifically for the series of studies. The measurement tool was based on the definition of mental toughness proposed in the introduction, namely, ‘a relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide range of different stressors’. Items focused on performers’ abilities to deal with the stressors that they typically face in competition. Items were generated by the first author in conjunction with various experienced sport coaches. Consensus amongst all authors was reached on 15 items which were retained for subsequent use in the inventory (see Table 1 for a full list of items). The informant was asked to rate how often a specific performer was able to maintain a high level of personal performance in different pressurized situations. Responses were based on a 7-point likert scale and ranged from 1 (rarely), to 7 (regularly) with a midpoint anchor of 4 (sometimes). Standard anti social desirability

instructions were included at the beginning of the inventory. Copies of the inventory can be obtained from the corresponding author upon request.

Procedure

After ethical approval, University students were initially approached prior to or following lectures to inform them of the nature of the study and the inclusion criteria. If the inclusion criteria were satisfied, the student was asked to identify a teammate or athlete they thought they could complete the mental toughness inventory on, and complete an informed consent form. Participants were advised to complete the Mental Toughness Inventory (MTI) on the teammate or athlete that they had observed the most (i.e., the team-mate they had played alongside for the longest). Participants were also instructed that the completed inventories would remain confidential and would not be shared with any third parties (e.g., coaches or team-mates).

Results

Confirmatory Factor Analysis (CFA) was used in an exploratory fashion to examine the factor structure of the Mental Toughness Inventory. A model was considered a good fit if the χ^2/df ratio was less than 2.00, the Comparative Fit Index (CFI) approached .95, the Root Mean Square of the Approximation (RMSEA) approached .05, and the Standardized Root Mean Square Residual (SRMR) was less than 0.8. Prelis 2.14 (Jöreskog & Sorbom, 2003) was used to generate a covariance matrix and Lisrel 8.5 (Jöreskog & Sorbom, 2003) was used to test the single factor model. The fit statistics for the initial 15 item model were not acceptable, $\chi^2(90) = 317.32$, CFI = .90, RMSEA = .11, SRMR = .08. To produce a good fit, post hoc model modifications were carried out by examination of the standardized residuals, the modification indices for Theta-Delta (unique item variance), and the theoretical content of each item. The post-hoc analysis revealed that 7 items possessed high standardised residuals and modification

indices. These were subsequently removed. The fit statistics for the resulting eight-item model were considered a good fit $\chi^2(20) = 33.82$, CFI = .98, RMSEA = .06, SRMR = .04. All of the standardized factor loadings were above 0.4, and only item 1 ('preparation hasn't gone to plan') was considered questionable at 0.46. This item was not removed from future analyses as it was considered a valuable item on theoretical grounds. Cronbach's alpha for the MTI was .87. The mean score (plus standard deviation) for informants' ratings of their peers on the MTI was 4.18 (SD = 1.06).

Discussion

Study 1 found a good fit for an eight-item Mental Toughness Inventory (MTI) across a sample of University athletes. The MTI focused on performers' abilities to maintain a high level of personal performance when confronted by a wide range of pressurized circumstances. The aim of the second study was to confirm the factor structure of the MTI on a separate sample of professional cricketers assessed by their coaches.

Table 1.

Items from the Mental Toughness Inventory used in Studys 1 & 2. Means (SD) are included for each item.

<i>Player X is able to maintain a high level of personal performance in competitive matches:</i>	Study 1		Study 2	
	Loadings	Mean (SD)	Loadings	Mean (SD)
1) When people are relying on him to perform well. *	0.67	4.24 (1.82)	0.68	4.77 (1.32)
2) When the conditions are difficult. *	0.70	4.59 (1.47)	0.69	4.69 (1.11)
3) When he has to perform at a high level all day. *	0.65	4.53 (1.58)	0.69	4.76 (1.14)
4) When it's a very important game in the season. *	0.79	4.31 (1.82)	0.81	4.84 (1.26)
5) When the match is particularly tight. *	0.77	4.34 (1.60)	0.78	4.79 (1.22)
6) When the opposition are using aggressive tactics. *	0.65	4.58 (1.72)	0.64	4.98 (1.31)
7) When there are a large number of spectators present. *	0.67	4.78 (1.56)	0.66	4.82 (1.20)
8) When his preparation has not gone to plan. *	0.53	3.94 (1.55)	0.46	4.38 (1.37)
9) When his recent performances have been poor. R	0.48	3.53 (1.70)		
10) When he is lacking in confidence. R	0.49	3.49 (1.52)		
11) When he is suffering from fatigue. R	0.44	4.02 (1.56)		
12) When he has received criticism from significant others. R	0.52	3.75 (1.65)		
13) When his team-mates are struggling. R	0.56	4.48 (1.69)		
14) When the opposition are of a particularly high standard. R	0.78	4.36 (1.72)		
15) When he is struggling with an injury. R	0.40	3.53 (1.47)		
Total Mental Toughness		4.18 (1.06)		4.76 (0.95)

* *Items retained in the eight-item model used in Studys 2, 3 & 4.*

R *Items removed from the eight-item model using in Studys 2, 3, & 4*

Study 2

Method

Participants

The participants for the second study were 110 male cricket coaches from the UK aged between 25 and 63 ($M_{age} = 41.86$, $SD = 9.92$). All of the coaches were fully qualified and had on average 8.64 years of coaching experience ($SD = 6.38$). A large proportion of the coaches recruited for this study ($n=91$) were employed by one of the 18 First Class Counties that play cricket professionally in the UK. The remaining nineteen coaches were affiliated to one of the 18 First Class Counties in a part-time capacity (i.e., school coach or club coach). All of the coaches recruited for this study were asked to complete the Mental Toughness Inventory for one of the county players they observed on a regular basis.

Measures

The eight-item MTI that was developed in Study 1 was used in this study.

Procedure

After ethical approval, coaches were contacted by email to inform them of the nature of the study. The first and second authors are known to many professional cricket coaches through other work with the England and Wales Cricket Board. Once permission had been granted, the coaches were emailed a copy of the Mental Toughness Inventory along with the relevant consent forms. All coaches were instructed to identify the player they had observed in competition the most. As a guideline, coaches were expected to have coached the player for at least one year and observed at least ten competitive performances. All of the coaches who agreed to participate returned the Mental Toughness Inventory and the consent forms within one week.

Results

To confirm the factor structure of the MTI, CFA was conducted on the whole sample of 110 coaches. The fit statistics for the eight-item model were considered very good, $\chi^2(20) = 25.28$, CFI = .98, RMSEA = .05, SRMR = .04. The standardized factor loadings exceeded 0.6 for all items in the model. Cronbach's alpha for the MTI was .89. Descriptive statistics for the MTI are shown in Table 1. The mean score (plus standard deviation) for the coaches ratings of their players was 4.76 (SD = 0.95). As one would expect, an independent samples t-test indicated that the coaches rated their professional cricketers as significantly more mentally tough than the university students rated their peers, $t(354) = 2.74$, $p < .01$.

Discussion

Study 2 confirmed the structural validity of the eight-item MTI in a separate sample of qualified cricket coaches. The MTI also discriminated between professional cricketers and university athletes in terms of mental toughness. However, as indicated in the general introduction, in order to progress the mental toughness research literature there is a need to identify relevant theory which is capable of accounting for the behaviors measured in Studies 1 and 2. This was the aim of Study 3.

Study 3

One theory that could explain individual differences in mental toughness is Gray's (1970) neuro-psychological theory of personality, now known as Reinforcement Sensitivity Theory (RST). Originally, Gray (1970) proposed that Eysenck's (1967) extraversion-introversion and neuroticism-stability dimensions should be rotated by approximately 30° to form the more causally efficient and biologically aligned axes corresponding to Reward Sensitivity and Punishment Sensitivity. Gray and McNaughton (2000) went on to describe in detail a biologically underpinned conceptual nervous system which was capable of accounting for these

personality dimensions. According to RST, reward sensitivity is underpinned by a neurological system known as the Behavioural Activation System (BAS) comprising the dopaminergic reward circuitry, involving projections from the substantia nigra and the ventral tegmental area to the dorsal and ventral striatum, and also their corresponding cortical projections to the prefrontal cortex (McNaughton & Corr, 2004). By responding to rewarding stimuli in the environment, this system was thought to be responsible for all approach behavior and peoples' movements towards their goals (Carver & White, 1994).

Punishment sensitivity is underpinned by a combination of the Fight-Flight-Freeze system (FFFS) and the Behavioral Inhibition System (BIS). The FFFS and the BIS make shared use of the periaqueductal grey, medial hypothalamus, amygdala. The FFFS also involves the anterior cingulate, and prefrontal ventral stream (Corr, 2004), while the BIS involves the septo-hippocampal system, posterior cingulate, and prefrontal dorsal stream (Gray & McNaughton, 2000). The FFFS is thought to be responsible for mediating all responses to aversive stimuli (unconditioned, conditioned, and innate) resulting in active avoidance behavior, that is when a person's chief concern is to remove him/herself from the situation. The Behavioral Inhibition System (BIS) is engaged during approach towards aversive stimuli and is responsible for resolving goal conflict between the BAS and the FFFS. Approach-avoidance conflict elicits a series of behavioral outcomes associated with anxiety, including; the inhibition of all pre-potent behavior; an increase in physiological arousal; and, where appropriate, the scanning of long term memory for information that might be relevant to resolving the conflict.

Encouragingly, RST has yielded many findings which are pertinent in the context of mental toughness. For example, reward sensitivity predicts positive indicators of well being in stressful occupational environments (Van der Linden, Beckers, Taris, & Kindt, 2007), and acts as

a buffer against risky health behaviours (Voigt, Dillard, Braddock, Anderson, Sopory, & Stephenson, 2009). Furthermore, high levels of reward sensitivity have been associated with mild reactions to highly threatening situations (Perkins & Corr, 2006), and high levels of performance in a military combat scenario (Perkins, Kemp, & Corr, 2007). In contrast, punishment sensitivity is associated with negative evaluations of capacity to deal with pain (Muris, Meesters, van den Hout, Wessels, Franken, & Rassin, 2007). In behavioral terms, Cavanagh and Allen (2008) found that when individuals made errors during a maths stress task, they were more likely to demonstrate deficits in ensuing performance if they were sensitive to punishment. There is also empirical evidence that punishment sensitivity positively predicts orientation away from threatening situations (Perkins & Corr, 2006), and negatively predicts performance outcomes in military combat tasks (Perkins et al., 2007).

The research cited above suggests that reward sensitivity is related to various cognitions and behaviors which one might associate with mental toughness. Equally punishment sensitivity is often associated with cognitive processes and behaviors that appear to imply a lack of mental toughness. However, it is important to note that all of the research cited above examined only the main effects of reward and punishment sensitivity, rather than interactions between the two systems. Considering that the neural networks responsible for punishment sensitivity and reward sensitivity are relatively independent (Gray & McNaughton, 2000), it seems likely that interactions between reward and punishment sensitivity will prove important. Corr (2001) has proposed that interactive effects are most likely to occur in environments containing mixed appetitive and aversive stimuli, where humans typically preside. Based on this thinking, the purpose of Study 3 was to examine main *and* interactive effects of reward sensitivity and punishment sensitivity on mental toughness in high level cricketers, as rated by coaches using

the eight-item Mental Toughness Inventory. On the basis of the empirical evidence available, high levels of coach rated mental toughness were hypothesised to occur only when reward sensitivity was high and punishment sensitivity was low. Furthermore, punishment sensitivity was hypothesised to be negatively related to mental toughness when reward sensitivity was high but unrelated to mental toughness when reward sensitivity was low.

Method

Participants

214 male cricketers from the UK aged between 15 and 19 ($M_{age} = 17.1$, $SD = 1.3$) were recruited to take part in the study. Cricket is a national sport in the United Kingdom with some similarities to baseball in that it requires players to make decisions and perform complex motor actions under considerable time and competition pressure. All participants were currently involved or recently graduated from a County Academy. There are 18 First Class County Academies based in the UK. Each Academy can select a maximum of 12 precociously talented players between the ages of 15-18 per year. Players are selected based on performances in training and competition which suggest they have the potential to play professional cricket. Each of the 214 cricketers recruited for this study were rated on the MTI by a County Coach. In total 30 coaches ($M_{age} = 38.94$ $SD = 8.21$ years) completed the MTIs; each coach rated between 2 and 15 cricketers ($M = 7.13$ ratings per coach).

Measures

Mental Toughness

The eight-item MTI, validated in studies 1 and 2, was used to measure mental toughness.

Reward and Punishment Sensitivity

Reinforcement sensitivity was assessed using Corr's (2001) transformations of the Eysenck Personality Questionnaire – Revised Short version (EPQR-S, Eysenck, Eysenck, & Barrett, 1985). The EPQR-S is a 36 item self-report questionnaire that provides scores on extraversion (12 items), neuroticism (12 items), and psychoticism (12 items). The EPQR-S scales have demonstrated good internal reliability ($\alpha = 0.77 - 0.88$), show good comparability to longer versions of the Eysenckian personality measures (Francis, Philipchalk, & Brown, 1991), and have been used on similar aged adolescent males (Eysenck et al., 1985). Each item is framed as a forced-choice question which is to be answered on a “yes” or “no” basis. In order to measure reward and punishment sensitivity, the EPQR-S scales were subjected to Corr's (2001) transformations: reward sensitivity = $((E \times 2) + N + P)$, and punishment sensitivity = $((12 - E) + (N \times 2) - P)$, where E = extraversion, N = neuroticism, and P = psychoticism. Scores were therefore free to range from 0 to 48 for reward sensitivity, and from -12 to 36 for punishment sensitivity.

Procedure

After ethical approval, Academy Directors from all 18 First Class Counties were contacted via email and provided with a brief description of the study and participant requirements. After Academy directors and coaches granted permission for data collection an information letter and consent forms were distributed to academy affiliated players. Information letters and consent forms were also distributed to parents / guardians for affiliated players who were under 16 years of age. To avoid socially desirable responses, the information letter deliberately made no mention of “mental toughness” or “performance under pressure”. All participation was voluntary and all parties were informed that they could withdraw at any time.

Data collection occurred immediately prior to an academy training session. All data were collected at least 24 hours before or after a competitive match to avoid competition specific biases. Affiliated players were given the EPQR-S along with standardized instructions about completion. All affiliated players were instructed that the data provided would be held in confidence and not shared with any third party (e.g., their coach). Whilst the affiliated players completed the EPQR-S the Academy Director was provided with the MTI for all those affiliated players involved in the study along with standardized instructions about completion. Due to time constraints there were occasions when the Academy Director was unable to complete the MTIs on the same day as the players provided their data. When this occurred the Academy Director was asked to return the forms by post or email within 48 hours.

Analysis

The current data consisted of two hierarchical levels, with cricketers (Level 1) nested within the coaches (Level 2). Multi-level modeling allows researchers to examine Level 1 and Level 2 relationships among variables simultaneously and provides estimates of individual slopes and intercepts for each set of level 1 units embedded within each level 2 unit. Analyses were conducted using the MLwIN software package (V. 2.1; Rasbash, Charlton, Browne, Healy, & Cameron, 2009). Consistent with procedures set out by Rashbash et al. (2009) all of the variables in the analysis were standardized (thus the coefficients in the analysis should be interpreted as β coefficients) and group mean centered (i.e., individual scores were centered on their respective group mean).

In a single-level regression model, both the intercept and slope are fixed for all observations. However, in a multi-level model the intercept is allowed to vary across level-2 variables (e.g., coaches). The multi-level model may further specify the slope (i.e., the regression

coefficient of the explanatory variable) to vary between level-2 (coach) units as well. To determine whether fitting random slopes improves on the random intercept model, an examination of the deviance, $-2 \log$ likelihood (χ^2) statistic is required. A significant reduction in the χ^2 statistic indicates that fitting random slopes does significantly improve the model, whereas a non-significant reduction indicates that the most parsimonious model is the random intercept (only) model. Estimates were obtained using the iterative generalized least squares (IGLS) procedure embodied in the MLwIN software. Following preliminary analysis of whether the Level 2 variances should be randomized or fixed, multilevel analyses were conducted in a sequential manner whereby each predictor variable was entered into the multilevel equation in turn. Model 1 displays the results for the predictor variable (punishment sensitivity), Model 2 displays the results for the predictor variable and the moderator variable (reward sensitivity), and Model 3 displays the results for the predictor variable, moderator and the interaction term predicting the dependent variable (mental toughness). The nature and form of significant interactions were followed up by plotting the interactions at one standard deviation above and below the mean (Aiken & West, 1991). Analyses of simple slopes were carried out using the software developed by Preacher, Curran, and Bauer (2006).

Results

Descriptive statistics and correlations for all study variables are displayed in Table 2. The unconditional model, where the dependent variable is entered without any predictors at any levels, represents the unexplained variation in mental toughness at both levels (i.e., individual and group). In this data set the interclass correlation for mental toughness was 0.00042, suggesting that 0.042% of the variance in mental toughness was at the between coach level and 99.96% of the variance in mental toughness was at the within players level. When the slopes

were allowed to vary in Model 1 and Model 2, a non-significant reduction in the χ^2 statistic was found, indicating that fitting random slopes did not improve on the random intercept model. This is in line with the theoretical perspective taken, as there is no reason to believe that the relationship between reinforcement sensitivities and mental toughness should vary as a function of coach related variables. Consequently, the level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. Model 3 in Table 3 reveals that having controlled for main effects of punishment sensitivity ($\beta_1 = -.055$ [SE = .057], $p > .05$), and reward sensitivity ($\beta_2 = .422$ [SE = .060], $p < .01$), the punishment x reward sensitivity interaction term was significant ($\beta_3 = -.470$ [SE = .062], $p < .01$). Figure 1 shows that when reward sensitivity is low, mental toughness increases as punishment sensitivity increases. However, the opposite relationship exists when reward sensitivity is high, whereby mental toughness decreases as punishment sensitivity increases. Using the Preacher et al. (2006) software to further explore the interaction revealed that the slope for low reward sensitivity was significant and positive $t(211) = 4.96$, $p < .01$, whereas the slope for high reward sensitivity was significant and negative, $t(211) = -6.27$, $p < .01$.

Table 2.

Means, SDs and inter-correlations among the variables in Study 3

	Mean (SD)	1	2
1 Punishment Sensitivity	9.24 (7.43)		
2 Reward Sensitivity	24.36 (5.59)	-.206**	
3 Mental Toughness	4.40 (0.98)	-.035	-.494**

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

Table 3.

Multilevel Analyses: Effects of Reinforcement Sensitivities on Mental Toughness in Study 3

Mental Toughness	Model 1		Model 2		Model 3	
	β	<i>SE</i>	β	<i>SE</i>	β	<i>SE</i>
Intercept, β_{0ij}	4.41	.068	4.41	.059	4.34	.054
Punishment Sensitivity, β_1	.010	.072	-.083	.064	-.055	.057
Reward Sensitivity, β_2			-.528**	.065	-.422**	.060
PS x RS, β_3					-.470**	.062

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

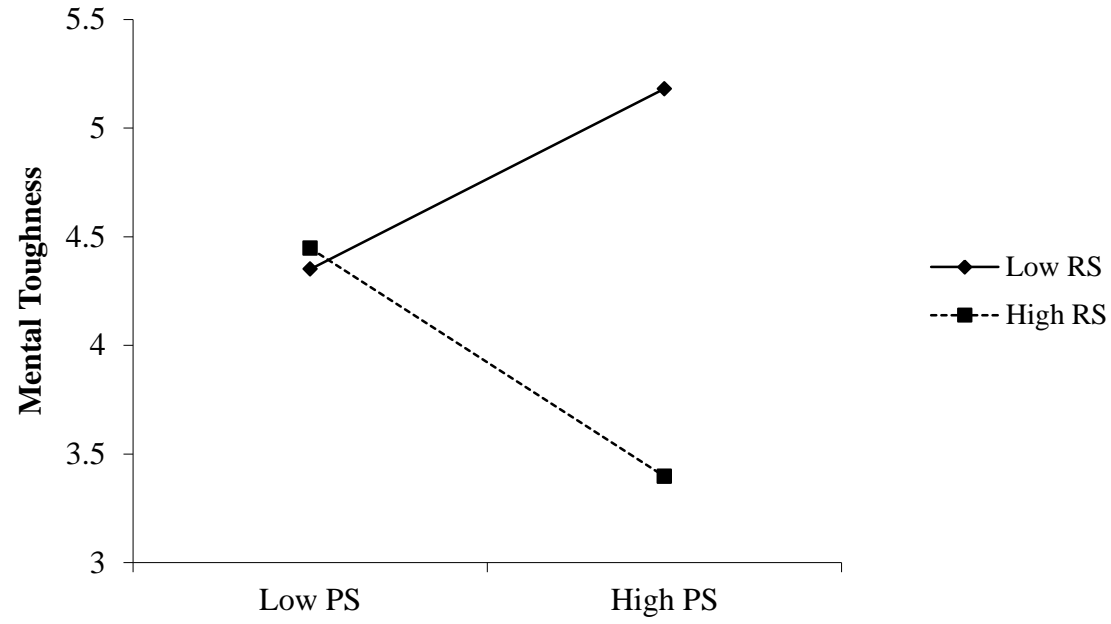


Figure 1

Interaction between Punishment Sensitivity and Reward Sensitivity predicting Mental Toughness in Study 3

Discussion

The main aim of Study 3 was to examine the relationship between reinforcement sensitivities and coach assessed mental toughness. The results were counter to our original hypotheses, in that punishment sensitivity was found to be significantly and positively related to mental toughness when reward sensitivity was low, and significantly and negatively related to mental toughness when reward sensitivity was high.

We were not expecting avoidance motivation to be adaptive in pressurized environments. However, one possible explanation for this finding is that individuals who are sensitive to punishment and insensitive to reward are predisposed to pick up threat earlier than their counterparts. A series of early studies by Fenz and associates (e.g., Fenz & Epstein, 1968; Fenz and Jones, 1972) found that early threat detection combined with an inhibitory control process was an adaptive mechanism used by experts in the mastery of stress. By identifying the potential threats earlier, the performer has more time and opportunity to implement an effective coping strategy. Of course, this argument relies on the assumption that the participants in the current study had developed effective coping mechanisms. Considering the population used in the present study contained cricketers who had been involved in highly competitive national level sport for approximately 4-5 years this appears a reasonable assumption to make. Without effective coping strategies it is likely that players (especially punishment sensitive players) would either have withdrawn from competitive cricket voluntarily or have been de-selected from county programs by their coaches. In the context of mental toughness, as it is conceptualized in the present investigation, early threat detection appears more advantageous than late threat detection or denying that threats exists, which is what may happen when players are insensitive to punishment cues. In a cricket specific context, one might imagine a batsman who identifies the

strengths of the opposition and the different tactics they might use well in advance of a match, and then mentally rehearses a range of behaviors designed to combat the opposition's strengths (see, for example, Hardy et al., 1996). It is not hard to imagine a coach rating this batsman highly on a measure of mental toughness.

To understand why the relationship between punishment sensitivity and mental toughness is negative when reward sensitivity is high, it is helpful to examine Gray and McNaughton's (2000) revisions to RST. The revised version of the theory states that the BIS is only activated by sources of conflict (i.e., stimuli that activate both the BAS and the FFFS concurrently). Such approach-avoidance conflict is most likely to occur when an individual is sensitive to both punishment and reward (i.e., high PS / high RS). Kambouropoulos and Staiger (2004) confirmed this line of thinking when they found that slower response times, indicative of behavioral inhibition, occurred for individuals who reported high scores on EPQ-derived punishment sensitivity *and* reward sensitivity. In a sporting context, the inhibition of all pre-potent behavior that occurs when the BAS and FFFS are activated concurrently, may well appear to a coach as if the player lacks composure and decisiveness. More specifically, in cricket one might picture a batsman who at one level is focused on winning the match for his team (i.e., reward) and at another level is worried about avoiding being dismissed so as not to let his team down (i.e., punishment). The conflict engendered is likely to lead to high levels of behavioral inhibition which coaches would likely observe as low levels of mental toughness.

Although the results of Study 3 can be explained in a relatively coherent manner by the above line of reasoning, further investigation was clearly required to test such a post hoc explanation. One aim of Study 4 was therefore to replicate the findings of Study 3. A second aim was to examine the relationship between reinforcement sensitivities and threat detection. On the

basis of the results that emerged in Study 3, it was hypothesised that threat detection would occur earlier as punishment sensitivity increases. The final aim of Study 4 was to examine context specific behavioural inhibition in high level cricketers. On the basis of Study 3's findings, it was hypothesised that higher levels of behavioural inhibition would be found in cricketers who were high in both punishment and reward sensitivity.

Study 4

Method

Participants

196 male cricketers from the UK aged between 15 and 18 ($M_{age} = 17.23$, $SD = 2.13$) were recruited to take part in the study. All participants were nominated by a county coach to attend the "National Cricket Talent Test" (NCTT). Players were only nominated if they were judged to have the potential to be a future World's best cricketer based on performances in training and competition. Each county coach was permitted to nominate up to a maximum of ten players. Each of the 196 cricketers recruited for this study were rated on the MTI by a County Coach. In total 45 coaches ($M_{age} = 41.28$ $SD = 7.90$ years) completed the MTI ; each coach rated between 2 and 8 cricketers ($M = 4.35$ ratings per coach).

Measures

Mental Toughness and Reinforcement Sensitivity

These were measured in the same way as in Study 3.

Threat Detection

Threat detection was measured using a questionnaire designed specifically for this study. The questionnaire depicted a series of 8 potentially threatening scenarios specific to cricket. The scenario was always framed in a potentially threatening manner. For example, "Your county side

(U-17 / U-19) are playing in a national final at Lords. There are approximately 1000 spectators present. Your team is batting second. You are chasing 250 and the score is currently 220-4 at the start of the 45th over. You are due to be batting at number 10.” Participants were then asked at what point they would start mentally preparing for the event. For each scenario there were five potential options to choose from. Each option was assigned a categorical rating from 1-5, where 1 referred to the latest time to begin mental preparation and 5 referred to the earliest time to begin mental preparation. As such high scores reflected early threat detection and long periods of mental preparation and low scores reflected late threat detection and short periods of mental preparation. Scores were standardized and then summed to give a total score which was used as the dependent variable in all further analyses.

Behavioral Inhibition

Behavioral Inhibition was assessed using a computer based decision making task designed specifically for this study. The task was designed to measure conflict induced behavioral inhibition. Participants were presented with a series of cricket specific scenarios on a PC computer screen. Each of the scenarios was a video clip obtained from television footage of the 2009 T:20 World Cup in England. The scenarios were selected by the second author in conjunction with a group of highly qualified cricket coaches. In order to generate conflict in participants, scenarios depicted pressurized situations where the game was closely contested and it was difficult to identify the best course of action. Prior to the presentation of each scenario the subject was made aware of the duration of the video footage, the match situation and the location of the fielders in the scenario. At the end of the scenario the subject was presented with two options; option A and option B. Option A was always a relatively cautious option, whereas Option B was always a relatively risky option (see below). Participants were instructed to decide

what the most appropriate option was if they were to find themselves in that situation. Behavioral Inhibition was measured as the processing time it took to make the decision. Longer processing times were taken to indicate greater behavioral inhibition. In total, there were 6 scenarios depicting fielding situations. Fielding scenarios were chosen because every player has to field in cricket whereas batting and bowling tasks are usually carried out by specialists. There was therefore a concern that level of expertise would account for greater effects in processing time than reinforcement sensitivities in batting or bowling scenarios. One example of the type of options used in the decision making task is as follows: “A: Let the ball bounce, B: Go for the catch”.

Procedure

After ethical approval, an information letter and consent forms were distributed to all players nominated for the National Cricket Talent Test. The same documentation was distributed to the parents/guardians of nominated players under 16 years of age. The National Cricket Talent Test occurred over 5 days in September 2010 at the conclusion of the competitive cricket season. All data were collected within this 5 day period. Participants completed the self report questionnaires (EPQR-S and threat detection) at the same time in a classroom type environment. All participants were given standardized verbal instructions regarding the completion of the questionnaires including standard anti social-desirability instructions which encouraged participants to respond honestly at all times. All participants were also informed that data provided would be held in confidence and not shared with any third party (e.g., their coach), or used for talent selection purposes.

Data related to behavioral inhibition was collected on the same day as the questionnaire data. Participants were divided randomly into groups of 5 to complete the decision making task.

PC computers were arranged in classroom style to avoid distractions. Instructions regarding the nature of the decision making task and the participant requirements were presented visually on the PC computer screen. Participants were instructed to place their left and right index finger on the letter “A” and the letter “B” on the keyboard so they could “respond as fast as possible without making an error of judgment”.

County coaches were sent the eight-item MTI one week prior to the NCCT for the players they had nominated for testing. Coaches were asked to complete the MTI based on observations from the 2010 season. Coaches were also asked to return the inventories by the final day of testing so data could be analyzed concurrently.

Analysis

The same multilevel modelling procedures were used as in Study 3.

Results

Mental Toughness

Descriptive statistics and correlations for all study variables are displayed in Table 4. The first model explored the relationship between reinforcement sensitivities and mental toughness. In this data set the interclass correlation for mental toughness was 0.013, suggesting that 1.30% of the variance in mental toughness was at the between coach level and 98.70% of the variance in mental toughness was at the within person level. When the slopes were allowed to vary a non-significant χ^2 statistic was found, indicating that fitting random slopes did not improve on the random intercept only model. Consequently, the level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. When punishment sensitivity, reward sensitivity and the interaction term (PS x RS) were added as Level 1 predictors the results were similar to Study 3 (see Table 5 for details). The main effect of punishment sensitivity on mental toughness

was not significant, $\beta_1 = -.027$ (SE = .059), $p = >.05$. The main effect of reward sensitivity was significant, $\beta_2 = -.146$ (SE = .064), $p < .05$. However, more pertinently, having controlled for main effects, the interaction term (PS x RS) was significant $\beta_3 = -.217$ (SE = .085), $p < .05$. Using the Preacher et al. (2006) software to further explore the interaction revealed that the slope for low reward sensitivity approached significance and was positive $t(193) = 1.73$, $p = .08$, whereas the slope for high reward sensitivity was significant and negative, $t(193) = -2.61$, $p < .01$. This interaction is depicted in Figure 2 and replicates the interaction found in Study 3.

Table 4.

Means, SDs and inter-correlations among the variables in Study 4

	Mean (SD)	1	2	3	4	5
1 Punishment Sensitivity	9.21 (5.85)					
2 Reward Sensitivity	24.02 (6.12)	-.201**				
3 Mental Toughness	4.33 (0.79)	-.029	-.136			
4 Threat Detection	-0.04 (2.85)	.173*	.036	-.060		
5 Processing Time(seconds)	6.63 (4.24)	-.064	-.121	.060	.043	
6 Decision Making Errors	2.00 (0.94)	.146*	.249**	-.110	.043	-.109

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

Table 5.

Multilevel Analyses: Effects of Reinforcement Sensitivities on Mental Toughness in Study 4

Mental Toughness	Model 1		Model 2		Model 3	
	β	<i>SE</i>	β	<i>SE</i>	β	<i>SE</i>
Intercept, β_{0ij}	4.33	.056	4.33	.055	4.30	.055
Punishment Sensitivity, β_1	-.027	.059	-.047	.059	-.044	.058
Reward Sensitivity, β_2			-.146*	.064	-.120*	.064
PS x RS, β_3					-.217*	.085

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

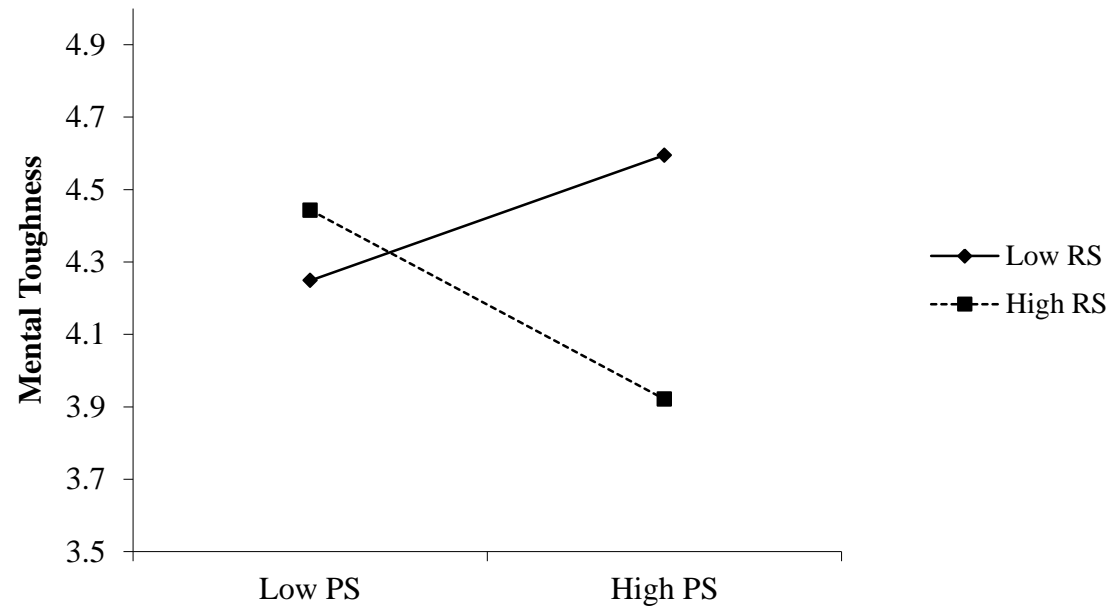


Figure 2

Interaction between Punishment Sensitivity and Reward Sensitivity predicting Mental Toughness in Study 4

Threat Detection

The second model explored the relationship between reinforcement sensitivities and threat detection. In this data set the interclass correlation for threat detection was 0.0020, suggesting that 0.20% of the variance in threat detection was at the between coach level and 99.80% of the variance in mental toughness was at the within person level. When the slopes were allowed to vary a non-significant χ^2 statistic was found, indicating that fitting random slopes did not improve on the random intercept model. Consequently, the level 2 slopes for punishment sensitivity and reward sensitivity were again treated as fixed factors. When punishment sensitivity, reward sensitivity and the interaction term (PS x RS) were added as Level 1 predictors the results were as hypothesized (see Table 6 for details). The main effect of punishment sensitivity on threat detection was significant, $\beta_1 = .560$ (SE = .44, $p < .01$, indicating that threat detection occurs earlier as punishment sensitivity increases. Having controlled for punishment sensitivity effects, the main effect of reward sensitivity was not significant, $\beta_2 = .135$ (SE = .241), $p > .05$. The PS x RS interaction term failed to account for significant additional variance in threat detection over and above the main effects, $\beta_3 = .139$ (SE = .292), $p > .05$.

Behavioural Inhibition

The third model explored the relationship between reinforcement sensitivities and behavioral inhibition. In this data set, the interclass correlation for threat detection was 0.0138, suggesting that 1.38% of the variance in threat detection was at the between coach level and 98.62% of the variance in mental toughness was at the within person level. When the slopes were allowed to vary a non-significant χ^2 statistic was found, so the level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. When reward sensitivity, punishment sensitivity and the cross product term (PS X RS) were added as Level 1 predictors

the results were not as hypothesized (see Table 6 for details). The main effect of punishment sensitivity on processing time was not significant, $\beta_1 = -392.3$ (SE = 317.1), $p > .05$. The main effect of reward sensitivity on processing time was not significant, $\beta_2 = -444.01$ (SE = 346.9), $p > .05$. However, having controlled for main effects, the interaction term (PS x RS) was significant $\beta_3 = -1520.2$ (SE = 455.8), $p < .01$. Using the Preacher et al. (2006) software to further explore the interaction revealed that the slope for low reward sensitivity was significant and positive $t(193) = 1.98$, $p < .05$, whereas the slope for high reward sensitivity was significant and negative, $t(193) = -3.57$, $p < .01$. Interestingly, the nature of the interaction suggested that processing time increased as punishment sensitivity increased only when reward sensitivity was low. When reward sensitivity was high the relationship between processing time and punishment sensitivity was negative, such that processing time for decisions became progressively shorter as punishment sensitivity (and therefore conflict) increased. The interaction which emerged (see Figure 4) was very different to the original hypothesis which proposed that the greatest levels of behavioral inhibition (longest processing times) would occur when punishment sensitivity and reward sensitivity were high.

In order to further examine this counter-intuitive finding for processing time, we examined decision making errors. It was thought that the high level of conflict engendered by high punishment sensitivity combined with high reward sensitivity might have led to panicky decision making resulting in shorter processing times, but poorer decisions. In order to examine this hypothesis we asked four qualified coaches to identify the most appropriate decision for each of the fielding scenarios used in Study 4. In four out of the six scenarios all four coaches were in agreement as to the correct decision (2 conservative decisions and 2 risky decisions). In the remaining two scenarios the coaches were unable to come to a consensus regarding the best

decision and the two ambiguous scenarios were subsequently removed from further analysis. The relationship between reinforcement sensitivities and processing time was the same when the two ambiguous scenarios were removed from the analysis. As a result we examined the relationship between reinforcement sensitivity profiles and decision making errors for the four scenarios where the coaches were in agreement.

In this data set, the interclass correlation for threat detection was 0.0142, suggesting that 1.42% of the variance in threat detection was at the between coach level and 99.58% of the variance in mental toughness was at the within person level. When the slopes were allowed to vary a non-significant χ^2 statistic was found, so the level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. When reward sensitivity, punishment sensitivity and the PS X RS interaction term were added as Level 1 predictors, the results were as hypothesized. Punishment sensitivity accounted for significant variance in decision making errors, $\beta_1 = .185$ (SE = .070), $p < .05$. Reward sensitivity accounted for significant variance in decision making errors over and above punishment sensitivity, $\beta_2 = .221$ (SE = .075), $p < .05$. Finally, the PS x RS interaction term significantly predicted variance in decision making errors over and above the main effects, $\beta_3 = .401$ (SE = .097), $p < .01$. Using the Preacher et al. (2006) software to further explore the interaction revealed that the slope for high reward sensitivity was significant and positive $t(193) = 5.28$, $p < .01$, whereas the slope for low reward sensitivity was marginally non-significant and negative, $t(193) = -1.75$, $p = .08$. This interaction is depicted in Figure 5.

Table 6.

Multilevel Analyses: Effects of Reinforcement Sensitivities on Threat Detection, Processing Time and Decision Making Errors.

	Model 1		Model 2		Model 3	
	β	<i>SE</i>	β	<i>SE</i>	β	<i>SE</i>
Threat Detection						
Intercept, β_{0ij}	-0.04	.208	-0.04	.208	-0.02	.213
Punishment Sensitivity, β_1	.560**	.244	.601**	.252	.607**	.260
Reward Sensitivity, β_2			.135	.241	.139	0.247
PS x RS, β_3					.139	.292
Processing Time						
Intercept, β_{0ij}	6631.91	300.73	6631.91	299.48	6438.05	297.07
Punishment Sensitivity, β_1	-392.29	317.10	-455.25	319.59	-395.66	311.40
Reward Sensitivity, β_2			-444.01	346.87	-273.49	341.28
PS x RS, β_3					-1520.20**	455.79
Decision Making Errors						
Intercept, β_{0ij}	2.00	.066	2.00	.065	2.05	.063
Punishment Sensitivity, β_1	.185**	.070	.217*	.069	.201*	.066
Reward Sensitivity, β_2			.221*	.075	.176*	.073
PS x RS, β_3					.401**	.097

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

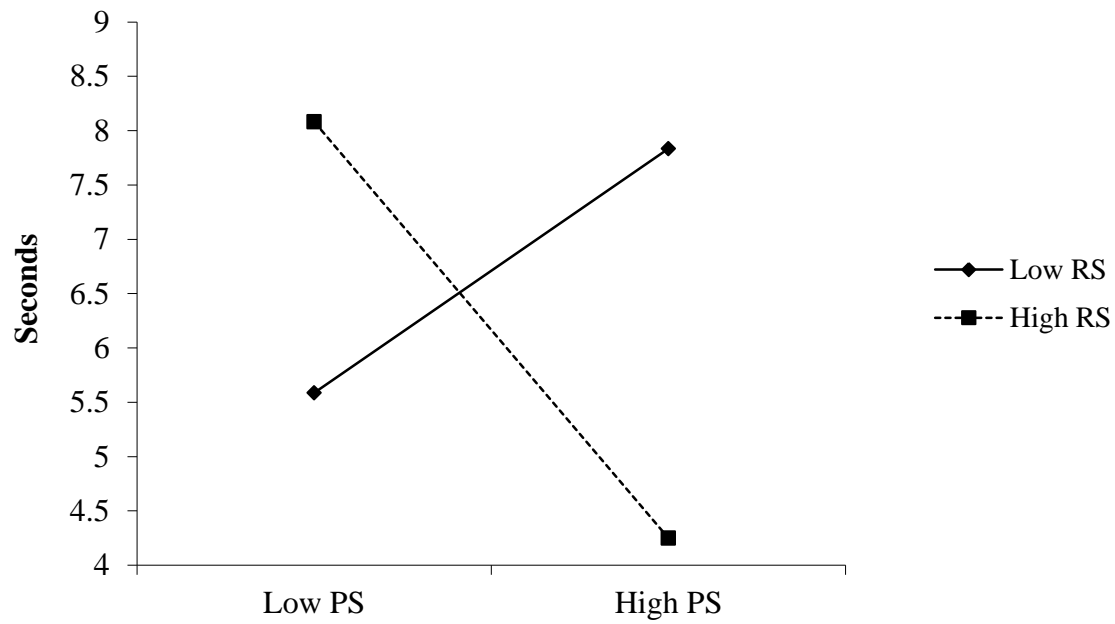


Figure 3

Interaction between Punishment Sensitivity and Reward Sensitivity predicting Processing Time in Study 4

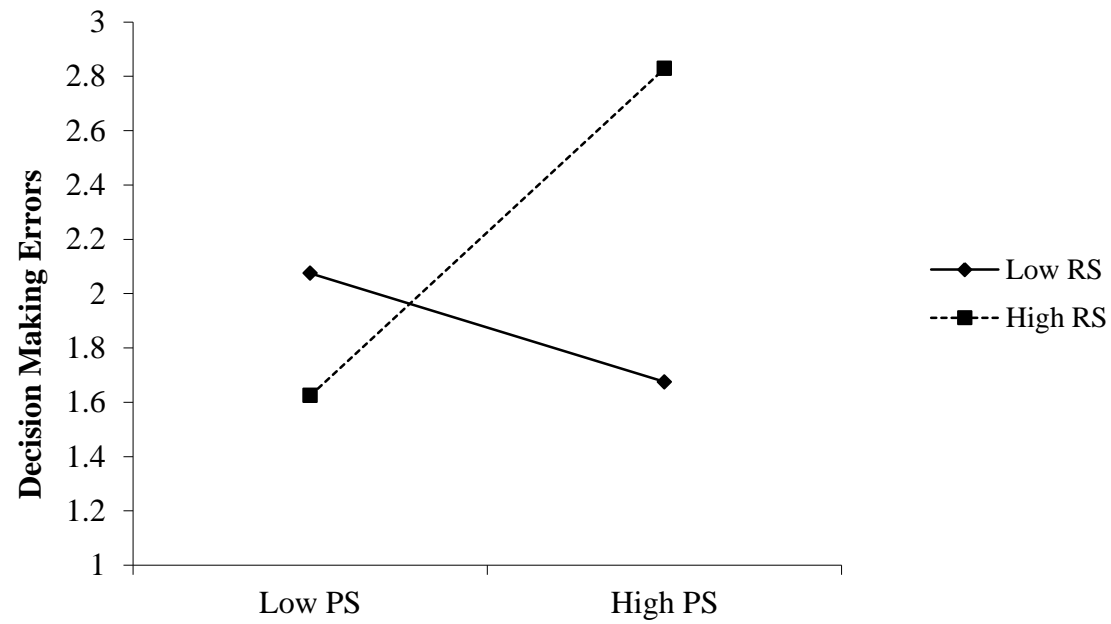


Figure 4

Interaction between Punishment Sensitivity and Reward Sensitivity predicting Decision Making Errors in Study 4

Discussion

The first aim of Study 4 was to confirm the relationship between reinforcement sensitivities and mental toughness. The results supported the findings from Study 3 that mental toughness is positively related to punishment sensitivity when reward sensitivity is low but negatively related to punishment sensitivity when reward sensitivity is high. The second aim of Study 4 was to offer some explanation for these somewhat counter intuitive relationships. As predicted, punishment sensitivity was positively related to threat detection such that high levels of punishment sensitivity were associated with early threat detection. Furthermore, the combination of high punishment sensitivity and high reward sensitivity was related to shorter processing times during decision making but a higher incidence of decision making errors. The most parsimonious explanation for these findings is that high levels of punishment sensitivity *and* high levels of reward sensitivity result in high levels of conflict.

General Discussion

The purpose of the present series of studies was to address some of the limitations in the Mental Toughness research which have been identified in recent review papers (e.g., Crust, 2007, 2008; Connaughton et al., 2008). More specifically, the present investigation had three objectives: (i) to conceptualize and operationalize mental toughness in a way that overcame the limitations of previous definitions: (ii) to develop a valid and reliable measure of mentally tough behavior; and (iii) to apply relevant personality theory to the examination of between-person differences in mentally tough behavior.

Studies 1 and 2 were concerned with the development of a valid, informant rated, questionnaire to measure mental toughness, conceptualized here as a “relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide

range of different stressors". The results of the confirmatory factor analyses from studies 1 and 2 found good support for the structural integrity of the eight-item MTI.

With regards to the application of relevant personality theory, the results of Studies 3 and 4 suggested that the relationship between RST and mental toughness is a somewhat complex one. The findings suggested that cricketers rated as mentally tough by their coaches tended to be sensitive to punishment cues and insensitive to reward cues. Although counter-intuitive, in two separate samples of highly talented young cricketers, mental toughness was positively related to punishment sensitivity only when reward sensitivity was low. In the same two samples of cricketers mental toughness was negatively related to punishment sensitivity when reward sensitivity was high. Further examination revealed that punishment sensitivity was significantly related to early threat detection which might explain some of the positive effects associated with punishment sensitivity. That is, individuals who are sensitive to punishment are pre-disposed to pick up threat early and this provides them with the time to plan effective responses to pressurized situations. Furthermore, in Study 4 it was found that the combination of high punishment sensitivity and high reward sensitivity was related to shorter processing times during a decision making task but a higher incidence of decision making errors. In line with RST (Gray & McNaughton, 2000), the thesis argued that this particular combination of reinforcement sensitivities results in feelings of conflict, uncertainty, and confusion which explains the pattern of behavior reported.

The relationships that emerged between reinforcement sensitivities and mental toughness in Studies 3 and 4 were not in line with previous research (e.g. Perkins et al., 2007), although a recent neuroimaging study by Vythilingam, Nelson, Scaramozza et al. (2009) found that special services soldiers demonstrated insensitivity to rewards in a signal detection task. One possible

explanation for the discrepancy between the results of the present investigation and previous research is the variability in the measurement of reinforcement sensitivities that exists in the literature. Most RST studies assess punishment sensitivity using measures that reflect a mixture of BIS and FFFS functioning and predominantly contain items assessing worry and fear (e.g., Carver & White, 1994).

In the present investigation, reinforcement sensitivities were assessed using Corr's (2001) rotations of the Eysenckian Personality dimensions. This method was chosen for two reasons: 1) the EPQR-S possessed strong psychometric validity; and 2) measuring worry and fear provides only an assessment of the emotions hypothesised to be associated with the BIS and the FFFS, not a direct measure of punishment sensitivity itself. Thus, neither of these methods provides a direct measure of punishment sensitivity. Nevertheless, it remains the case that our indirect measure of reinforcement sensitivities is not an ideal solution, and this is especially true in the present case because our measure fails provide a means of distinguishing the BIS from the FFFS. As it stands, very little work has been done to separately assess these two systems from a psychometric perspective (cf., Heym, Ferguson & Lawrence, 2008) and it appeared premature to attempt to measure the systems separately in this series of studies. Furthermore, it seemed reasonable to discount the direct influence of the FFFS in the sporting contexts considered in the present studies because it seems likely that there is almost always contextual conflict inherent in such performance environments, which is likely to activate the BIS rather than the FFFS. Irrespective of this, there is good reason to think that items which separately reflect worry and fear might have different predictive qualities from items that reflect a 30° rotation of introversion and neuroticism. With this in mind, future research should focus on the development of psychometrically valid, direct measures of the BAS, BIS, and FFFS which take into account the

biological hardware and neurological processes that underpin these three systems as described in the revised RST (Gray & McNaughton, 2000).

One interesting aspect of the current research is its focus on the interactive relationship between punishment and reward sensitivity. Traditionally, RST research has examined only main effects, i.e., the independent relationships of punishment and / or reward sensitivity with an outcome variable. Until now, interactions between punishment and reward systems have been largely ignored by reinforcement sensitivity theorists. An examination of the interactive relationship at play is warranted because recently theorists have argued that the effect of a stimulus on behaviour depends not only on the strengths of the stimulus and the reactivity of the system that it activates, but also on the strength of competing systems (Corr, 2001). Joint effects are hypothesized to occur in environments containing mixed appetitive / aversive stimuli and where rapid attentional and behavioral shifts between reinforcing stimuli are required, i.e., those environments in which humans typically preside (Corr, 2004). This is especially pertinent to the present studies because the dependent variable of interest was performance under pressure. Pressurized environments almost always contain mixed appetitive and aversive stimuli so joint effects of the systems are likely to occur. Previous RST research has not examined this complex interactive relationship in this type of environment before. Our results suggest that the best way to manage the mixed appetitive and aversive stimuli in a pressurised sporting environment is to identify the aversive stimuli as early as possible and so that coping strategies can be used to deal with the stimuli effectively (cf., for example, Hardy et al., 1996)

One surprising result from Study 4 was the shorter processing times associated with increases in punishment sensitivity when reward sensitivity was high. Previous RST research (e.g., Kambouropoulos & Staiger, 2004) has found that the greatest levels of behavioural

inhibition occur for individuals who report high scores on EPQ-derived punishment sensitivity *and* reward sensitivity. However, the letter identification task used in Kambouropolos and Staiger (2004) was more akin to a threat detection task, where certain letters were associated with large punishments so that they would serve as aversive stimuli. It was only when these threat loaded letters were presented that the increases in behavioral inhibition occurred. This type of letter-identification task is qualitatively different from the decision making task used in Study 4, where there were equal amounts of reward and punishment inherent within the scenarios and the correct decision could lead to a positive outcome. The difference between the tasks might explain why high levels of punishment sensitivity combined with high levels of reward sensitivity resulted in fast response times in one study and slow response times in another. More pertinently, in both studies, the performance of individuals high in punishment *and* reward sensitivity was impaired compared to individuals with other combinations of reinforcement sensitivities. Kambouropolos and Staiger (2004) reported that University students were slower to identify target letters and in the present investigation cricketers made more decision making errors. The present thesis posits that the poor performance under pressure occurs due to conflict and uncertainty.

Whilst the findings of the present research are suggestive of some neuro-cognitive structures that might be involved in mental toughness, what is really required is a much more detailed understanding of the cognitive neuroscience of mental toughness, together with appropriate psycho-physiological and behavioral markers. A fundamental aspect of mental toughness is that it will be revealed where the environment presents complex cues, a rapid decision for action is required, and there are real (positive and/or negative) consequences. Extensive behavioral studies of the processes underlying this kind of decision making have been

performed in the past decade with a rich fMRI literature that identifies the human brain areas that evaluate options, anticipate threats and rewards, make decisions, and learn from the consequences of decisions (e.g., Hsu, Bhatt, Adolphs, Tranel & Carmenger, 2005). This research has largely focused on basic mechanisms and their application to disordered decision making (e.g., in problem gambling). One interesting future direction for research would be to use such functional Magnetic Resonance Imaging (fMRI) techniques to examine the neural networks involved in decision making in elite performers working in their area of expertise, under the most difficult circumstances imaginable. Such research would be of interest to both mental toughness researchers and RST and other personality researchers.

A number of limitations are evident in the present research. First, as previously mentioned, punishment and reward sensitivity were measured indirectly by using Corr's (2001) rotations of the Eysenckian axes. Furthermore, our measurement of punishment sensitivity does not differentiate between the involvement of the FFFS and the involvement of the BIS. Unfortunately, there is at present no solution to this problem. Second, no objective measures of performance were used. Having said that, our informant rated measure of mental toughness does at least avoid the single source data problem that has plagued the existing mental toughness literature. Furthermore, we would argue that most objective measures of performance are confounded by ability; as such this is not an easy problem to resolve. What are required are objective measures of performance that control for ability. Third, our measures of early threat detection and behavioral inhibition are relatively crude and this aspect of our research could be greatly improved using more sophisticated designs and (fMRI) techniques. Nevertheless, the fact that we obtain significant result in the hypothesised directions using such crude measures is heartening.

In summary, the present investigation offered an alternative definition of mental toughness and presented a novel measure to assess mentally tough behavior. Strong evidence has been provided to support the notion that RST is capable of explaining the behaviors associated with mental toughness. Generally speaking, the highest level of mental toughness reported by coaches occurred when individuals were sensitive to punishment and insensitive to reward. The most parsimonious explanation for this pattern of results is that mentally tough cricketers are predisposed to identify threat early which gives them the best possible opportunity to plan an effective response for the pressurized environments they encounter.

Chapter 3

Enhancing mental toughness in elite young cricketers: a 2 year longitudinal intervention ²

² This chapter is submitted for publication as;

Bell, J. J., Hardy, L., & Beattie, S. J. (under review). Enhancing mental toughness in elite young cricketers: a 2 year longitudinal intervention. *Sport, Exercise and Performance Psychology*.

Abstract

The purpose of the present study was to evaluate the effectiveness of a mental toughness intervention delivered to a group of elite youth cricketers. The central feature of the intervention was exposure to punishment conditioned stimuli in the training environment. To avoid the deleterious effects of punishment the intervention was designed and delivered in a multi-disciplinary, transformational manner and participants were taught a variety of coping strategies to deal with the threatening environment. A mixed model (group x time) design was employed to compare the intervention group against a comparison control group on various markers of mental toughness over time. Generally speaking, the intervention group demonstrated significant improvements in mental toughness in comparison to the control group. To the best of our knowledge, this is the first theoretically derived mental toughness intervention that has shown meaningful effects that can be differentiated from a general psychological skills training package. Theoretical implications are discussed in the context of systematic desensitization training (Wolpe, 1958) and applied recommendations are offered in relation to the intelligent use of punishment in athletic training environments.

KEYWORDS: mental toughness, performance under pressure, punishment conditioned stimuli, transformational leadership, coping.

Mental Toughness has often been described as one of the most used but least understood phrases in sport psychology (Jones, Hanton & Connaughton, 2007). Recently, this important construct has been examined using more rigorous scientific approaches to the point that current understanding of the term is much improved (Jones et al., 2007). However, despite continued interest in mental toughness research, there remain a number of enduring criticisms that can be levelled at the literature (Crust, 2008). These include: (i) circuitous and somewhat confusing definitions, (ii) modest attempts to draw upon relevant theory to inform a priori hypothesis testing, (iii) a lack of valid measurement tools, and (iv) limited experimental studies that focus on the development of mental toughness. The purpose of the present study is to address the final criticism by designing a theoretically grounded mental toughness intervention.

For some time, coaches have rated mental toughness as one of the most important psychological characteristics in determining competitive success (e.g., Gould, Hodge, Peterson & Pelitchkoff, 1987). Given the interest expressed by applied practitioners it is somewhat surprising there are so few examples of effective mental toughness interventions in the literature. One of the reasons for the lack of experimental studies is the difficulty in distinguishing a mental toughness intervention from a typical psychological skills training package (e.g., Thelwell, Greenlees & Weston, 2006). For example, Gucciardi, Gordon and Dimmock (2009) failed to find any differences in self, parent or coach ratings of mental toughness between a psychological skills training program and a specially designed mental toughness intervention. By the authors' own admission, a large majority of the material delivered in the mental skills program was also delivered in the mental toughness program (e.g., self-efficacy, arousal regulation, and mental rehearsal). As a result, it is unsurprising that the authors concluded that the common components of the programs were probably responsible for the similar observed effects.

In order to avoid the problems associated with previous mental toughness programs, the central focus of the intervention in the present study is to enhance the ability to perform under pressure. Pressurised performance environments are unique in that they contain a high prevalence of punishment conditioned stimuli (Hardy, Jones & Gould, 1996). A punishment conditioned stimulus is a neutral stimulus that is associated with a punishment after repeated pairing and therefore elicits a punishment conditioned response (Gray, 1970). In a pressurized athletic environment, punishment-conditioned stimuli come in the form of mistakes and poor performances (e.g., missed tackles, dropped catches) where the punishment is the negative emotions (e.g., disappointment, shame) that are experienced as a result. Approach towards punishment conditioned stimuli stimulates a very specific area of the brain which is independent of the neural networks that deal with non-threatening information (Gray, 1970). Gray and McNaughton (2000) have provided empirical evidence that a conceptual system known as the Behavioural Inhibition System (BIS) is responsible for mediating all affective and behavioural responses that occur when approaching threatening stimuli. The BIS is thought to centre on the septo-hippocampal circuits within the brain. Activation of the BIS generates anxiety and causes the inhibition of ongoing behavior, an increase in physiological arousal, and the scanning of short term memory for potential actions. The combination of these behavioral and affective responses may explain why athletes find it difficult to perform under pressure. Persistent inhibited behaviour along with high levels of physiological arousal is unlikely to lead to optimal levels of performance.

One technique that is often used to help individuals cope with punishment conditioned stimuli in clinical settings is systematic desensitization training (Wolpe, 1958). Systematic desensitization is an effective form of behavioural therapy that is typically used to overcome

phobias and anxiety related conditions (Deffenbacher & Suinn, 1988). Usually an individual is trained in relaxation techniques and gradually exposed to punishment conditioned stimuli in a hierarchical manner. In the context of a mental toughness intervention, the principles of systematic desensitization might be useful in helping athletes to enhance their performance in highly pressurized situations. In line with systematic desensitization, athletes exposed to punishment conditioned stimuli in the training environment would be expected to cope better with the threatening situations they are likely to face in real competition. In order to replicate the pressures of elite sport, athletes could be exposed to some of the negative consequences which can occur when elite athletes perform poorly in competition (e.g., disappointment, failure, embarrassment, etc). Crucially, it is exposure to the *threat* of negative consequences which is the central to this form of therapy, as opposed to the negative consequences themselves. However, in order for the threat to be perceived as real, there needs to be genuine negative consequences attached to poor performance.

In some ways systematic desensitization training is similar to simulation training (Hardy et al., 1996). Typically simulation training involves physical practice in the presence of simulated competition stressors (Jones & Hardy, 1990). Consistent with the concept of simulation training, recent research has found that practicing perceptual-motor tasks under mild levels of anxiety can prevent choking when performing with higher levels of anxiety (Oudejans & Pijpers, 2010). Systematic exposure to punishment conditioned stimuli in the training environment is one method of inducing anxiety under practice conditions. Despite strong theoretical and empirical rationale for exposing athletes to punishment conditioned stimuli in the training environment, interventionists have yet to use punishments as part of a mental toughness training program (e.g., Gucciardi et al., 2009). Perhaps this is because some practitioners are

overly concerned with developing “unshakeable self belief” via a mastery environment that focuses on rewarding successes rather than punishing failures (e.g., Connaughton, Wadey, Hanton & Jones, 2008, p. 195). In many ways, exposure to punishment conditioned stimuli is exactly what is missing from modern development programs that promote cooperation over competition and discourage the use of punishment for fear of the negative emotional and motivational consequences (Smith, Smoll & Curtis, 1979). For some (e.g., Seifried, 2008), modern development programs do not prepare athletes to deal with the threats they will face on a regular basis in the world of elite sport. Consequently, one might argue that presenting athletes with regular opportunities to deal with stressors that threaten performance is exactly what separates a mental toughness intervention from a typical psychological skills training package.

In order to avoid the deleterious effects associated with punishing training environments (cf. McNaughton & Corr, 2000), there are two additional aspects of a mental toughness training program that need to be considered. Firstly, there is a need to create a supportive climate that enables the punishments to work effectively. One of the most effective ways to positively influence the climate is through leadership behaviours (Day & Lord, 1988). Transformational leadership theory (Bass, 1985) posits a range of leader behaviors which inspire followers to transcend self interest for the success of a greater cause. This is proposed to result in greater productivity and follower satisfaction, as well as augmented performance levels, when compared to traditional transactional approaches to leadership. In the context of a punishment focused mental toughness intervention, transformational leadership behaviors may encourage athletes to embrace the opportunity to deal with a stressful, demanding training environment that includes unpleasant punishment conditioned stimuli. This is consistent with evidence from a military context where transformational leadership behaviors have been used in stressful training

environments, to increase resilience and effort levels in infantry recruits (Hardy et al., 2010). Transformational leadership behaviors that are particularly pertinent in a mental toughness intervention are: (i) *inspirational motivation*, where practitioners repeatedly articulate a positive vision of the future and express confidence in the followers' capacity to achieve that vision, (ii) *intellectual stimulation*, where leaders challenge followers to re-examine their assumptions about their work, and re-think how it can be performed, and (iii) *appropriate role modelling*, where practitioners set examples for followers to emulate that are consistent with values that the program espouses (Hardy et al., 2010).

Secondly, in order to maximise the use of threat as part of a mental toughness intervention it is necessary to equip athletes with effective coping strategies (Gould, Eklund & Jackson, 1993). The literature on coping in sport suggests that coping is a complex and multidimensional process and it is highly unlikely that any single coping strategy will be effective in all situations (Hardy et al., 1996). However, there are some general implications that can be drawn from the literature that guide best practice. In particular there is a need to develop a broad spectrum of coping strategies to deal with the many and varied stressors that often afflict elite athletes (Gould et al., 1993). Linked to this point, it is important that athletes individualise the strategies by experimenting with them regularly so they can be refined as appropriate. Ultimately coping strategies need to be extremely well learned and practiced to the point that they can be executed automatically (Gould, Dieffenbach & Moffett, 2002). Crucially, athletes should be able to identify potential stressors along with effective coping responses at the earliest possible opportunity because often it is the unforeseen events that are the most difficult to deal with (Gould et al., 1993).

The purpose of the present study was to evaluate the effectiveness of a mental toughness intervention delivered to a group of young elite cricketers. The central feature of the intervention was exposure to punishment conditioned stimuli in the training environment. To avoid the deleterious effects of punishment it was deemed important to (i) design a multi-disciplinary program that was delivered transformationally, and (ii) develop effective coping strategies to manage threat. Based on previous criticisms of mental toughness interventions (e.g., Gucciardi et al., 2009), the dependent variables were chosen to demonstrate the proposed link between mental toughness and performance. As such the intervention was evaluated using competitive performance statistics, coach rated assessments of mental toughness, and indoor performance data, all of which were collected pre and post intervention. A significant two-way interaction (group x time) was hypothesised, whereby measures of mental toughness between a control and experimental group were expected to show no differences at pre-test but significant differences across time.

Method

Overview

Every year the England and Wales Cricket Board (ECB) run a winter training program for the best under-18 cricketers in the UK. All of the cricketers involved in the program are nominated by coaches within the professional game based on the potential to be World's best. The program provides an opportunity to accelerate the development of the best young cricketers in the UK by presenting them with access to world class coaching and facilities. In 2009 the ECB changed the emphasis of the program and approached the authors to design a mental toughness intervention in place of the typical cricket skills program. The program was designed and delivered in conjunction with full-time staff (e.g., performance directors and coaches) from the

ECB. The central purpose of the revised program was to develop mentally tough cricketers who were capable of performing excellently under pressure.

An information session was held for all nominated players, plus parents and coaches, at the start of an Induction Weekend. During the information session the purpose and principles of the program were clearly communicated by the Program Director and other key members of staff, including ex-World's best cricketers. Throughout the information session the players were repeatedly presented with an inspirational vision of what it takes to be a World's best cricketer, the sacrifices required and the England Cricket Pathway. At the end of the information session, the players and parents were given an opportunity to ask questions and were given 12 hours to consider whether they wanted to consciously sign-up to the program.

Players were selected onto the program by National Selectors based on future potential to be a World's best player for England. Criteria included competition statistics, observation, and scouting reports from County Coaches. Those players that were not selected onto the program were invited to join a comparison control group. The non-random allocation of participants to the experimental group is problematic. However, the opportunity to conduct research with such an elite group of young athletes is rare. Any experimental research design involving genuinely elite-level athletes (e.g., Olympians) is likely to be compromised in terms of a meaningful comparison group. This should not stop researchers from investigating such a unique sample, especially when the investigation focuses on enhancing elite sporting performance. In this instance, every attempt was made to control for the non-random selection of participants including the most appropriate comparison group available in the UK and a mixed model design that controlled for differences at pre-test.

Participants

41 male cricketers aged between 16 and 18 ($M_{age} = 16.9$, $SD = 0.8$) were recruited to take part in the study. All participants were attached to a First Class County, which correspond to the 18 professional teams that compete in the County Championships. Players were nominated by professional coaches based on the potential to be a future World's best cricketer. In total 54 players were nominated and invited to attend the Induction weekend where they were introduced to the program. Based on the aforementioned selection criteria 20 cricketers were assigned to the Intervention Group. All of those players not selected onto the program ($n=34$) were offered the opportunity to join the Comparison Control Group, of which 13 declined the opportunity due to lack of time or interest. The remaining 21 cricketers were assigned to the Control Group.

Outcome Variables

Coach-rated Mental Toughness

Mental Toughness was assessed using an informant-rated inventory designed to assess performance under pressure (Hardy, Bell & Beattie, under review). The inventory contained 8 items which focused on performers' abilities to deal with the stressors that they typically face in competition. The informant (County Coach) was asked to rate how often the player was able to maintain a high level of personal performance in a series of pressurized situations, for example: "When the opposition are using aggressive tactics". Responses were based on a 7-point likert scale and ranged from 1 (rarely), to 7 (regularly) with a midpoint anchor of 4 (sometimes). Confirmatory factor analyses consistently demonstrated good fit statistics for an 8-item model, with Cronbach's alpha ranging from .87 - .89 (Hardy, Bell, & Beattie, under review).

Competitive Performance Statistics

A number of objective performance statistics were collated for each of the participants involved in the study, including, total runs scored, batting average, batting strike rate, percentage of team runs scored, total wickets taken, bowling average, bowling strike rate, percentage of team wickets. Although the performance statistics collected for each individual were comprehensive it was difficult to make comparisons between the intervention group and the control group because the performance information was so varied. The majority of participants played competitive matches for more than one team and the standard of cricket and opportunities available differed greatly from team to team. In total participants had the potential to play for County 1st XI's, County 2nd XI's, Academy teams, County U-17's, and Club sides. Consequently it was deemed meaningless and inappropriate to compare raw performance statistics (e.g., batting and bowling averages). In order to combat this problem, four professionally qualified (Level IV) coaches were recruited to analyze the performances subjectively. The coaches had at least ten years experience in the professional game and were selected on the basis of their extensive knowledge of age group cricket across all 18 first class counties. Each coach was given a blinded spreadsheet with all the relevant performance information for each player, including a breakdown of performance statistics for each different standard of cricket played. The spreadsheet was designed so that the coach was unable to identify which player data referred to so as to avoid rater bias. Based on this information the four coaches were asked to provide a number ranging from 0-100, where 0 referred to consistently poor performance for an Academy Cricketer, 100 referred to consistently exceptional performances for an Academy Cricketer and 50 referred to consistently average performances for an Academy Cricketer. The coaches evaluating performance in the study were familiarized with the performance criteria via a series

of group discussions and rating exercises using hypothetical performance data. Once inter-rater reliability was consistently greater than 0.8 the coaches were sent the genuine performance data.

Indoor Cricket Tests

As part of the England Cricket Pathway, players are routinely assessed on standardized cricket-specific tests. These tests are conducted indoors to attempt to control some of the extraneous variables that can affect outdoor performances (e.g. environmental conditions, standard of opposition). The tests are inherently pressurized because they are conducted by practitioners from the England and Wales Cricket Board, the results are published and disseminated amongst the First Class Counties and can be used to inform selection onto England Cricket Programs. Given the pressurized nature of the tests they were considered relevant assessments of mental toughness.

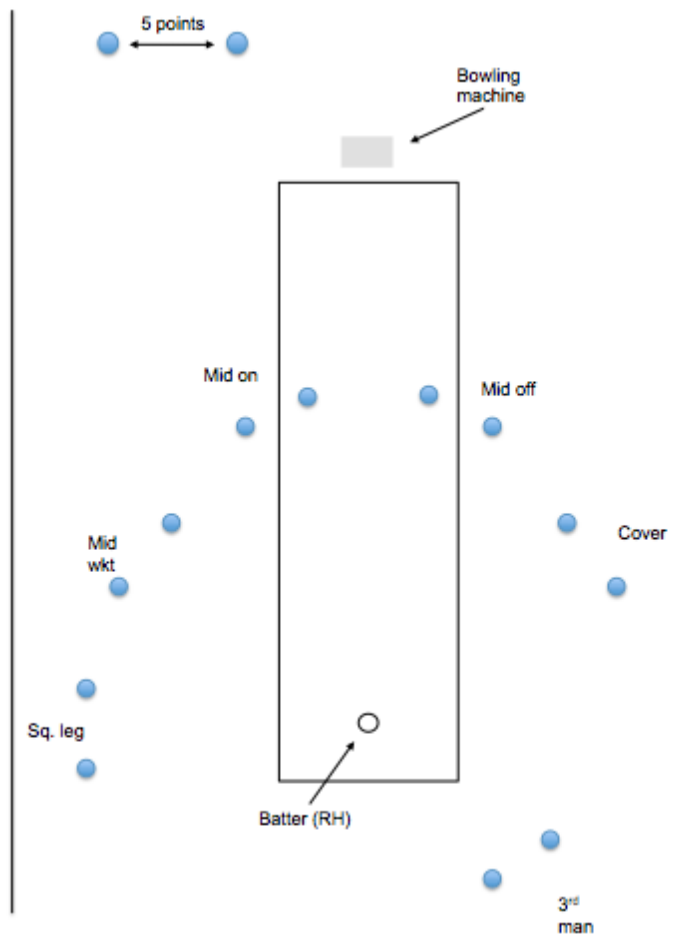
Batting against Pace

Participants received deliveries from a standard Bola (Cotham, Bristol, UK) at a speed of 85 mph. The bowling machine was positioned to replicate a right-arm over bowler to a right-handed batsman with the machine directed at the batsman's off stump. Bias was set at left + 1 for right-handed batsmen and right + 1 for left-handed batsmen to ensure the ball was always swinging away from the batsman. Batsmen were required to hit the ball to a one of six pre designated targets (see Figure 1 for positioning of the targets). The test administrator designated a target according to a randomized schedule immediately prior to deliver. The batsman was awarded either a score of 5 points for hitting the ball through the target, 2 points for hitting a ball in close proximity to the target whilst demonstrating good technique or 0 points if neither of the previous criteria were met. In total batsmen received 24 deliveries across 2 lengths. The full length deliveries pitched 3.5m from the stumps and the short length deliveries pitched 8.4m from

the stumps. Pilot testing suggested the batting against pace test demonstrated reasonable test re-test reliability ($r = 0.50$) and excellent discriminant validity between batters of different abilities.

Batting against Spin

Participants received deliveries from a standard Merlyn bowling machine (Bola: Cotham, Bristol, UK) at a speed of 49 mph with 2000 RPM of spin imparted on the ball. The bowling machine was positioned to replicate a right-arm over bowler and the laser was centered on middle stump. Right-handed batters faced off-spin deliveries and left-handed batters faced leg spin deliveries to ensure that the ball was always spinning into the batsman. The protocol mirrored the batting against pace test except the two lengths were adjusted for spin bowling, such that the full length deliveries pitched 2.9m from the stumps and the short length deliveries pitched 6.6m from the stump. Pilot testing suggested the batting against spin test demonstrated excellent test re-test reliability ($r = 0.70$) but minimal discriminant validity between batters of different abilities.



	Distance from centre stump (to front of cone)	
	Left cone (m)	Right cone (m)
Mid off	19.1	19.3
Cover	10.0	9.5
3 rd man	5.0	4.3
Sq. leg/deep sq. leg	5.1	5.9
Mid wicket	9.5	10.0
Mid on	19.3	19.1

Figure 1

Batting against Pace Target Positions

Indoor Fitness Tests

As part of the England Cricket Pathway, players are also routinely assessed on a number of standardized fitness tests. The tests are used by the Science and Medicine practitioners to monitor the physical characteristics of players in the England Cricket Pathway. Two of the indoor fitness tests were considered relevant to this study. The multi-stage fitness test was considered a relevant assessment of mental toughness because: (i) it exposes the participants to sustained physical adversity which requires high levels of persistence and determination, and (ii) the results from the test were used to inform selection onto England Cricket Programs. The vertical jump test was *not* considered an assessment of mental toughness because: (i) it requires a short maximal effort that is not painful and, (ii) the results from the test were *not* used to inform selection. The vertical jump test was included to demonstrate that the intervention does not have a generic performance enhancing affect across all tests and effects should only occur for assessments designed specifically to assess mental toughness.

Multi-Stage Fitness Test

Full details of the Mutli-Stage Fitness test are available in Léger, Mercier, Gadoury and Lambert (1988), including reliability and validity information.

Vertical Jump

The vertical jump test required participants to perform a 2-footed countermovement jump from a stationary position with the intention of attaining maximum height. Full details of the testing procedure are available in Little and Williams (2006) with accompanying reliability and validity information.

Experimental Treatments

Mental Toughness Training Program

The mental toughness intervention was delivered over 46 separate contact days, 29 of those days were spread over 4 distinct training camps in the UK and the remaining 17 days were delivered on a competitive tour to India. The primary objective of the intervention was to provide players with opportunities to practice under conditions of high threat. In order to generate a threatening environment the players were systematically exposed to punishment conditioned stimuli in the form of ‘consequences’. Players were informed at the outset that failure to meet strict disciplinary standards (e.g. punctuality, tidiness, correct kit) or specific performance standards (e.g., during testing) would result in a negative consequence (punishment). A list of potential consequences was provided to the players at the beginning of the intervention. Typically, the exact nature of the consequence was decided by the staff in consultation with the players on a case by case basis. Wherever possible the consequences were designed to be unpleasant but relevant, e.g. cleaning the changing rooms, missing the next session, repeating a test in front of the group. The consequences were designed to be unpleasant so the conditioned stimuli associated with them would be interpreted as punishment conditioned stimuli and processed by the Behavioural Inhibition System. The importance of consequences was explained to the players as a fundamental aspect of professional cricket training, where the consequences of poor performance and / or poor discipline are potentially expensive, distracting, humiliating and career ending.

The second novel aspect of the intervention was the multi-disciplinary and transformational nature of program delivery. A multi-disciplinary team of coaches, ex-international cricketers, medical staff, psychologists and administrators delivered the program together in a transformational manner. This meant staff repeatedly articulated an inspirational vision of the future for the player’s involved in the program and the pathway towards World’s

best. Staff also expressed belief in the players that they were capable of achieving the vision if they remained dedicated to the pursuit of their goals. The presentation of an inspirational vision was often achieved through ex-international World's best cricketers who were involved in the day to day delivery of the program. In addition, staff were encouraged to role-model appropriate behaviors, including taking responsibility for mistakes and completing consequences alongside players. Finally, all the staff involved were responsible for regularly re-enforcing the objectives of the program and ensuring that the players understood the purpose of every practice session. Staff meetings were held at the end of every day to review the day's activities, to discuss any consequences which had been accrued, to evaluate the performance of the staff, and to plan the next day's activities. Two players, known as daily co-captains, were required to attend the staff meeting to provide feedback on the day's activities and to inform decision making around consequences. The daily co-captains were rotated amongst the players in the squad on a daily basis so that every player had at least one opportunity to assume leadership responsibilities. Day reviews were also held on a daily basis with all players and staff in attendance. Day reviews provided opportunities for players to reflect and learn from the day's activities and to provide developmental and motivational feedback to each other.

Another crucial aspect of the program was the need for a structure that provided plenty of opportunities to practice under pressure. A four day cycle was designed as follows: (i) skill development, (ii) pressure training, (iii) testing (iv) review and goal setting. This schedule was followed throughout the training camps in the UK and wherever appropriate on the competitive tour to India. Skill development days were designed to give players opportunities to practice in a non-threatening environment and experiment with technical, physical and psychological skills without fear of being punished. Crucially, players were exempt from performance consequences

on skill development days. On pressure training days players were exposed to a series of inherently pressurized cricket specific tests designed by the coaches. A minimum criterion was clearly communicated to the players for each of the tests and consequences were administered to the players for failing to meet the criteria. Although the tests were designed to be pressurized, support staff provided advice and feedback throughout the tests. Testing days operated in an almost identical manner to pressure training days except support and encouragement were *not* provided by the staff. The environment was designed to be objective and clinical so as to increase the pressure on the players and encourage the players to develop individualized coping strategies. During the competitive tour to India the testing days were replaced with match days. On review days the players had individual consultations with relevant members of staff to review what had worked well, what required improvement, and methods by which those improvements might be achieved. By identifying the key learning points from the previous three days the player was able to set goals and construct plans to be more successful in the ensuing four day cycle.

The psychological support for the players was also delivered in a multi-disciplinary manner. Over the duration of the 46 days there were only 3 classroom based workshops which focused on mental preparation principles and psychological skills. Instead, the sport psychologist worked alongside other practitioners (e.g., coaches) and helped players develop individual psychological coping strategies during skill development, pressure training, and review sessions. The psychological strategies were always designed around the individual needs of the players, although as a general rule, players were encouraged to identify potential threats at the earliest possible opportunity and to begin mentally preparing to deal with those threats in a timely manner. Mental preparation strategies used by the players included goal setting (with a particular focus on process goals), imagery techniques, self-talk, re-focusing strategies, arousal regulation,

and cognitive restructuring. All of these psychological skills have been found to enhance performance in athletic contexts (see Greenspan & Feltz, 1989 for a review). Players were also taught to use relevant psychological skills within the broad framework of a pre-performance routine (e.g., Boutcher, 1990).

Comparison Control Group

As explained earlier, the control group included players nominated by County Academies who were not selected for the Intervention Group. County Academies provide a minimum of eight hours cricket training per week delivered in more traditional methods (e.g., net practices, fitness sessions). All of the training was delivered regionally within the counties and as such each member of the comparison control group received relatively individualized programs. All County Academies are run by highly qualified coaches and as such the quality of the technical coaching was not expected to account for any differences in performance of the two groups. However, there was a concern that the intervention group would receive more hours of coaching than the comparison control group. To ensure that differences between the control group and the intervention group did not emerge due to quantity of practice, both groups were asked to complete a training diary accounting for the volume and intensity of cricket related activity on a weekly basis.

Design and Procedure

All participants were made aware of the purpose and requirements of the study prior to providing informed consent at the information session in September 2009. A mixed model (group x time) design was employed to examine the effects of the mental toughness intervention. Pre-test data was collected in 2009 and post-test data was collected in 2010. All indoor pre-test data was collected at the Induction weekend. Pre-test coach-rated mental toughness was

compiled within one month of the end of the season by County Academy Directors. Competitive performance statistics were collected from centralized ECB competition administrators. All competitive performance data was sent to players and County Academy Directors to verify that it was accurate and comprehensive. The Mental Toughness Training Program ran from October 2009 until March 2010. In that time, all participants sent a weekly email to the primary researcher outlining the volume and intensity of their cricket related activity for the previous week. All participants were invited to a testing weekend to collect post-test indoor assessment data in April 2010. This occurred one week before the start of the 2010 season. Post-test coach-rated mental toughness was collected in October 2010 in an identical manner to the pre-test data. Competitive performance statistics from the 2010 season were combined with data from the 2009 season and subjectively assessed by four professionally qualified (Level IV) coaches in November 2010.

Results

Descriptive data for all dependent variables for the control and experimental groups are displayed in Table 1. Initially, training data was analyzed to check for between group differences that might account for changes in mental toughness. An independent samples t-test revealed no significant differences between the control and experimental group on time dedicated to training, $t(39) = -0.054, p > .05$, or intensity of effort in training $t(39) = -1.213, p > .05$. As such, training effects were not treated as co-variates in the subsequent analyses.

Table 1.

Descriptive data for dependent variables across experimental conditions in 2009 (pre-intervention) and 2010 (post-intervention)

Outcome Variables	Intervention Group		Control Group	
	2009	2010	2009	2010
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Coach Rated Mental Toughness	4.55 (1.13)	5.06 (0.82)	4.49 (0.60)	4.29 (0.72)
Competitive Performance Statistics	50.78 (7.95)	57.03 (10.40)	50.22 (7.49)	50.85 (9.57)
<i>Indoor Batting Assessments</i>				
Pace	28.31 (7.90)	33.95 (5.14)	28.90 (5.25)	27.81 (7.24)
Spin	24.05 (9.56)	27.42 (8.78)	22.76 (9.28)	20.76 (7.89)
<i>Indoor Fitness Assessments</i>				
Vertical Jump	34.41 (4.32)	38.28 (4.81)	35.63 (4.43)	38.80 (4.59)
Multi-Stage Fitness	11.56 (0.63)	12.67 (0.57)	11.54 (1.26)	11.50 (1.26)

Coach Rated Mental Toughness

For coach rated mental toughness, a 2 x 2 (group x time) mixed model analysis of variance (ANOVA) demonstrated a marginally non-significant main effect for group ($F_{1,39} = 3.34, p = .07, \eta^2 = .079$) a non-significant main effect for time ($F_{1,39} = 1.47, p > .05, \eta^2 = .036$), and a significant group by time interaction ($F_{1,39} = 8.14, p < .01, \eta^2 = .173$). Tukey's post-hoc tests indicated that the coach rated mental toughness scores did not differ between the groups at pre-test ($p > .05$) but significant differences emerged at post-test ($p = .003$), where scores were significantly higher in the experimental group compared to the control group. Furthermore, coach rated mental toughness scores for the control group did not differ from pre-test to post-test ($p > .05$), whereas significant increases occurred from pre-test to post-test for the experimental group ($p = .02$). See Figure 2 for more details.

Competitive Performance Statistics

Correlations amongst all of the coaches' subjective ratings of performance revealed moderate to high correlations ranging from .675 - .744 for the 2009 data and .796 - .892 for the 2010 data. Split-pair reliability ratings ranged from .801 - .816 for the 2009 data and .891 - .910 for the 2010 data. As such, mean coach ratings were considered a reliable indicator of overall performance and were used as the dependent variable for all further analyses. A 2 x 2 (group x time) mixed model analysis of variance (ANOVA) demonstrated a non-significant main effect for group ($F_{1,39} = 1.75, p > .05, \eta^2 = .043$) a significant main effect for time ($F_{1,39} = 9.03, p < .01, \eta^2 = .188$), and a significant group by time interaction ($F_{1,39} = 5.99, p < .05, \eta^2 = .133$). Tukey's post-hoc tests indicated that performance scores did not differ between the groups at pre-test ($p > .05$) but marginally significant differences emerged at post-test ($p = .05$), where scores were significantly higher in the experimental group compared to the control group. Furthermore,

performance scores for the control group did not differ from pre-test to post-test ($p > .05$), whereas significant increases emerged for the experimental group ($p < .01$). See Figure 3 for more details.

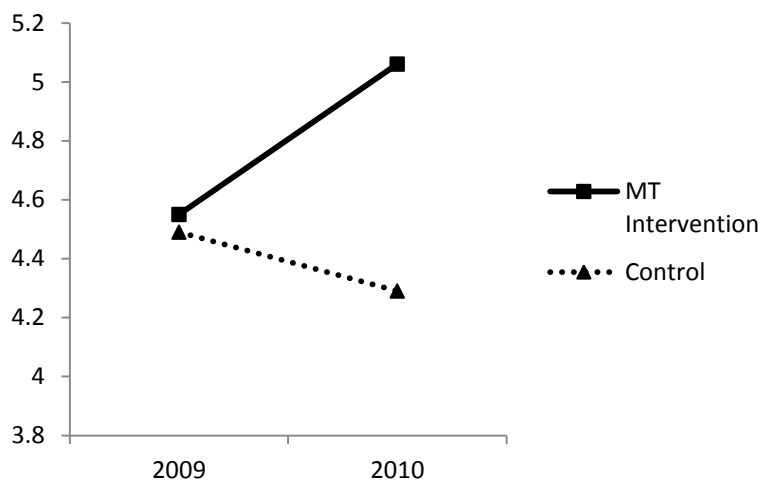


Figure 2

Group x Time Interaction for Coach Rated Mental Toughness

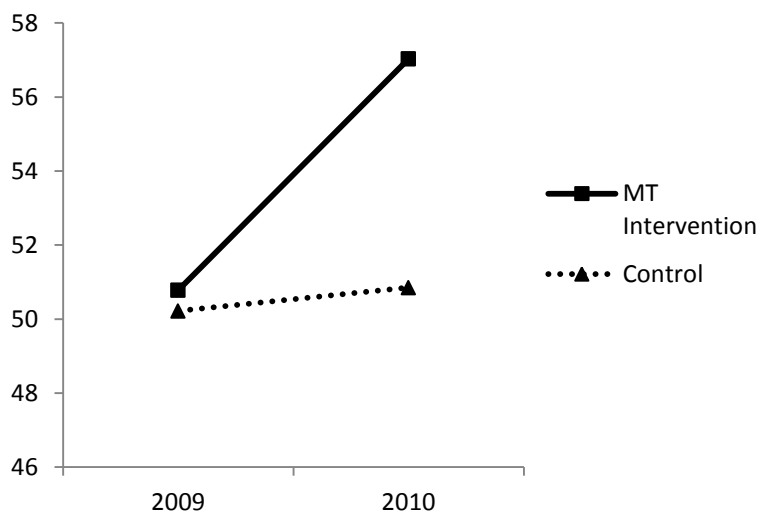


Figure 3

Group x Time Interaction for Evaluation of Competitive Performance Statistics

Indoor Assessments

Five participants (3 from control group, 2 from experimental group) were unable to complete the post-test indoor assessments due to injury, illness or educational commitments. Data for all five participants were removed prior to analysis.

Batting Assessments

A 2 x 2 (group x time) multivariate analysis of variance (MANOVA) was used to assess differences between the groups over time on indoor batting assessments. The MANOVA demonstrated a marginally non-significant main effect for group ($F_{2,32} = 2.79, p = .07, \eta^2 = .131$) a non-significant main effect for time ($F_{2,32} = 1.49, p > .05, \eta^2 = .075$), and a significant group by time interaction ($F_{3,32} = 4.14, p < .05, \eta^2 = .183$). Discriminant function analysis was used to identify which of the batting tests contributed to the significant multivariate effect. A priori hypotheses stated that between-group differences were not expected pre intervention and were expected post intervention. As such two separate discriminant function analyses were conducted, one on pre-intervention batting scores and another on post-intervention batting scores. This analysis revealed that the combination of the pre-intervention batting tests did not discriminate between the groups ($\chi^2(2) = 0.268, p > .05$), but the combination of the post-intervention batting tests discriminated between the control and the experimental groups ($\chi^2(2) = 10.85, p < .01$). The standardized structure coefficients suggested that the discrimination was largely due to scores in the post-intervention pace test (.73), although scores in the post-intervention spin test also made a significant contribution (.53). Visual scanning of the group centroids for the post intervention batting tests indicated that the experimental group outperformed the control group in both instances.

Fitness Assessments

A 2 x 2 (group x time) multivariate analysis of variance (MANOVA) was used to assess differences between the groups over time on the vertical jump and multi-stage fitness assessment. The MANOVA demonstrated a non-significant main effect for group ($F_{2,32} = 1.83, p > .05, \eta^2 = .092$) a significant main effect for time ($F_{2,32} = 47.72, p < .01, \eta^2 = .726$), and a significant group by time interaction ($F_{2,32} = 23.21, p < .01, \eta^2 = .563$). A discriminant function analysis was used to verify which of the fitness tests contributed to the significant multivariate effect. This analysis revealed that the combination of the pre-intervention fitness tests did not discriminate between the groups ($\chi^2(2) = 0.72, p > .05$), but the combination of the post-intervention fitness tests discriminated between the control and the experimental groups ($\chi^2(2) = 10.90, p < .05$). The standardized structure coefficients suggested that this discrimination was exclusively due to scores in the post-intervention multi-stage fitness test (.99). The vertical jump test did not make a significant contribution to the discriminant function ($r < .40$). Visual scanning of the group centroids indicated that the experimental group significantly outperformed the control group on the multi-stage fitness test.

Discussion

The results of the present study lend support for the efficacy of the mental toughness intervention designed to enhance performance under pressure in elite young cricketers. Generally speaking, the results are in line with a priori hypotheses. For the dependent variables of most interest: coach rated mental toughness and evaluation of competitive performance statistics, significant improvements occurred for the intervention group that did not occur for the control group. For the indoor assessment data, the experimental group improved significantly in comparison to the control group in both of the batting assessments and the multi-stage fitness

tests. In the vertical jump test, there were no significant differences between the groups, although both groups improved significantly from pre-test to post-test.

To the best of our knowledge, this is the first theoretically derived mental toughness intervention that has shown meaningful effects that can be differentiated from a general psychological skills training package. Based on the results of the present study, researchers and applied practitioners are encouraged to investigate further the constructive use of punishment conditioned stimuli in training contexts. This is especially the case because punishment remains a relatively “taboo” subject in the sport psychology community (e.g., Albrecht, 2009), and as a result the intelligent use of punishment remains largely unexplored. Presumably, this is because applied psychologists are concerned about some of the negative consequences associated with the use of punishment, for example: reduced self-efficacy and increased anxiety (Albrecht, 2009), reduced intrinsic motivation (Vallerand, Gauvin & Halliwell, 1986) and in extreme situations, learned helplessness (Maier & Seligman, 1976). Furthermore, sport psychologists tend to be preoccupied with self-efficacy enhancing interventions that focus on maximising mastery experiences (e.g., Connaughton et al., 2008). Punishing players for poor performance may appear to some as though it prevents the accumulation of mastery experiences. However, most of the concerns with the use of punishment are based on misconceptions that they are going to be administered randomly or inappropriately (Seifried, 2008). The evidence from the present study suggests that punishments, and more specifically the threat of punishment, can lead to enhanced performance under pressure if they are presented in a transformational manner. This sits comfortably with evidence from other fields which suggest that appropriately administered punishments can lead to improvements in adolescent delinquent behaviour (Morris & Gibson, 2011), decreases in a variety of phobias and neuroses (c.f., Deffenbacher & Suinn, 1988), and

improvements in performance in organisational settings (c.f., Arvey & Ivancevich, 1980). There is even preliminary evidence that the active use of punishment is significantly and positively related to improvements in a variety of attitudinal variables, including self-esteem and satisfaction, in military training recruits (Arthur, Hardy & Wagstaff, 2010).

An issue worthy of further consideration in punishment based mental toughness interventions is whether exposure to punishment-conditioned stimuli sensitizes or desensitizes individuals to threatening cues? Systematic desensitization (Wolpe, 1958) involves graded exposure to anxiety-inducing situations in combination with relaxation strategies. Given the considerable overlap between desensitization training and the principles of the mental toughness intervention used in the present study, one might argue that the participants in the intervention group were desensitized to punishment conditioned stimuli as they become accustomed to regular exposure. Alternatively, one might argue that consistent exposure to punishment conditioned stimuli *sensitizes* individuals to threat because they are trained to identify threatening cues earlier. This would sit comfortably with evidence from a recent set of studies which suggests that mentally tough cricketers, as rated by their county coaches, tend to be sensitive to punishment (Hardy, Bell & Beattie, under review). Reinforcement sensitivities were not measured as part of this study so we cannot say with any degree of certainty whether the intervention had a sensitizing or desensitizing effect. To resolve this issue, the present thesis would argue for defining *sensitivity* differently from *reactivity*. More specifically, sensitivity could be defined in terms of the speed of detection of a stimulus and reactivity could be defined in terms of the emotional reaction to a stimulus. Using these definitions, it is feasible for exposure to punishment conditioned stimuli to increase sensitivity, in the form of earlier threat

detection, and simultaneously reduce emotional reactivity, as described in classic desensitization training. Further work is required to confirm this line of thinking.

From an applied perspective it is interesting to reflect on the manner in which the punishments were presented in the intervention. As noted above, in order to avoid learned helpless responses (Maier & Seligman, 1975) it was considered crucial to present and administer punishments transformationally. According to organisational psychologists punishments are best administered: (i) immediately after an undesirable behaviour on a consistent schedule, and (ii) on a contingent basis with a clear explanation of the reasons behind the punishment for all relevant parties, including those not being punished (Arvey & Ivancevich, 1980). The present intervention was structured in line with these recommendations such that players were made aware of the likely punishments prior to every pressure test along with clear instructions about what constituted success and failure. More importantly, punishments were consistently presented as part of an inspirational vision of what it takes to be a World's best player for England. Ultimately, the purpose of the punishments was to provide the players with opportunities to cope with the pressures and threats that are commonplace in the world of elite competitive sport. Applied psychologists are advised to make use of these recommendations to maximise the effectiveness of exposure to punishment conditioned stimuli in the training environment.

We acknowledge three notable limitations that may give rise to important avenues for future research. The primary limitation concerns the non-random allocation of participants to the control and experimental groups. This limitation has already been addressed in the methods section. To briefly recap, a group of elite-level, age-matched, county cricketers were recruited to act as a comparison control group. All of the cricketers involved in the control group were nominated by professional coaches based on demonstrated potential to be a future World's best

player for England, which constitutes the most appropriate control group available in the UK. In addition, a mixed model design was employed to control for differences between the two groups at pre-test. Crucially, the control group showed no significant differences from the intervention group in any of the designated outcome variables at pre-test. The combination of these factors suggests changes which emerged between the groups over time occurred exclusively as a result of intervention effects rather than pre-existing differences between the groups.

The second limitation concerns the measurement of the mental toughness. There are numerous empirical and theoretical problems with the instruments that have been used to measure mental toughness in the literature (Crust, 2008). As recommended by previous researchers (e.g., Gucciardi et al., 2010), the outcome measures in the present study focused on coach ratings and objective performance scores rather than self-report data. However, one might argue that objective competition statistics do not represent a direct test of mental toughness. The authors have previously argued that mental toughness is distinct from overall performance and that measures of mental toughness should focus on performance *under pressure*, as opposed to global performance. Unfortunately, collecting objective competition data that focuses exclusively on performance under pressure is extremely challenging for the population of cricketers used in this study. Ideally, future research should identify specific pressurized scenarios that cricketers are likely to face (e.g., bowling the final over when defending a small total or recovering after a batting collapse) and measure the difference between performances in non-pressure settings and performance in pressurized settings. In cricket, this would require access to ball-by-ball performance statistics which were not available in the present study.

The third methodological limitation of the present study concerns the measurement of the different aspects of the intervention. Having designed a multi-modal intervention it is

unfortunate that no attempts were made to measure the separate effects of the punishment conditioned stimuli, the transformational delivery, or the efficacy of the coping skills. As a result we are limited in our ability to clearly identify those aspects of the intervention that contributed most to the observed changes in mental toughness. Equally, we can only speculate about the interactive effects that may have occurred. Having said that, the primary purpose of the study was to design an intervention and establish its effectiveness as a mental toughness development program. The results of the study support the efficacy of the intervention and it is hoped that future research will explore possible moderating and mediating variables which may explain this effect further.

Chapter 4

General Discussion

Summary of Results

The final chapter aims to briefly remind the reader of the research questions presented and to discuss the general findings from the two empirical chapters contained in the thesis. The results are discussed in terms of the theoretical and applied issues that emerged from the research which leads to an analysis of the strengths and limitations of the thesis. Future directions for research are considered and personal reflections on the 4 year research process are included as a conclusion to the thesis.

Chapter 1 critically reviewed the mental toughness literature and highlighted a number of theoretical and empirical limitations which need to be resolved. The areas that were of particular interest were the conceptualisation and operationalisation of mental toughness, the application of relevant cognitive neuroscience theory to the study of mental toughness, and the need for experimental studies which evaluate a mental toughness intervention that enhances performance under pressure in athletes. The chapter finishes by proposing alternative positions on the neuro-cognitive systems which might underpin mentally tough behaviour based on the predictions of the revised Reinforcement Sensitivity Theory (RST: McNaughton & Gray, 2000).

Chapter 2 aimed to address some of the limitations in the Mental Toughness research that have been identified in recent review papers (e.g., Crust, 2007, 2008; Connaughton et al., 2008). The chapter had three main objectives: (i) to conceptualize and operationalize mental toughness in a way that overcame the limitations of previous definitions; (ii) to develop a valid and reliable measure of mentally tough behaviour; and (iii) to apply relevant personality theory to the examination of between-person differences in mentally tough behaviour. Studies 1 and 2 were concerned with the development of a valid, informant rated, questionnaire to measure mental toughness, conceptualized here as a “relatively stable disposition that enables one to maintain or

enhance performance under pressure from a wide range of different stressors". The results of the confirmatory factor analyses from studies 1 and 2 found good support for the structural integrity of the eight-item MTI. Studies 3 and 4 were concerned with the application of relevant personality theory (RST) to explain individual differences in mental toughness, as assessed by the MTI. In two separate samples of highly talented young cricketers, punishment sensitivity was positively related to mental toughness only when reward sensitivity was low. In the same two samples of cricketers punishment sensitivity was negatively related to mental toughness when reward sensitivity was high. Further examination in study 4 revealed that punishment sensitivity was significantly related to early threat detection. In addition, the combination of high punishment sensitivity and high reward sensitivity was related to shorter processing times during a decision making task but a higher incidence of decision making errors.

Chapter 3 reported a quasi-experimental; longitudinal intervention study. The study involved the design and delivery of a theoretically grounded mental toughness training program for youth aged Academy cricketers. The central feature of the intervention was exposure to punishment conditioned stimuli in the training environment. To avoid the deleterious effects of punishment the intervention was designed and delivered in a multi-disciplinary, transformational manner and participants were taught a variety of coping strategies to deal with the threatening environment. The intervention was evaluated against a control group of youth aged Academy Cricketers who participated in County Academy training programs around the UK. Generally speaking, the results were in line with the a priori hypotheses. The dependent variables of most interest: coach-rated mental toughness and evaluation of competitive performance statistics, significantly improved in the intervention group only. For the indoor performance data, both control and experimental groups showed significant improvements in the majority of the tests.

However, the intervention group tended to improve significantly more than the control group, especially in the tests thought to be most related to mental toughness, such as the multi-stage fitness test and batting against pace.

Theoretical Issues

The theoretical implications that are derived from the empirical data in this thesis are addressed in detail in the discussions from Chapter 2 and 3 and will only be summarised in this Chapter.

Punishment Sensitivity

The most prominent theoretical implications from the thesis concern the apparent positive effects of punishment. Beneficial effects of punishment might be considered a little surprising because there is evidence which suggests punishment sensitivity is associated with cognitive and behavioural outcomes that imply a lack of mental toughness (e.g., Perkins et al., 2007). However, the neural pathways that underpin punishment sensitivity, (e.g., BIS and FFFS) have an adaptive evolutionary function, to help animals escape and / or approach dangerous situations. Therefore it shouldn't come as a complete surprise that punishment sensitivity is often related to positive outcomes in threatening environments (Corr, 2004). The evidence for the positive effects of punishment came in varied forms. Evidence from Chapter 2 consistently found that punishment sensitivity was positively associated with mental toughness when reward sensitivity was low. This relationship was established in two independent samples of elite level, youth-aged cricketers. Similarly, repeated exposure to punishment conditioned stimuli in Chapter 3 resulted in improvements in a variety of indicators of performance under pressure, further supporting the beneficial effects of punishment. Follow up work in Chapter 2 suggested that the beneficial effects of punishment sensitivity may be related to early threat detection. By detecting threat

early, athletes who are sensitive to punishment have sufficient time to employ coping strategies and begin mentally preparing for the pressurised situations they are likely to encounter. This is consistent with evidence relating punishment sensitivity to attentional biases toward threat-related stimuli (Avila & Parcet, 2002). Equally, neuropsychological studies (e.g., Mathews, Yiend & Lawrence, 2004) have found that the fMRI BOLD response to threatening stimuli in the amygdala and hippocampus was qualified by individual variation in self-reported punishment sensitivity. Furthermore, autonomic data derived from signal detection theory found that individuals who are sensitive to punishment are more likely to *anticipate* threat and demonstrate enhanced preparedness to respond prior to exposure (Lefave & Neufeld, 1980). The combination of the current collection of studies and previous research implies that the ability to detect and deal with threatening information is a crucial determinant of performance in a pressurised environment.

Reward Sensitivity

Another important theoretical implication concerns the negative effects of reward sensitivity, especially in combination with high punishment sensitivity. On the one hand, the negative effects of reward sensitivity are not entirely surprising because high levels of reward sensitivity are associated with impulsivity, failure to identify aversive cues in the environment and failure to learn from punishment (Patterson & Newman, 1993). All of these behaviours are unlikely to be helpful in pressurised sporting environments and as such the negative relationship that emerged between reward sensitivity and mental toughness is understandable. Perhaps of greater theoretical significance is that the negative relationship between punishment sensitivity and mental toughness *only* emerged when reward sensitivity was high. The revised version of RST predicts that the combination of high reward sensitivity and high punishment sensitivity

should lead to the highest levels of behavioural inhibition. Kambouropoulos and Staiger (2004) confirmed this line of thinking when they found that slower response times, indicative of behavioural inhibition, occurred for individuals who reported high scores on EPQ-derived punishment sensitivity *and* reward sensitivity. However, the combination of high reward sensitivity and high punishment sensitivity produced the shortest response times in a decision making task in study 4 (Chapter 2), reflecting the lowest levels of behavioural inhibition. The unexpected short response times were associated with the greatest number of decision making errors which might explain the low levels of mental toughness. Nonetheless, the results bring into question the exact conditions which activate the BIS and the specific cognitive, affective and behavioural outcomes that result from BIS activation.

Interactive Effects

Perhaps the most consistent theoretical implication from the present collection of studies is support for the Joint Subsystems Hypothesis (Corr, 2004). While the systems which underpin punishment and reward sensitivity are neurally independent, and can be assessed for separate trait sensitivities, their outputs are expected to interact when they are concurrently activated (McNaughton & Corr, 2008). Interactive effects of punishment and reward sensitivity are most likely to occur under real-life human conditions, where mixed appetitive and aversive stimuli exist in the environment, especially on tasks that are sensitive to motivational influences (McNaughton & Corr, 2008). Competitive cricket performance environments, which were the focus of this thesis, appear to contain mixed appetitive and aversive stimuli and interactive effects consistently emerged. Interactions between punishment and reward sensitivity imply the involvement of the BIS, which fits with Corr's (2004) assertion that "clear-cut effects of the BIS will be easier to find in ego-involving, important real-life situations" (p.322). The results from

the thesis also support the view expressed by Avila and Torrubia (2008) that “the BIS, not the BAS, mediates performance in conditions of mixed reward and punishment” (p.250). Given the relationship between reinforcement sensitivities and performance is dependent on the motivational context in which performance is assessed (Avila & Torrubia, 2008), it remains unclear whether the present results are generalizable to other performance contexts. It is possible that the relative balance of punishment to reward differs within and across competitive athletic environments. For example, batsmen in Test Match cricket tend to assume a relatively cautious approach because it is more important not to lose a wicket than it is to proactively score runs. Under these circumstances, the ability to detect and deal with threatening information that prevents an individual from losing a wicket, is likely to aid performance. In contrast, in the shorter form of cricket (e.g., one-day matches or twenty over matches) it is more important to score runs proactively and as such greater risks are taken in terms of shot selection. Under these circumstances, reward sensitivity may be more strongly related to performance outcomes. Similar distinctions can be made in other sports and, as such, it is important to consider the relative balance of punishment conditioned stimuli to reward conditioned stimuli in the environment, when generating hypotheses regarding the relationships between reinforcement sensitivities and performance. Nevertheless, the focus of the present collection of studies was performance *under pressure*, and given the higher incidence of punishment conditioned stimuli under pressurised circumstances the results are in line with the predictions of RST.

The relationship between mental toughness and reinforcement sensitivities is complex and future work is required to further clarify the separate effects of the neural networks that underpin the BAS, BIS and FFFS in performance environments. Although the results from the thesis consistently point towards BIS effects, there are a number of unanswered questions on this

matter that warrant further research. From a theoretical perspective, it is unclear to what extent the beneficial effects of punishment can be explained by the BIS or the FFFS. One of the most important differences between Gray's (1970) original theory and the revised theory proposed by Gray & McNaughton (2000) is the separation of fear from anxiety. Underpinning this separation is the independent functioning of two neural systems, the BIS and the FFFS. No attempt was made to measure the separate influence of these two systems in the current collection of studies. We have argued earlier in the thesis that the role of the FFFS is limited in competitive sport because it is very rare for an athlete to face a situation that contains only punishment conditioned stimuli. It seems much more likely that contextual conflict is inherent in all pressurised performance scenarios, which is likely to activate the BIS rather than the FFFS. Nevertheless, there may be occasions in sport where the FFFS is crucial, e.g. ducking out of the way of a fast short pitched ball in cricket. Furthermore, Corr (2004) has stated that "if anything FFFS (fear) not BIS (anxiety) is more associated with general punishment sensitivity" (p.325) although it remains unresolved whether neurotic introversion (as it was assessed in this thesis) relates to fear alone or fear plus anxiety.

Based on the theorizing above, further research is required to understand how the FFFS and the BIS interact in performance contexts. In addition, further elaboration of the BIS is required to understand how it contributes to optimal performance under pressure. It is noteworthy that punishment sensitivity is implicated in the highest (high PS / low RS), and the lowest (high PS / high RS), levels of mental toughness reported in this thesis, yet the involvement of the BIS remains ambiguous at both levels. McNaughton and Corr (2008) propose that the BIS has multiple functions, including (i) conflict detection (based in the subiculum region of the hippocampus), (ii) conflict resolution mechanisms (based in the orbitofrontal

cortex), and (iii) an arousal component (based in the amygdala). Currently, it remains unresolved which of these functions is crucial to performance under pressure and exactly how dysfunction within these neural networks might contribute to performance impairment.

Measurement Issues

In the present collection of studies, reinforcement sensitivities were assessed using Corr's (2001) rotations of the Eysenckian Personality dimensions. This is in contrast to the majority of the RST literature, where Carver and White's (1994) BIS/BAS scale is most widely used. Eysenckian rotations were preferred for two reasons: i) the EPQR-S possessed strong psychometric validity; and ii) the BIS scale focuses almost exclusively on the emotions hypothesized to be associated with the BIS *and* the FFFS, rather than the behaviors associated with punishment sensitivity. Given the differences between the two scales it is possible that the results that emerged in the thesis were specific to Eysenckian rotations. After all, there is good reason to think that items which reflect combined worry and fear might have different predictive qualities from items that reflect a 30° rotation of introversion and neuroticism. In reality, neither of these methods provides a direct measure of punishment sensitivity. Furthermore, both of these personality scales are based on the unrevised theory and neither accurately reflects the revised RST constructs (Gray & McNaughton, 2000). In order to fully investigate the relationship between reinforcement sensitivities and mental toughness it is necessary to directly assess the different functions of the BAS, BIS and FFFS. Recently, there have been renewed attempts to separately assess the three systems from a psychometric perspective (e.g., Heym, Ferguson & Lawrence, 2008.). Currently, this involves separating items from the original BIS scale into BIS items and FFFS items, and as such, the measure continues to focus on affective components of punishment sensitivity rather than any of the cognitive and behavioral functions. Measurement

issues are likely to remain a fundamental limitation of all RST based personality research until a comprehensive measure of the revised RST constructs is fully developed (e.g., Corr & Cooper, in prep). Ideally, this measure should take into account the biological hardware, neurological processes and behavioral outputs that are specific to each system, as described in the revised RST (Gray & McNaughton, 2000).

Insensitivity to Pressure

Thus far, theoretical implications have focused on the conceptual ambiguity that exists within RST and the complex interactive effects of the BAS, BIS and FFFS. It is equally important to consider the conceptualisation of mental toughness as it was described in this thesis. Previous conceptualisations of mental toughness have been criticised for being atheoretical and incapable of distinguishing central components from correlates (Crust, 2008). Studies from this thesis were the first to define mental toughness as “a relatively stable disposition that enables one to maintain or enhance performance under pressure from a wide range of different stressors”. Some researchers might consider this a relatively narrow definition that fails to take into account the complexity of mental toughness, which is normally considered a multi-dimensional construct (Jones et al., 2007). The strength of the present approach is that it allows for more meaningful examination of the personality factors that might underpin mentally tough behaviour. Having said that, others might argue that performance under pressure constitutes a fairly broad definition and this may have contributed to the counter-intuitive findings from Chapter 2. There is, after all, more than one way of maintaining or enhancing performance under pressure (Hardy et al., 1996). If we had conceptualised mental toughness as “a relatively stable disposition that enables one to remain insensitive to pressure and adversity”, it may have generated very different results. Defining mental toughness in terms of insensitivity to pressure would be more in line with

definitions of material toughness, “the ability of material to absorb energy without rupturing” or dictionary definitions of toughness, “the ability to withstand great strain without tearing or breaking”. Perhaps the confusion surrounding the mental toughness literature would be alleviated if researchers were able to distinguish between different types of mental toughness (e.g., insensitivity to pressure versus performance under pressure). Further clarity would emerge if the distinction between different types of mental toughness could be explained with existing cognitive neuroscience theory (e.g., RST).

The concept of insensitivity to pressure in the context of RST is noteworthy. Individuals who are insensitive to pressure could be insensitive to punishment but sensitive to reward, equally they could be insensitive to all appetitive and aversive stimuli. When considering insensitivity to pressure it is worth examining the psychopathy literature (e.g., Corr, 2010). The core features of the psychopathic syndrome include poor judgement, inability to learn from negative consequences, impulsive behaviour, lack of remorse and superficial emotional reactions (Cleckley, 1964). Fowles (1980) has argued that psychopaths can be differentiated from non-psychopathic controls according to their under-reactivity to anticipated aversive stimuli, behaviours one would equally associate with a performer who is insensitive to pressure. Following Karpman (1949), psychopathy is often differentiated into primary and secondary types. Primary, or true, psychopaths are said to possess an innate fearless temperament that impairs socialisation, and experience low levels of anxiety. Secondary or neurotic psychopaths experience relatively high levels of negative affect (e.g. depression, guilt), with their anti-social behaviour occurring mainly as a reaction to emotional conflicts or distress. Given these descriptions it is possible to argue that insensitivity to pressure may be closely related to primary psychopathy. Numerous studies have investigated the relationship between primary psychopathy

and reinforcement sensitivities (e.g., Newman, MacCoon, Vaughn & Sadeh, 2005). Typically, these studies relate primary psychopathy to a weak BIS and a normal BAS. However, most of these studies have failed to differentiate between the FFFS and the BIS. In a very recent study that differentiated the BIS from the FFFS, primary psychopathy was negatively correlated with the BIS, the FFFS and BAS Fun seeking, but positively correlated with BAS Drive and BAS reward sensitivity (Hughes, Moore, Morris & Corr, 2012). Based on this evidence, one might expect similar relationships to emerge between RST systems and insensitivity to pressure. Future research in this area is warranted to clarify the distinction between maintained high performance under pressure and insensitivity to pressure.

Sensitivity versus Reactivity

The remaining theoretical issue that requires further discussion concerns the effect of exposure to punishment conditioned stimuli. Evidence from the intervention study (Chapter 3) suggested that exposure to punishment had a positive effect on performance under pressure; however the mechanisms which account for the higher levels of mental toughness are not fully understood. On the one hand, it is possible to contend that exposure to punishment might have sensitized the participants to threatening stimuli in the training environment thus enhancing the threat detection processes that are thought to underpin performance under pressure (Hardy, Bell & Beattie, under review). On the other hand, exposure to anxiety provoking stimuli is a technique used in systematic desensitization training to create a habituation effect, whereby the emotional reaction to the anxiety provoking stimuli is significantly reduced. This is typically done in a hierarchical fashion in conjunction with relaxation training and the results consistently demonstrate the efficacy of this type of intervention across a variety of contexts and conditions (Deffenbacher & Suinn, 1988). This finding raises two questions that warrant future research.

First, if repeated presentation of an aversive stimulus is the only *necessary* condition for desensitization to occur (Levin & Gross, 1985), what other variables might exist which moderate this relationship? In the intervention study in this thesis, exposure to punishment was combined with transformational delivery and psychological preparation strategies, although neither of these aspects of the intervention were measured so any moderating effects remain speculative. Future research might seek to understand more about the moderating influence of other psychological variables. Second, does exposure to punishment in isolation have a sensitizing or a desensitizing effect? Reinforcement sensitivities were not measured in Chapter 3 so we cannot say with any degree of certainty whether the intervention had a sensitizing or desensitizing effect. To answer this question it may be necessary to differentiate sensitivity from reactivity. If sensitivity is defined in terms of the detection of a stimulus and reactivity is defined in terms of the emotional reaction to a stimulus, then it is possible that exposure to punishment may simultaneously sensitize and reduce the reactivity to threatening information. Further work is required to confirm this line of thinking, not least a valid and reliable direct measure of reinforcement sensitivities.

Alternative Theories

From a theoretical perspective, the present collection of studies focused almost exclusively on RST and its capacity to explain individual differences in mentally tough behaviour. Other personality dispositions (e.g., anxiety, hardiness, narcissism) are also capable of accounting for between-person differences in performance under pressure. A review of alternative personality theories and how they relate to the results from the present collection of studies is warranted in order to identify gaps in the literature and questions that remain unanswered.

Anxiety Theories

Trait anxiety is a personality disposition that could be related to mental toughness, especially given pressurised performance environments are inherently anxiety provoking and the BIS, as discussed within the tenets of the revised RST, is supposed to be the neural substrate of anxiety (McNaughton & Corr, 2000). Attention control theory (Eysenck, Derakshan, Santos, & Calvo, 2007), attempts to explain the deleterious effects of anxiety on cognitive performance. The theoretical model distinguishes between a goal-directed attentional system driven by expectation, knowledge and current goals, and a stimulus-driven system which responds to salient or conspicuous stimuli (Eysenck et al., 2007). Gray and McNaughton (2000) may well have argued that the goal directed attentional system is the equivalent of the BAS and the stimulus driven system is the equivalent of the BIS. According to attention control theory, anxiety disrupts the balance between these two systems, increasing the influence of the stimulus driven system and decreasing the influence of the goal directed system (Eysenck et al., 2007). The increased influence of the stimulus driven system occurs via automatic processing of threat related stimuli which impairs: a) the inhibition of pre-potent responses towards task irrelevant stimuli, and b) the shifting of attention back and forth between multiple tasks (Eysenck et al., 2007).

Pijpers, Oudejans, and Bakker (2005) tested the predictions of attention control theory during a series of rock climbing tasks. They found that climbers made more explorative movements; took longer when grasping holds and made slower movements between holds, when traversing at elevated, anxiety provoking heights. Nieuwenhuys, Pijpers, Oudejans, & Bakker (2008) found that heightened cognitive and somatic anxiety resulted in slower performance as climbers were still for longer, and spent longer gazing and fixating on hand and foot holds. These studies may have confirmed the predictions of attention control theory but it appears equally

feasible to explain the results in terms of BIS activity. One might argue that visual fixation combined with being still for longer reflects behavioural inhibition and memory scanning, both of which are outputs of the BIS during approach-avoidance conflicts. Preliminary evidence suggests that RST and attention control theory are complementary and future work might seek to clarify how the combination of these theories can explain in greater detail the cognitions and behaviours which underpin performance under pressure.

Hardiness

Previous research has established hardiness as a dispositional factor in preserving and enhancing performance and health despite stressful circumstances (Maddi, 2002). Hardiness is conceptualised as a stable personality disposition that is formed from three interrelated attitudes, normally referred to as the 3 C's (Maddi & Khoshaba, 1994). Individuals who score high on *commitment* find it interesting and meaningful to stay involved with the people and events around them rather than retreating into isolation under stress. *Control* involved struggling to have an influence on outcomes going on around oneself, rather than sinking into passivity and powerlessness. *Challenge* signified wanting to learn continually from one's experience, whether positive or negative, rather than playing it safe by avoiding uncertainties and potential threats. Given the stress-buffering functions of hardiness, it is unsurprising that many of the original conceptualisations of mental toughness shared considerable overlap with conceptualisations of hardiness (e.g., Clough et al., 2002). However, the conceptualisation of mental toughness in this thesis is different from other conceptualisations of mental toughness reported in the literature (e.g., Jones et al., 2002), and the proposed mechanisms that account for the stress buffering effects of hardiness appear incompatible with the beneficial effects associated with punishment sensitivity reported in this thesis. This is because the attitudes which underpin hardiness seem to

reflect reward sensitivity rather than punishment sensitivity. For example, in a study involving the Eysenckian personality dimensions, hardiness was found to be negatively correlated to neuroticism and positively correlated to extraversion (Parkes & Rendell, 1988). Furthermore, the control and challenge attitudes which underpin hardiness emphasise active coping and embracing change as opposed to passivity and avoiding uncertainty. These are actions one would associate with reward sensitivity and approach behaviour as opposed to punishment sensitivity and avoidant or inhibited behaviour.

At first glance, the mechanisms by which hardiness buffers against the deleterious effects of stress appear contradictory to the proposed mechanisms by which punishment sensitivity maintains or enhances performance under pressure (e.g., early threat detection). Having said this, hardy individuals are said to possess a heightened awareness of stressful circumstances and an acknowledgement of potential threats (Maddi et al., 2006). The heightened awareness is necessary for effective planning, active coping and decisive action to take place. If hardy individuals possess a heightened awareness of stressful circumstances, one would expect them to be capable of identifying threats and dealing with them effectively, as per the findings from the thesis. It is important to remember that one of the major assumptions from the present collection of studies concerned the advanced coping ability of elite cricketers that participated in the investigations from Chapter 2. Given that hardiness primarily focuses on the interpretation and situational reconstruction of stressful life events, one might think of hardiness as an advanced form of coping which helps individuals deal with stress and adversity (e.g., Maddi, 2002). In this way, hardiness might represent a distinct but complimentary aspect of the process of performing under pressure. More specifically, the beneficial effects of punishment sensitivity seem to be related to the early identification of threatening information, whereas the beneficial effects of

hardiness seem to be related to the coping behaviours which are employed *after* the threatening situation has been identified. Both of these aspects of performing under pressure might represent distinct functions of the BIS. In a similar vein, some of the principles of hardiness training are also consistent with the mental toughness intervention depicted in Chapter 3. Khoshaba and Maddi (1999) designed and evaluated a hardiness training program which provided empirical evidence that hardiness develops in people who are encouraged by those around them to believe that they can turn adversity into opportunity and who observe themselves actually making this happen. In the same way, the mental toughness intervention in Chapter 3 was delivered in a transformational manner, whereby participants were encouraged to think of learning to deal with punishments as a fundamental aspect of what it takes to be a World's best player for England. As such, practicing under stressful circumstances was viewed as an opportunity to learn to cope with threat and perform exceptionally under pressure.

One of the other issues which arises from the hardiness literature is the proposed health benefits associated with a hardy personality. In a wide range of stressful contexts, ranging from life-threatening events of military combat and peacekeeping (e.g., Bartone, 1999), through the culture shock of immigration (e.g., Kuo & Tsai, 1986) or work missions abroad (e.g., Atella, 1989), to everyday work or school pressure and demands (e.g., Maddi, 2002), the buffering effect of hardiness has been shown in decreasing mental and physical illness symptoms, whether these be self-reported or more objectively measured. The predominant focus on health related outcomes in the hardiness literature is distinct from the predominant focus on performance related outcomes in the mental toughness literature. One line of questioning which has yet to be fully explored is the possible health related costs associated with mental toughness. Anecdotally, athletic demonstrations of mental toughness often come at the expense of the athlete's health and

well-being (e.g., competing through an injury and making it worse in the process). Previously, researchers have been unable to investigate the relationship between mental toughness and health related outcomes due to lack of clarity regarding the conceptualisation and operationalisation of mental toughness. Using RST to differentiate performance under pressure from insensitivity to pressure might allow future researchers to investigate the specific physical and mental consequences of different forms of mental toughness. For example, one might expect individuals high in punishment sensitivity to experience more anxiety related illnesses due to persistent hyper-vigilance to threat related information. Equally one might expect individuals who are insensitive to all forms of stimuli to be more susceptible to repetitive strain and excessive use injuries.

Narcissism

Narcissism is another personality trait that is relevant in a discussion of mental toughness. Wallace and Baumeister (2002) demonstrated that narcissists tend to perform well under pressure, most likely as a result of an increase in on-task effort (Woodman, Roberts, Hardy, Callow, & Rogers, 2011). However, a subtlety within the narcissism-performance literature is that, while narcissists perform very well under pressure, they perform poorly when pressure is off. This is because narcissists are motivated by the opportunity to gain personal glory, and so will perform well in situations that they believe offer such an opportunity, but will remove effort in situations where they believe this is lacking (e.g., Woodman et al., 2011). Implicit within this “opportunity for glory” argument is that narcissists are primarily driven by rewards, as opposed to being sensitive to punishment. Empirical research (e.g., Foster & Trimm, 2008) has provided evidence that narcissists are strongly motivated by reward acquisition (BAS) and weakly motivated by punishment avoidance (BIS). At first sight, the positive relationship between

narcissism and reward sensitivity is incongruent with the findings of the present thesis which highlighted the deleterious effects of reward sensitivity in the context of mental toughness. In order to investigate these conflicting results further, it would be interesting to examine the relationship between narcissism, reinforcement sensitivities and performance under pressure. Perhaps there are situations that offer more opportunities for glory where narcissists would outperform neurotic introverts and other situations with a greater incidence of threatening stimuli where neurotic introverts would be expected to outperform narcissists.

Applied Issues

The evidence from the empirical studies in Chapter 2 suggests that athletes and coaches should be encouraged to identify threats to their performance at the earliest possible opportunity so they are able to plan effective responses and employ suitable coping strategies in a timely manner. One technique that might be useful for athletes and coaches to consider is ‘What-if’ scenario planning (Miller, 1997). Typically this involves identifying a number of possible worst case scenarios that are liable to occur prior to competition (e.g., starting the match slowly and going behind early against a team we would normally expect to beat or picking up an injury half way through the match). An appropriate response is planned for each of the scenarios, in case they actually occur and the athlete is then prepared for the different eventualities that may emerge during competition (Miller, 1997).

The findings from the intervention study (Chapter 3) suggest that exposure to punishment conditioned stimuli in the training environment enhances mental toughness in elite young cricketers. The evidence from Chapter 3 is consistent with research from the anxiety literature which finds that exposure to anxiety provoking situations in training enhances performance under anxiety provoking conditions during retention tests (Oudejans & Pijpers, 2010). Based on

this evidence, coaches and sport psychology practitioners are advised to utilise punishments as a development tool to enhance performance under pressure and encourage behaviour change. Having said this, the exact mechanisms by which punishment influences mental toughness are not yet clearly understood. It is thought that exposure to punishment conditioned stimuli might encourage individuals to detect threatening information earlier and simultaneously reduce the emotional reaction to threatening information via a desensitization process. More work is required to confirm this line of thinking. In addition, in the present research, the punishment conditioned stimuli were deliberately delivered in a transformational manner in combination with a variety of mental preparation strategies (e.g., cognitive restructuring, process goals, arousal control, and visualisation) that were designed to help the cricketers cope with the threatening environment. It remains unclear whether the intervention would have been as effective without these two aspects embedded within the program. Equally, it remains unclear whether the different aspects of the intervention interact or affect mental toughness independently. Given the lack of clarity around the mechanisms underpinning the intervention effects, practitioners are advised to adopt a cautious approach when applying punishment conditioned stimuli to the training environment. To prevent punishments being delivered inappropriately, practitioners are advised to follow recommendations from Podsakoff, Podsakoff and Kuskova (2010). More specifically, punishments are most effective when they are administered consistently and contingently, in a timely manner as close as possible to the undesirable behaviour (Podsakoff et al., 2010).

From an applied perspective, it is possible to use the results from Chapter 2 to advocate an assessment of reinforcement sensitivities to inform talent identification. Given the consistent findings across two samples of cricketers it appears reasonable to use an assessment of

reinforcement sensitivity to identify cricketers with high levels of punishment sensitivity and low levels of reward sensitivity. The results from the Chapter 2 suggest these cricketers are likely to perform optimally in a pressurised competitive environment, which is useful information for practitioners charged with identifying talent. Using reinforcement sensitivities to identify talent might be considered a risky strategy given the problems around the indirect measurement of reinforcement sensitivities and the questions surrounding the generalisability of the results to other performance contexts. Equally, there are almost certainly performers who are *insensitive* to punishment who are able to perform optimally under pressure using strategies that are not discussed in this thesis. However, a more reasonable question is how sport psychology practitioners might make best use of reinforcement sensitivity data when designing individualised programs for athletes? For instance, in the case of a cricketer who is sensitive to reward but relatively insensitive to punishment, exposure to punishment in the training environment may have a detrimental effect on performance under pressure. Enhanced sensitivity to punishment in combination with high levels of reward sensitivity may lead to high levels of conflict and ineffective decision making, as discussed in Chapter 2. Based on this thinking it may be appropriate to design different interventions for athletes with different combinations of reinforcement sensitivities. In addition, practitioners may also want to consider the motivational context in which performance is to be assessed, which almost certainly differs across sports. For example, the optimal combination of reinforcement sensitivities might be different in situations which promote risk-taking (e.g., trying to overtake a car on the final corner of the track to win a championship) than situations which require caution and vigilance (e.g., trying to complete an unassisted climb up a difficult rock-face in adverse weather conditions).

Strengths and Limitations of the Thesis

Limitations

The most pressing empirical limitations of the thesis centre on the measurement of the independent variables in Chapters 2 and 3. More specifically, there are concerns regarding the rotations of the Eysenckian axes to measure reinforcement sensitivities in Chapter 2 and the distinction between *sensitivity* to punishment and *reactivity* to punishment in Chapter 3, neither of which was formally assessed. However, the specific limitations derived from the empirical studies have been addressed in detail elsewhere; consequently this section will focus on the general limitations of the thesis as a collection of research studies.

Firstly, this thesis relies exclusively on quantitative data. This might be considered an asset because quantitative methodologies “produce factual, reliable outcome data that are usually generalizable to some larger population” (Steckler, McLeroy, Goodman, Bird, & McCormick, 1992, p.2). However, the candidate has little experience of conducting qualitative analyses which would be desirable in terms of generating a broad research experience. Having said that, most of the problems with the mental toughness research can be attributed to a reliance on qualitative methodologies and it would have been problematic if qualitative methodologies were used to drive the research agenda in this particular thesis.

Secondly, the current thesis does not contain a true experimental design. The intervention was quasi-experimental in nature because the participants were not randomly assigned to experimental groups. In fact the participants in Chapter 3 were selected into the intervention group based on their potential for future performance, which is problematic. However, the intervention study was designed to control for pre-experimental; between-group differences in ability and the hypothesised mental toughness effects still emerged. Nevertheless, the intervention study highlighted the very real challenges of conducting research in applied settings,

where the goals of the researcher may not be entirely compatible with the goals of the organisation sponsoring the research.

Strengths

There are several strengths to this thesis. From a theoretical perspective, the thesis has incorporated established personality theory from the cognitive neuroscience literature to explain mentally tough behaviour. As far as the candidate is aware, this is the first study of mental toughness which formed a priori hypotheses regarding predictions of mental toughness based on existing theory. Furthermore, the thesis follows one single focus throughout, concentrating on the construct of mental toughness and its relationship with reinforcement sensitivities and punishment conditioned stimuli. Generally speaking, the empirical evidence points to a positive effect of punishment sensitivity on the development of mental toughness in young cricketers. This consistent theme that runs through the thesis, especially the replication of novel findings in Chapter 2, was also considered a strength.

From the perspective of research training, the thesis does not follow the traditional approach whereby each study is reported and written-up separately. The first four studies of the thesis were written in a condensed manner so they could be submitted as one article for publication. The preparation of a multi-study paper encouraged the candidate to write for and submit work to higher impact journals in the scientific community which might achieve 3* or 4* standard for Research Excellence Framework purposes. This approach has a number of associated benefits. Firstly, it trains the candidate to write and submit work in multi-study papers for peer review which is extremely advantageous in the current research climate. Secondly, it allows for a research question to be addressed and answered “in depth”. Third, ownership of the

thesis is passed on relatively quickly to the candidate in terms of developing independent and critical thinking and generating future research directions.

Future Directions

Below is a list of future research questions that are worthy of future consideration. These questions are arranged into three sections, (i) priority questions that emerged directly from the research conducted within the thesis, (ii) some generic questions about mental toughness, (iii) some psycho-physiological questions that focus on neural, physiological and biological markers of mental toughness. Generally speaking, the rationale for each of these research questions was covered in the theoretical issues section of this chapter, therefore the research questions are phrased in a brief and succinct manner.

Priority Questions

1. Can we develop a more reliable and direct measure of the revised RST constructs, which includes all the relevant functions of the BAS, BIS and FFFS?
2. Can we distinguish between the effect of the BIS and FFFS in terms of the relationship between punishment sensitivity and mental toughness? Does the FFFS have any relevance in a sport performance context that inherently contains contextual conflict? How might the FFFS and the BIS interact in pressurised performance contexts? Which of the functions of the BIS are crucial to maintaining or enhancing performance under pressure and which of the functions might impair performance under pressure?
3. If repeated presentation of an aversive stimulus is the only *necessary* condition for de-sensitization to occur, what other psychological variables might moderate this relationship?

In particular, how do transformational delivery and psychological preparation strategies interact with punishment conditioned stimuli to enhance mental toughness?

4. Does exposure to punishment conditioned stimuli sensitize or desensitize individuals to threat? When defining sensitivity, is it possible to distinguish between the detection of stimuli and emotional reactivity to stimuli? How might RST account for the differences between these forms of sensitivity?
5. What are the cognitive and behavioural differences between the maintenance of performance under pressure and insensitivity to pressure? Is it possible to use RST as an explanatory framework to differentiate the two constructs? Is insensitivity to pressure related to low levels of punishment sensitivity and high levels of reward sensitivity or low levels of punishment *and* reward sensitivity?

Generic Mental Toughness Questions

6. What is the relationship between trait anxiety and mental toughness? Do mentally tough athletes experience more, less, or the same amount of anxiety as less mentally tough athletes?
7. What is the nature of the relationship between mental toughness, reinforcement sensitivities and attention control theory? Are mentally tough athletes better able to shift attention and inhibit attention away from pre-potent stimuli? If so, is that because they have a more robust goal driven system or because they have a more effective BIS?
8. What is the relationship between hardiness and mental toughness? Is it possible to use RST to distinguish between hardy individuals and mentally tough individuals?

9. On a similar note, how might other personality dispositions related to performance under pressure account for the results in the present study? For example, what is the relationship between psychotocism and mental toughness? Or narcissism and mental toughness? Is it possible to create an encompassing theory of performance under pressure based on the tenets of RST?
10. Given the divergent findings regarding performance under pressure across different personality dispositions, it appears reasonable to question the generalisablity of the results from the present collection of studies to other performance environments? Are there alternative (non-cricket) pressurised performance contexts where different relationships may emerge?
11. At a more generic level, what is the relationship between mental toughness and effort? Do mentally tough athletes put more or less effort into performing under pressure and how does that enable them to perform optimally under pressure? Are mentally tough athletes able to sustain effort for longer? If so how do they do that?
12. Equally, what is the relationship between coping (use and/or frequency and/or effectiveness) and performance under pressure? What is the optimum combination of coping strategies to maximize performance under pressure?

Psycho-physiological Questions

13. What are the neural substrates of mental toughness and more specifically, which neural networks are crucial to performing under pressure (e.g., the amygdala, the pre-frontal cortex, the septo hippocampus)? One interesting future direction for research would be to use functional Magnetic Resonance Imaging (fMRI) techniques to examine the neural networks

involved in decision making in elite performers working in their area of expertise, under the most difficult circumstances imaginable. Such research would be of interest to both mental toughness researchers and RST and other personality researchers.

14. What is the best psycho-physiological marker of mental toughness (e.g., cortisol, norepinephrine, dopamine, etc)? Can these psycho-physiological markers be linked to reinforcement sensitivity theory?

Personal Reflections

This section of the thesis focuses on three questions: (i) what did I find helpful? (ii) what did I find difficult? (iii) how could I have learned more? This section of the thesis does not contribute any new thinking over and above the ideas covered in the main body of the thesis. It was thought that this section might prove informative for the candidate and the supervisors (and possibly the examiners) in offering greater insights into the highs and lows of the research training process.

What did I find helpful?

The most valuable time spent over the past 4 years were the lengthy tutorials with candidate and supervisors discussing and debating high level theory and its application to the concept of mental toughness. Initially, those discussions revolved around Pribram and McGuiness's (1968) theory of activation; arousal and coordination, and more specifically the centrality of activation versus coordination in explaining mentally tough behaviour. More recently, they have focused on the concept of cognitive perfection in relation to insensitivity to pressure and the distinct contributions of the BIS, BAS and FFFS to those constructs. The thinking I did before, during, and after those discussions was the single biggest influence on the direction of this thesis and without those discussions I think the thesis would be indisputably

weaker. The second most important thing I learned during my PhD is the importance of dedicating significant chunks of time to thinking and writing. I was at my most productive when I had 4-6 weeks dedicated solely to research. I was at my least productive when I was trying to squeeze writing or thinking into a spare day (or even a spare hour). I am incredibly grateful that I was advised to write on an ongoing basis throughout my PhD and I am convinced this is the only reason I have managed to submit my thesis within my four year registration period. Finally, I think that the combination of supervision I received from Lew and Stuart was extremely effective. Lew's high-level support at a theoretical level was complimented by Stuart's availability to discuss the finer details of the research process (e.g., statistics, writing, submitting for publication). The complementary nature of my supervision was a significant contributory factor to the quality of research produced.

What did I find difficult?

My single biggest regret regarding this thesis is the fact that it does not contain a 'final' study. As far as I can remember I had at least 3 different opportunities to 'complete' my thesis more thoroughly. At one stage I was planning to collect fMRI data to further explore the neural networks that underpin performance under pressure. I also had plans to collect follow-up data on a second intervention study to understand more about the interactive effects of punishment conditioned stimuli in combination with transformational delivery and psychological coping. Finally, I designed a study that might have identified the cognitions and behaviours which separate those that are cognitively perfect from those that are insensitive to pressure. Unfortunately, none of these studies appear in my thesis and this is almost entirely because I found it difficult to manage the expectations of my external sponsors, myself, and my supervisors, and as a result I never effectively balanced my time between research commitments

and applied work. The agreement between the ECB and Bangor University was an 80:20 split of my time, with 1 day of applied work for every 4 days of research activity. In reality, I only achieved this balance in the first year of my PhD, partly because I thoroughly enjoyed all aspects of the applied work I was involved in, and partly because I found it difficult to say no! On reflection, if I had been better at managing the expectations of the ECB I think I would have at least one more study to show for my work.

The other aspect of my research which I found difficult was gaining a thorough appreciation of Reinforcement Sensitivity Theory. Four years after I first read about the BIS and the BAS in the context of defensive behaviour (Perkins & Corr, 2006), I still don't understand the full extent of the theory, nor how it applies to performance contexts. My thinking about the relationships between reinforcement sensitivities and mental toughness has changed numerous times, sometimes based on empirical data, sometimes based on further reading. In hindsight, I could have dedicated more time prior to data collection, reading up on the theory, especially the revisions to the theory (Gray & McNaughton, 2000) and the implications that would have for my own research. This would almost certainly have given me a better grasp of the cognitive neuroscience which underpins the theory, of which I am still not completely familiar. In reality, it was an enormous challenge to apply RST to performance environments, when the specific predictions of the revised theory remain unclear, even to those who understand it best. Perhaps there were less complex research questions that I could have pursued which would have produced a 'tidier' thesis with fewer unresolved questions. Having said that, the theoretical uncertainty is something I have come to enjoy (courtesy of my supervisors) and after four years I am far more comfortable with the 'discomfort' that comes from not 'knowing' the answer and realising I probably never will!

The final aspect of the PhD which I found challenging was the pace at which the research was conducted. This is most likely an outcome of poor time management (point 1) and limited understanding of RST (point 2). However, I find this the most frustrating aspect of the research process in general because the vast majority of the research questions in my future directions section were written over two years ago and it is irritating that they remain unanswered two years later. The fact that I didn't collect any new data after December 2010 (18 months ago) is even more frustrating. There are plenty of suggested actions which might have alleviated some of that frustration which I will come to in the next section. For the time being I think it is worth acknowledging the frustration and being wary of the potential for it to occur in future projects of this type (e.g., applied research projects).

What could I have done to learn more?

There are numerous actions I could have taken which might have improved the quality of the thesis and increased the probability of conducting a final study to complete the PhD. They are listed as follows:

- (i) Committed to fMRI training in my 2nd year of study regardless of the sacrifices it required. My knowledge and understanding of cognitive neuroscience would have improved as a result and I would be better placed to conduct innovative future research if I had continued this training.
- (ii) Planned ahead of my main multi-study paper and identified opportunities to collect additional data (outside of a cricket context) that would have complemented the research I was conducting in the field. I identified a number of small, relatively simple studies in my 2nd year that could have been included within my thesis if I had chosen to pursue them. The studies were suitable for student populations (as opposed to elite athletes) and

may have improved my understanding of mental toughness and enhanced my research profile.

- (iii) Linked to the recommendation above I only started collaborating with other members of staff (outside of my supervisors) and PhD students in the final year of my PhD. I could have prioritised this process earlier in my PhD and it may well have improved my knowledge and understanding as a researcher if I had.
- (iv) Explored the links between psychopathy and performance under pressure earlier in my PhD and pursued a research question on this topic as part of my thesis. It is interesting that psychopathy has been a consistent theme within my PhD since the first year of my studies, yet it remains peripheral and is never addressed empirically within my thesis. In hindsight, I should have prioritised this line of thinking at some stage because it remains the aspect of my PhD that I am most interested in.
- (v) Focused my reading on RST at an earlier stage of my PhD so I had a genuine grasp of the theory and its applications from the beginning of data collection. Most PhD students report that they could and should have read more during their registration period and this obviously applies to me as much as anyone else. However, even in my final year I seemed to learn something new about RST every time I spent time reading about it. I could have recognised the complexity of the theory at an earlier stage and this may have helped me clarify my thinking and the direction of the research before my data muddied my thinking further.

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