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A Neuropsychological Model of Mentally Tough Behavior

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Abstract

Four studies were conducted with two primary objectives: (a) to conceptualize and measure mental toughness from a behavioral perspective and (b) to apply relevant personality theory to the examination of between-person differences in mentally tough behavior. Studies 1 ($N = 305$ participants from a range of different sports) and 2 ($N = 110$ high-level cricketers) focused on the development of an informant-rated mental toughness questionnaire that assessed individual differences in ability to maintain or enhance performance under pressure from a wide range of stressors. Studies 3 ($N = 214$) and 4 ($N = 196$) examined the relationship between reinforcement sensitivities and mentally tough behavior in high-level cricketers. The highest levels of mental toughness reported by coaches occurred when cricketers were sensitive to punishment and insensitive to reward. Study 4 suggested that such players are predisposed to identify threatening stimuli early, which gives them the best possible opportunity to prepare an effective response to the pressurized environments they encounter. The findings show that high-level cricketers who are punishment sensitive, but not reward sensitive, detect threat early and can maintain goal-directed behavior under pressure from a range of different stressors.

Mental toughness is a term that has been used to describe the ability of some people to continue to strive toward and achieve their goals in psychological circumstances where others "fall by the wayside" and fail. It has relevance to a wide range of contexts, including business, military action, the performing arts, rehabilitation from major surgery, death from terminal illness, and high-level sport (Jones, 2004). Nevertheless, despite a considerable volume of research into mental toughness, there is still much debate regarding its conceptualization and measurement (see, e.g., Anderson, 2010; Clough & Strycharczyk, 2012; Gucciardi & Gordon, 2011). Detailed discussion of this issue is beyond the scope of the present article. However, the vast majority of researchers seem to agree that mental toughness is a (dispositional) construct that allows individuals to deal with obstacles, distractions, pressure, and adversity from a wide range of stressors (cf. Clough & Strycharczyk, 2012; Gucciardi & Gordon, 2011; Jones, Hanton, & Connaughton, 2002).

Most conceptualizations of mental toughness are multidimensional in nature and focus on some collection of values, attitudes, emotions, and cognitions that are hypothesized to enable people to behave in such a way as to achieve their goals in the face of obstacles. For Jones et al. (2002), these characteristics are determination, focus, confidence, and perceived control. For Gucciardi, Gordon, and Dimmock (2009), they are thriving through challenge, sport awareness, tough attitude, and desire for success. For Clough and colleagues (see Clough & Strycharczyk, 2012), they are challenge appraisals, perceived control, commitment, and confidence. Clearly, there are both similarities and differences between these conceptualizations. Equally clearly, there are also similarities between these conceptualizations and those of other constructs, such as hardiness and coping with adversity. However, the nuances and subtleties of such similarities and differences are not the focus of the present research either; they are discussed elsewhere in some detail by Clough and Strycharczyk (2012) and Gucciardi and Gordon (2011). Consequently, they will not be addressed here.

Much of the extant literature on mental toughness has focused on demonstrating that high achievers have high levels of mental toughness as defined by some set of psychological characteristics like the ones identified above. This literature has generally used one of two methodologies. A number of studies have used the interview-based qualitative method that was originally employed in Jones and colleagues' (2002) seminal article on the subject. At the exploratory stage of any research program, or when complex effects need to be untangled, such qualitative approaches are, of course, frequently the method of choice. However, a number of researchers (see, e.g., Anderson, 2010) have argued that, in the context of mental toughness, these methods have been "overused" and it is time for other (more robust) methods to be brought to bear on the subject. In particular, interview-based qualitative

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methods do not allow researchers to differentiate between the causes of mental toughness, the process of being mentally tough, the outcomes of mental toughness, and other correlates associated with mental toughness, a problem that the current authors believe is inextricably linked to most conceptualizations of mental toughness.

Other researchers have used self-report measures of the psychological characteristics conceptualized to underpin mental toughness to discriminate between populations that they assume will differ in mental toughness. However, in this research, independent assessments of mentally tough behavior (i.e., actual goal achievement in the face of pressure or adversity) are rare, or possibly even nonexistent. As an example, Gucciardi et al. (2009) showed that their four components of self-assessed mental toughness (thriving through challenge, sport awareness, tough attitude, and desire for success) discriminated between groups of Australian footballers that differed in age, experience, and playing level. Of course, such groups may well differ in their ability to achieve goals in the face of pressure or adversity, but it seems unreasonable to expect that this would be the only variable on which they differed or, indeed, that they did differ on this variable without some behavioral evidence to substantiate that assumption. However, when Gucciardi and colleagues attempted to corroborate their participants' self-assessments of thriving through challenge, sport awareness, tough attitude, and desire for success, using parent and coach assessments of these variables, the correlations were almost universally very weak. We single out this study not as an example of poor research in the area. Indeed, it is probably one of the better studies; at least the authors attempted to corroborate their self-report ratings independently. Many other studies may be even more fundamentally flawed; for example, a recent confirmatory factor analysis by Gucciardi, Hanton, and Mallett (2012) has called into question all studies that have used Clough, Earle, and Sewell's (2002) Mental Toughness Questionnaire (MTQ 48) on the grounds that it lacks factorial integrity. However, our primary objective was not to critique the previous mental toughness research, but rather to point out that it leaves some fairly fundamental issues still to be resolved.

The real point of the present article was to take a rather different approach to the conceptualization and measurement of mental toughness. Our starting point was twofold. First, mentally tough behavior is just that, a behavior. Consequently, for the purposes of the present article, we will define mental toughness as *the ability to achieve personal goals in the face of pressure from a wide range of different stressors.* Many psychological variables may influence mental toughness, or be correlates of it, but our contention is that, fundamentally, we need to evaluate whether mentally tough behavior has occurred before we make any claims about the importance of different cognitions, attitudes, and emotions. Consequently, assessing mentally tough behavior via self-report would clearly not be the procedure of choice because of the obvious confound that would exist with social desirability and self-presentation. Similarly, objective indicators of achievement were also not the measure of choice for assessing mental toughness because they are confounded by talent, practice, skill level, and no doubt a host of other psychosocial and physiological variables associated with high achievement. For these reasons, the initial purpose of the current program (Studies 1 and 2) was to construct a measure to be completed by an informant (e.g., a coach) that could be used to assess mentally tough behavior in high-level sports performers, as opposed to the cognitions, attitudes, and affect associated with such mental toughness. High-level 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, Jones, & Gould, 1996), the present set of studies focused on a subset of those stressors that were especially relevant to competitive performance because these have been reported to be particularly salient to high-level athletes (Gould, Dieffenbach, & Moffett, 2002; Woodman & Hardy, 2001).

Second, implicit in our conceptualization of mental toughness is the notion that mental toughness is a relatively stable disposition that is unlikely to change quickly over time. There is nothing new about this. Most mental toughness researchers seem to make this assumption. However, one of the ways in which the current program of research is different from previous research is that, rather than focus upon the psychological skills, attitudes, emotions, and other cognitions that may underpin mental toughness, we examined the extent to which mental toughness could be predicted from existing personality theory. Of particular interest was Gray and McNaughton's (2000) revised Reinforcement Sensitivity Theory (rRST), derived from neuropsychological research, which has a number of advantages over other personality theories with regard to mental toughness. This theory, and its neuropsychological basis, will be discussed in more detail prior to Study 3.

STUDY 1

Method

Participants. Two hundred forty-six 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 active members of university and/or local sports teams from athletics (*n* = 18), hockey (*n* = 87), netball (*n* = 26), rugby union (*n* = 64), rugby league (*n* = 30), and soccer (*n* = 51).

Fifty-nine different UK university sports science students (35 male and 24 female) from the UK, aged between 20 and 26 (M_{age} = 20.8, *SD* = 1.28), were recruited for the second stage of data collection. All the participants were active members of university sports teams from hockey ($n = 14$), netball ($n = 17$), rugby ($n = 12$), and soccer ($n = 16$).

Measures. Mental toughness was assessed using an informant-rated scale designed for this study. The measure was based on the definition of mental toughness proposed in the introduction. Items focused on the pressures and stressors that performers typically face in competition (Woodman & Hardy, 2001). They were generated by the authors (all experienced sport psychology researcher-practitioners) in conjunction with five experienced high-performance coaches. Item formulation and content were discussed until unanimous agreement was reached on 15 items that were retained for subsequent use in the inventory (see Table 1). Participants were asked to identify a specific performer whom they knew well and rate how well that performer was able to maintain a high level of personal performance in the different pressurized situations identified by the items. Responses were based on a 7-point Likert scale that ranged from 1 (*rarely*) to 7 (*regularly*), with a midpoint anchor of 4 (*sometimes*). Standard antisocial 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 obtaining university ethical approval, students were initially approached prior to or following lectures to inform them of the nature of the study and obtain their informed consent. For Stage 1, participants were asked to complete the Mental Toughness Inventory (MTI) on the teammate or athlete whom they had performed alongside for the longest time. Participants were informed that the completed inventories would remain confidential and would not be shared with any third parties (e.g., coaches or teammates). The procedure for Stage 2 was identical to that used for Stage 1, except participants completed the MTI twice, three weeks apart, with regard to the same performer in order to assess the test-retest reliability of the inventory.

Results

In line with recommendations from Jöreskog and Sorbom (2003), confirmatory factor analysis (CFA) was used in an exploratory fashion to examine the factor structure of the Mental Toughness Inventory. Based on recommendations from Hu and Bentler (1999), 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 error of approximation (RMSEA) approached .05, and the standardized root mean square residual (SRMR) was less than 0.8. Prelis 2.14 was used to generate a covariance matrix, and Lisrel 8.5 was used to test the single-factor model. The initial 15-item model was normally distributed, but the fit statistics 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, and the theoretical content of each item. Seven items were removed, and the resulting eight-item model was normally distributed and demonstrated good fit statistics, $\chi^2(20) = 33.82$, CFI = .98, RMSEA = .06, SRMR = .04. The standardized factor loadings of the remaining eight items were all above 0.5. Cronbach's alpha for the MTI was .87. The mean score for informants' ratings of their peers on the MTI was 4.18 ($SD = 1.06$).

Table 1 Studies 1–2: Items From the Mental Toughness Inventory

Player X is able to maintain a high level of personal performance in competitive matches:	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 teammates 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)

Note. *Items retained in the eight-item model used in Studies 2, 3, and 4.
R = Items removed from the eight-item model used in Studies 2, 3, and 4.

The mean score for the test data at Stage 2 was 5.26 ($SD = 0.91$), and the mean score for the retest data was 5.21 ($SD = 0.86$). A paired sample *t* test indicated that these means were not significantly different, $t(58) = 1.60$, $p > .05$. The test-retest reliability for the MTI was 0.96.

Discussion

Although Study 1 demonstrated a good fit for the eight-item MTI, some readers might argue that university-level athletes are not of a high enough standard to experience the high levels of pressure necessary to demonstrate mental toughness. However, the authors would prefer to argue that many university sports clubs in the UK play in semiprofessional leagues so that such participants are of an adequate standard for preliminary scale development. In any case, the aim of Study 2 was to confirm the factor structure of the MTI on a separate sample of professional cricketers assessed by their coaches.

STUDY 2

Method

Participants. The participants for the second study were 110 male cricket coaches from the UK aged between 25 and 63 ($M_{age} = 41.86$, $SD = 9.92$). Cricket is a national sport in the UK with some similarities to baseball in that it requires players to make decisions and perform complex, interceptive motor actions under considerable time and competition pressure. All participants were fully qualified coaches with an average of 8.64 years of coaching experience ($SD = 6.38$). The large majority of the coaches recruited ($n = 91$) were employed by one of the 18 first-class counties where cricket is played professionally in the UK. The remaining 19 coaches were affiliated with one of the counties in a part-time capacity. The coaches were asked to complete the MTI for one of the county (professional) 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 MTI, together with the relevant consent forms, and asked to identify the player they had observed most in recent competition. As a guideline, coaches were expected to have coached the player for at least one year and observed at least 10 competitive performances. All the coaches who agreed to participate returned the Mental Toughness Inventory and the consent forms within one week.

Results

CFA of the eight-item model revealed a very good fit, $\chi^2(20) = 25.28$, CFI = .98, RMSEA = .05, SRMR = .04. The standardized factor loadings exceeded 0.4 for all items in the model. Cronbach's alpha was .89. The mean score for the coaches' ratings of their players was 4.76 ($SD = 0.95$). The reader may recall that the mean score for the 246 university athletes rated in Stage 1 of Study 1 was 4.18 ($SD = 1.06$), which an independent-samples *t* test indicated was significantly lower than the coaches' ratings of their professional cricketers , $t(354) = 2.74$, $p < .01$.

Discussion

Study 2 confirmed the structural validity of the eight-item MTI in a sample of professional cricket coaches. The MTI also discriminated between professional cricketers and university-level athletes in terms of mental toughness.

STUDY 3

The primary aim of Study 3 was to examine the extent to which relevant personality theory could predict mentally tough behavior as measured by the MTI. One theory that offered considerable potential to explain individual differences in mental toughness was Gray and McNaughton's (2000) rRST. In its original format, reinforcement sensitivity theory proposed that Eysenck's (1967) extraversion-introversion and neuroticism-stability dimensions should be rotated by approximately 30° to form more causally efficient axes that were biologically aligned to neural networks underpinning reward sensitivity (RS) and punishment sensitivity (PS). According to rRST, reward sensitivity is underpinned by a neurological network known as the behavioral 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 is proposed to be responsible for all goal-focused approach behavior.

In the rRST, 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, and amygdala. The FFFS also involves the anterior cingulate and prefrontal ventral stream, whereas the BIS involves the septo-hippocampal system, posterior cingulate, and prefrontal dorsal stream (Gray & McNaughton, 2000). According to the theory, the FFFS is responsible for mediating all responses to aversive stimuli (unconditioned, conditioned, and innate) that result in active avoidance behavior, that is, when a person's chief concern is to remove him- or herself from the situation. The BIS is engaged during approach toward aversive stimuli and is responsible for resolving goal conflict between the BAS and the FFFS. Such approach-avoidance conflict elicits a series of behavioral responses associated with anxiety, including the inhibition of all pre-potent behavior, an increase in physiological arousal, and the scanning of long-term memory for information that might be relevant to resolving the conflict.

The evidence in support of rRST is impressive (for reviews, see Corr, 2008; Gray & McNaughton, 2000), and one of its major strengths in the context of mental toughness is that, potentially, it offers a neuropsychological explanation of the maintenance of goal-focused behavior in the face of stressful stimuli. Furthermore, research examining the basic tenets of rRST has yielded a number of findings that are highly pertinent to mental toughness. For example, reward sensitivity has 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 has been associated with negative evaluations of the capacity to deal with pain (Muris et al., 2007), orientation away from threatening situations (Perkins & Corr, 2006), and poor performance in military combat tasks (Perkins et al., 2007).

This research suggests that reward sensitivity is related to various cognitions and behaviors that one might associate with mental toughness, whereas punishment sensitivity is related to cognitions and behaviors that appear to imply a lack of mental toughness. However, it is important to note that reward and punishment sensitivity are supposed to be orthogonal to each other (Gray & McNaughton, 2000), and most previous research has examined only their separate main effects, rather than interactions between the two systems. Corr (2001) has proposed that interactive effects are most likely to occur in environments containing a mixture of strong appetitive and aversive stimuli, which is, of course, exactly the sort of environment one might want to examine for evidence of mentally tough behavior. Based on this thinking, the purpose of Study 3 was to examine the main *and* interactive effects of reward and punishment sensitivity on mental toughness in high-level cricketers. It was hypothesized that the highest levels of mental toughness would be associated with high levels of reward sensitivity and low levels of punishment sensitivity. Furthermore, if there was an interaction between punishment and reward sensitivity, then high levels of reward sensitivity would offset any negative effects associated with punishment sensitivity.

Method

Participants. Two hundred fourteen 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. All participants were currently involved in or had recently graduated from one of the 18 first-class county academies. Each academy can select a maximum of 12 precociously talented players between the ages of 15 and 18 per year. Each of the 214 cricketers recruited for this study were rated on the MTI by their county coach. In total, 30 coaches (M_{age} = 38.94, *SD* = 8.21 years) completed the MTI, with each coach rating 2 to 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 (α = 0.77–0.88), show good comparability (*r* = 0.71–0.96) to longer versions of the Eysenckian personality measures (Francis, Philipchalk, & Brown, 1991), and have been used before on similar-aged adolescent males (Eysenck et al., 1985). Each item is framed as a forced-choice question that has to be answered yes or no. In order to use the EPQR-S to measure reward and punishment sensitivity, Corr (2001) proposed the following transformations: reward sensitivity = (E x 2) + N + P), and punishment sensitivity = (12 – E) + (N x 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 had granted permission, an information letter and consent form were distributed to academy-affiliated players and the parents/guardians of affiliated players who were under 18 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-related affect interfering with the players' responses. Affiliated players were given the EPQR-S along with standardized instructions about completion. They were instructed that the data provided would be held in confidence and not shared with any third party (e.g., their coach). While the affiliated players completed the EPQR-S, the players' coach was provided with the MTI for all those players involved in the study along with standardized instructions about completion. Due to time constraints, there were occasions when the coach was unable to complete all the MTIs on the same day that the players provided their data. When this occurred, the coach 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). Because of the multilevel nature of the data, an a priori decision was made to use multilevel analysis. Multilevel 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 Rasbash et al. (2009), all of the variables in the analysis were group mean–centered prior to analysis.

In a single-level regression model, both the intercept and slope are fixed for all observations. However, in a multilevel model, the intercept is allowed to vary across Level 2 variables (e.g., coaches). The multilevel 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 significantly improves the model, whereas a nonsignificant 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 displayed the results for the predictor variable (punishment sensitivity), Model 2 displayed the results for the predictor variable and the moderator variable (reward sensitivity), and Model 3 displayed the results for the predictor variable, the 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. 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. Alpha coefficients for EPQR-S variables ranged from 0.78 to 0.85. The alpha coefficient for the MTI was .84. 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 the present data set, the interclass correlation for mental toughness was .055, suggesting that 5.5% of the variance in mental toughness was at the between-coach level and 94.5% of the variance in mental toughness was at the within-coach level. When the slopes were allowed to vary in Model 1 and Model 2, a nonsignificant 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, since while there is reason to believe that the mental toughness levels of players may vary across coaches, there is no reason to believe that the relationship between reinforcement sensitivities and mental toughness should vary across coaches. Consequently, the Level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. Model 3 revealed 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 × Reward

Table 2 Studies 3–4: Means, Standard Deviations, and Intercorrelations Among Variables

	Mean (*SD*)	1	2	3	4	5
Study 3						
1 Punishment sensitivity	9.24 (7.43)					
2 Reward sensitivity	24.36 (5.59)	–.206**				
3 Mental toughness	4.40 (0.98)	–.035	–.494**			
Study 4						
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

Note. ***p* < .01. **p* < .05.

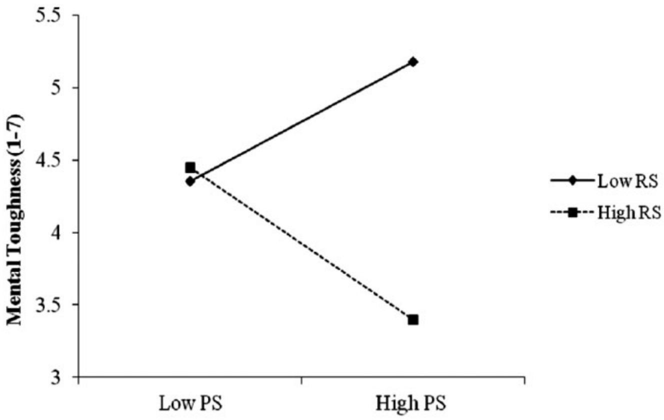

Figure 1 Study 3: Interaction between punishment sensitivity and reward sensitivity predicting mental toughness.

Sensitivity interaction term was significant, $\beta_3 = -.470$, $SE = .062$, $p < .01$. Figure 1 shows that when reward sensitivity was low, mental toughness increased as punishment sensitivity increased. However, the opposite relationship exists when reward sensitivity was high, whereby mental toughness decreased as punishment sensitivity increased. 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, $t(211) = -6.27$, $p < .01$.

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 hypothesis, 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.

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 (see, e.g., Fenz, 1973) 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. This assumption appears reasonable given that the participants had been involved in highly competitive national-level sport for approximately four to five years. Without effective coping strategies, it seems likely that players (especially punishment-sensitive players) would either have withdrawn from competitive cricket voluntarily or have been deselected 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 being unaware that threats exists, which is what may happen when players are insensitive to punishment cues. Further support for this line of reasoning comes from recent research by van Wingen, Geuze, Vermetten, and Fernandez (2011), who found enhanced amygdala sensitivity in *trained* military personnel returning from deployment on combat duty. As well as being part of the BIS and FFFS, the amygdala is integrally involved in threat detection.

Of course, these findings are not at first sight consistent with Perkins and colleagues' (2007) finding that punishment sensitivity was negatively related, and reward sensitivity was positively related, to performance in a military combat scenario. However, it is important to note that Perkins and colleagues' participants were military recruits undergoing *initial training*, not high-level performers with well-rehearsed coping skills. Furthermore, earlier research by Perkins and Corr (2005) found a positive relationship between worry (one aspect of punishment sensitivity) and workplace performance in high-ability workers, but not in lower-ability workers. To understand why the relationship between punishment sensitivity and mental toughness is negative when reward sensitivity is high, it is helpful to revisit rRST. According to the theory, the BIS is only activated by approach-avoidance conflict. Such conflict is most likely to occur when an individual is sensitive to both punishment and reward. Kambouropoulos and Staiger (2004) confirmed this line of thinking when they found that individuals scoring high on EPQ-derived punishment sensitivity *and* reward sensitivity demonstrated slower response times, indicative of behavioral inhibition, in a letter identification task. In a cricket context, one might imagine a batsman who at one level is motivated by the prospect of winning the match for his team (i.e., reward) and at another level is worried about avoiding being dismissed easily and letting his team down (i.e., punishment). The conflict engendered is likely to lead to high levels of behavioral inhibition, which might manifest itself as a lack of composure and decisiveness in shot selection.

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. Consequently, the aims of Study 4 were to (a) replicate the findings of Study 3; (b) examine the relationship between reinforcement sensitivities and threat detection—it was hypothesized that threat detection would occur earlier as punishment sensitivity increased; and (c) examine the relationship between punishment and reward sensitivity and context-specific behavioral inhibition—it was hypothesized that higher levels of behavioral inhibition would be found in cricketers who were high in both punishment and reward sensitivity compared to cricketers who were low in either or both reward and punishment sensitivity.

STUDY 4

Method

Participants. One hundred ninety-six different 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 10 players. Each of the 196 cricketers recruited for this study were rated on the MTI by their county coach. In total, 45 coaches ($M_{age} = 41.28$, $SD = 7.90$ years) completed the MTI; each coach rated 2 to 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 eight cricket-specific scenarios that previous research (for a review, see Woodman & Hardy, 2001) has shown to be potentially threatening. An example is "Your County's 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 to 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 that was used as the dependent variable in all further analyses. Copies of the questionnaire can be obtained from the first author.

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 six cricket-specific scenarios depicting fielding situations on a 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 other 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 would be if they were to find themselves in that situation. Behavioral inhibition was measured as the processing time it took to make the decision. Fielding scenarios were chosen because every player has to field in cricket, whereas batting and bowling tasks are usually carried out by specialists. One example of the type of options used in the decision-making task was "A: Let the ball bounce, B: Go for the catch."

Procedure. After obtaining 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 18 years of age. The National Cricket Talent Test occurred over 5 days 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) in small groups in a classroom-type environment. All participants were given standardized verbal instructions regarding the completion of the questionnaires, including standard antisocial-desirability instructions that encouraged them to respond honestly at all times. Participants were also informed that data would be treated confidentially and not used for talent selection purposes.

Data related to behavioral inhibition were collected on the same day as the questionnaire data. Participants were divided randomly into groups of five to complete the decision-making task. Personal computers (PCs) 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 screen. Participants were instructed to place their left and right index fingers 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 NCTT for the players they had nominated for testing. Coaches were asked to complete the MTI based on observations from the just completed 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 modeling procedures were used as in Study 3.

Table 3 Studies 3–4: Multilevel Analyses: Effects of Reinforcement Sensitivities on Mental Toughness

	Model 1		Model 2		Model 3	
Mental Toughness	β	*SE*	β	*SE*	β	*SE*
Study 3						
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 × RS, β_3					–.470**	.062
Study 4						
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 × RS, β_3					–.217*	.085

Note. PS = punishment sensitivity; RS = reward sensitivity.
**$p < .01$. *$p < .05$.

Results

Mental Toughness. Descriptive statistics and correlations for all study variables are displayed in Table 2. In this data set, the interclass correlation for mental toughness was .110, suggesting that 11.0% of the variance in mental toughness was at the between-coach level and 89.0% was at the within-coach level. When the slopes were allowed to vary, a nonsignificant 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 again treated as fixed factors. When punishment sensitivity, reward sensitivity, and the interaction term (PS × RS) were added as Level 1 predictors, the results were similar to Study 3 (see Table 3 for details). The main effect of punishment sensitivity on mental toughness was not significant, $\beta_1 = –.027$, $SE = .059$, $p \geq .05$. 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 × RS) was again 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.

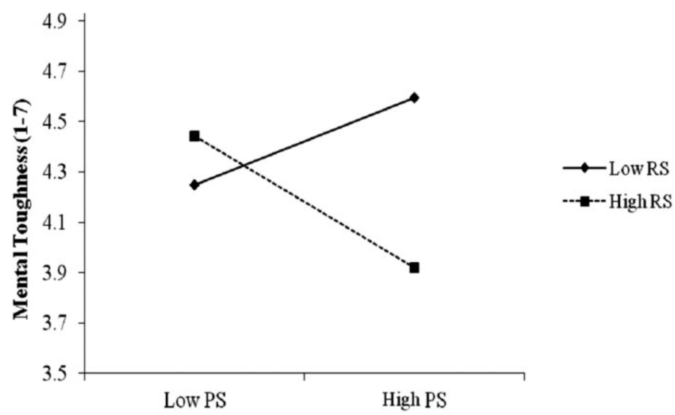

Figure 2 Study 4: Interaction between punishment sensitivity and reward sensitivity predicting mental toughness.

Threat Detection. The second model explored the relationship between reinforcement sensitivities and threat detection. 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% was at the within-coach level. When the slopes were allowed to vary, a nonsignificant 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 × RS) were added as Level 1 predictors, the results were as hypothesized (see Table 4 for details). The main effect of punishment sensitivity on threat detection was significant, $\beta_1 = .560$, $SE = .244$, $p < .05$, 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, $\beta_2 = .135$, $SE = .241$, $p > .05$, and having controlled for both punishment and reward sentitivity, the PS × RS interaction term was also nonsignificant, $\beta_3 = .139$, $SE = .292$, $p > .05$.

Behavioral Inhibition. The interclass correlation for behavioral inhibition was 0.0138, suggesting that 1.38% of the variance was at the between-athlete level and 98.62% of the variance was at the within-athlete level. When the slopes were allowed to vary, a nonsignificant χ^2 statistic was found, so the Level 2 slopes for punishment sensitivity and reward sensitivity were treated as fixed factors. When punishment sensitivity, reward sensitivity, and the cross-product term (PS × RS) were

Table 4 Study 4: Effects of Reinforcement Sensitivities on Threat Detection, Processing Time, and Decision-Making Errors

	Model 1		Model 2		Model 3	
Threat Detection	β	*SE*	β	*SE*	β	*SE*
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	.247
PS × 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 × 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 × RS, β_3					.401**	.097

Note. PS = punishment sensitivity; RS = reward sensitivity.
**$p < .01$. *$p < .05$.

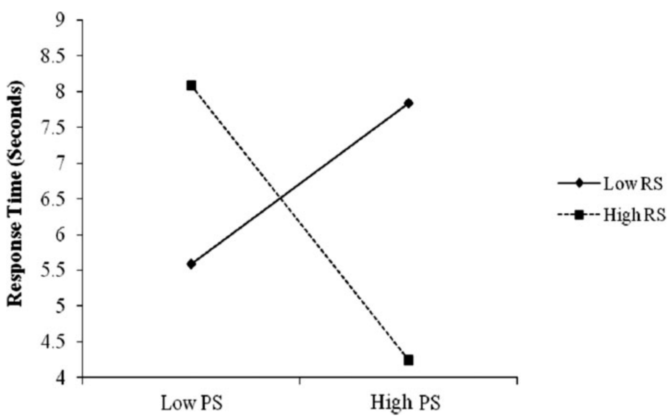

Figure 3 Study 4: Interaction between punishment sensitivity and reward sensitivity predicting processing time.

added as Level 1 predictors, the results were not as hypothesized (see Table 4 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, $\beta_2 = –444.01$, $SE = 346.9$, $p > .05$. Having controlled for main effects, the interaction term (PS × RS) was significant, $\beta_3 = –1520.2$, $SE = 455.8$, $p < .01$. However, the Preacher et al. (2006) software revealed that the simple slope for low reward sensitivity was significant and positive, $t(193) = 1.98$, $p < .05$, whereas the simple slope for high reward sensitivity was significant and negative, $t(193) = –3.57$, $p < .01$. Thus, the nature of the interaction suggested that processing time increased as punishment sensitivity increased when reward sensitivity was low and decreased as punishment sensitivity increased when reward sensitivity was high. Thus, processing time for decisions was *shortest* when both punishment sensitivity and reward sensitivity were high. This interaction (see Figure 3) was very different from the original hypothesis, which proposed that the greatest levels of behavioral inhibition (*longest* processing times) would occur when punishment sensitivity and reward sensitivity were both high.

In order to further examine this counterintuitive finding for processing time, the authors examined decision-making errors. It was thought that the high level of conflict engendered by high punishment sensitivity and high reward sensitivity might have led to panicky decision making, resulting in shorter processing times but poorer decisions. In order to examine this hypothesis, the authors asked four highly 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 (two conservative decisions and two risky decisions). In the remaining two scenarios, the coaches were unable to come to a consensus regarding the best decision, so these two scenarios were removed from further analysis.

In the remaining four-scenario data set, the interclass correlation for behavioral inhibition was 0.0142, suggesting that 1.42% of the variance was at the between-coach level and 98.58% of the variance was at the within-coach level. When the slopes were allowed to vary, a nonsignificant χ^2 statistic was found, so the Level 2 slopes for punishment sensitivity and reward sensitivity were again treated as fixed factors. When reward sensitivity, punishment sensitivity, and the PS × RS interaction term were added as Level 1 predictors, the results were as hypothesized. Punishment sensitivity accounted for significant variance in decision-making errors, $\beta_1 = .185$, $SE = .070$, $p < .01$. Reward sensitivity accounted for significant variance in decision-making errors over and above punishment sensitivity, $\beta_2 = .221$, $SE = .075$, $p < .01$. Finally, the

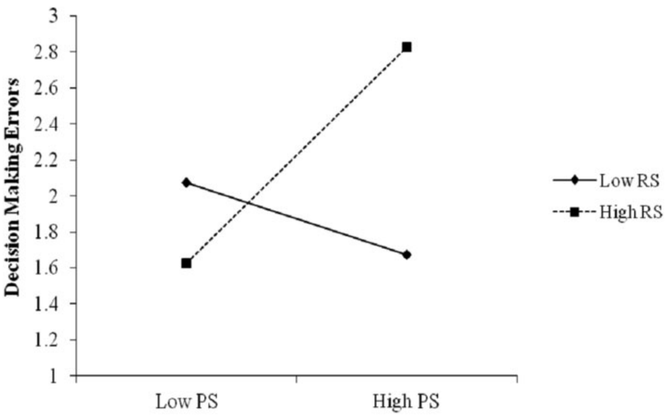

Figure 4 Study 4: Interaction between punishment sensitivity and reward sensitivity predicting decision-making rrrors.

PS × RS interaction term significantly predicted variance in decision-making errors over and above the main effects, $\beta_3 = .401$, $SE = .097$, $p < .01$ (see Table 4 for details). 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 nonsignificant and negative, $t(193) = -1.75$, $p = .08$. This interaction is depicted in Figure 4.

Discussion

The results confirmed 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 counterintuitive relationships. As predicted, punishment sensitivity was positively related to early threat detection. Furthermore, the combination of high punishment sensitivity with high reward sensitivity was associated with shorter processing times during decision making, but significantly more decision-making errors. The most parsimonious explanation for these findings seems to be that high levels of punishment sensitivity coupled with high levels of reward sensitivity result in some sort of conflict that causes a speed-accuracy trade-off, which results in poor decision making.

GENERAL DISCUSSION

The purpose of the present series of studies was to (a) develop a measure of mentally tough behavior and (b) examine the ability of rRST to predict between-person differences in mental toughness. Studies 1 and 2 were concerned with the development of a valid, informant-rated questionnaire to measure mental toughness from a behavioral perspective. The results of the confirmatory factor analyses from Studies 1 and 2 found good support for the structural integrity of the eight-item MTI. Furthermore, the eight scenarios described in the items of the MTI have all been shown to be stressful to performers in previous research (see, e.g., Woodman & Hardy, 2001), thereby offering some evidence of its content validity.

With regard to the application of relevant personality theory, the results of Studies 3 and 4 suggested that the relationship between rRST and mental toughness is a somewhat complex one. In particular, the most interesting finding of the present research was that cricketers rated as mentally tough by their coaches tended to be sensitive to punishment cues but insensitive to reward cues. Although counterintuitive at first sight, this finding was replicated in a separate sample of highly talented young cricketers. 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 predisposed to pick up threat early, and this provides them with the time to plan effective responses to pressurized situations. Although the finding of performance benefits associated with trait anxious (high punishment sensitive, low reward sensitive) performers may seem implausible to some readers, it is not unprecedented and a number of researchers have demonstrated such effects, especially in experienced and/or high-achieving performers (for a review, see Woodman & Hardy, 2001). While not wishing to suggest that anxiety is simply the polar opposite of confidence, the present findings with regard to punishment sensitivity and early threat detection do present something of a challenge for cognition-based approaches to mental toughness that promote the importance of self-confidence as a central component of mental toughness (e.g., Clough & Strycharczyk, 2012).

One surprising result from Study 4 was the shorter processing times (admittedly coupled with larger numbers of errors) associated with the combination of high punishment sensitivity and reward sensitivity. Previous RST research (e.g., Kambouropoulos & Staiger, 2004) has found that the greatest levels of behavioral inhibition occur for individuals who report high scores on EPQ-derived punishment sensitivity *and* reward sensitivity. However, the letter identification task used in Kambouropoulos 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. 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 the present study and slow response times in Kambouropoulos and Staiger's study. 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. Kambouropoulos 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 authors posit that the poor performance under pressure occurred because of poor decision making under pressure due to reinforcement conflict.

One important distinction between the paradigm used by the present research and that used by most previous mental toughness research is that we have attempted to identify the reinforcement sensitivity (neurocognitive) profiles of mentally tough cricketers, and then the cognitive processes that such cricketers engage in, not the cognitions, attitudes, and affect associated with mental toughness. If these three approaches of identifying the reinforcement sensitivity profiles, cognitions, attitudes, and affect and the cognitive processes underpinning mentally tough behavior were integrated, then they could yield insightful implications for talent identification and development programs with regard to mental toughness.

Another novel aspect of the current research is its focus on the interactive relationship between punishment and reward sensitivity. Traditionally, rRST research has examined only 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. An examination of the interactive relationship at play is warranted because recently theorists have argued that the effect of a stimulus on behavior 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. This is especially pertinent to the present studies because the dependent variable of interest was essentially performance under pressure, and pressurized environments almost always contain mixed appetitive and aversive stimuli.

While the findings of the present research are suggestive of some neurocognitive 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 psychophysiological and behavioral markers. One interesting future direction for research would be to use such functional magnetic resonance imaging (fMRI) techniques to examine the neural networks involved in mental toughness. Such research would be of interest to both mental toughness researchers and RST and other personality researchers.

LIMITATIONS

A number of limitations are evident in the present research. First, punishment and reward sensitivity were measured indirectly 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. Nevertheless, the finding that punishment sensitivity is associated with mental toughness as assessed by the coaches of high-level cricketers was replicated and remains interesting.

Second, our measure of mental toughness was very narrowly conceptualized as the ability to perform well in the face of pressure from a wide range of different stressors, and no objective measures of performance were used. Having said that, our informant-rated measure of mental toughness was well validated and does at least avoid the single-source data problem that has plagued the existing mental toughness literature. Furthermore, the authors would argue that most objective measures of performance are confounded by ability, so that the development of objective measures of mental toughness is not an easy problem to resolve.

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 obtained significant results in the hypothesized directions using such crude measures is heartening.

CONCLUSION

In summary, the present program of research developed a novel measure of mentally tough behavior and presented replicable evidence that, in high-level cricketers, mentally tough behavior is associated with high punishment sensitivity and low reward sensitivity. The most parsimonious explanation for the pattern of results obtained is that high punishment sensitive, low reward sensitive cricketers are predisposed to identify threat early, which gives them the best possible opportunity to plan an effective response to the pressurized environments they encounter. At another level, the present research program points to the possibility of integrating neurocognitive approaches with the more social cognitive approaches that have previously been used to study mental toughness.

References

Anderson, M. B. (2010). Who's mental, who's tough, and who's both? Mutton constructs dressed up as lamb. In D. F. Gucciardi & S. Gordon (Eds.), *Mental toughness in sport developments in theory and research* (pp. 50–80). Oxford: Routledge.

Clough, P., & Strycharczyk, D. (2012). *Applied mental toughness: A tool kit for the 21st century*. London, UK. Kogan Page.

Clough, P. J., Earle, K., & Sewell, D. (2002). Mental toughness: The concept and its measurement. In I. Cockerill (Ed.), *Solutions in sport psychology* (pp. 32–45). London: Thomson Publishing.

Corr, P. J. (2001). Testing problems in J. A. Gray's personality theory: A commentary on Matthews and Gilliland (1999). *Personality and Individual Differences*, **30**, 333–352.

Corr, P. J. (Ed.). (2008). *The reinforcement sensitivity theory of personality*. Cambridge: Cambridge University Press.

Eysenck, H. J. (1967). *The biological basis of personality*. Springfield, IL: Charles C. Thomas.

Eysenck, S. B., Eysenck, H. J., & Barrett, P. (1985). A revised version of the Psychoticism Scale. *Personality and Individual Differences*, **6**, 21–29.

Fenz, W. D (1973). Stress and its mastery: Predicting from laboratory to real life. *Canadian Journal of Behavioral Science*, **5**, 332–346.

Francis, L. J., Philipchalk, R., & Brown, L. B. (1991). The comparability of the short form EPQR with the EPQ among students in England, Canada, and Australia. *Personality and Individual Differences*, **12**, 1129–1132.

Gould, D., Dieffenbach, K., & Moffett, A. (2002). Psychological characteristics and their development in Olympic champions. *Journal of Applied Sport Psychology*, **14**, 177–210.

Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*. Oxford: Oxford University Press.

Gucciardi, D. F., & Gordon, S. (2011). *Mental toughness in sport: Developments in research and theory*. Abingdon, Oxon: Routledge.

Gucciardi, D. F., Gordon, S., & Dimmock, J. A. (2009). Development and preliminary validation of a mental toughness inventory for Australian football. *Psychology of Sport and Exercise*, **10**, 201–209.

Gucciardi, D. F., Hanton, S., & Mallett, C. J. (2012). Progressing measurement in mental toughness: A case example of the Mental Toughness Questionnaire 48. *Sport, Exercise and Performance Psychology*, **1**, 194–214.

Hardy, L., Jones, G., & Gould, D. (1996). *Understanding psychological preparation for sport*. Chichester, UK: Wiley.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modelling*, **6**, 1–55.

Jones, J. G. (2004). High-performance leadership: Turning pressure to your advantage. *Human Resource Management*, **12**, 34–38.

Jones, G., Hanton, S., & Connaughton, D. (2002). What is this thing called mental toughness? An investigation of elite sport performers. *Journal of Applied Sport Psychology*, **14**, 205–218.

Jöreskog, K. G., & Sorbom, D. (2003). *Lisrel 8 (Version 8.54)* [Computer software]. Chicago: Scientific Software International.

Kambouropoulos, N., & Staiger P. K. (2004). Personality and responses to appetitive and aversive stimuli: The joint influence of behavioural approach and inhibition systems. *Personality and Individual Differences*, **37**, 1153–1165.

McNaughton, N., & Corr, P. J. (2004). A two-dimensional neuropsychology of defense: Fear/anxiety and defensive distance. *Neuroscience and Biobehavioral Reviews*, **28**, 285–305.

Muris, P., Meesters, C., van den Hout, A., Wessels, S., Franken, I., & Rassin, E. (2007). Personality and temperament correlates of pain catastrophizing in young adolescents. *Child Psychiatry and Human Development*, **38**, 171–181.

Perkins, A. M., & Corr, P. J. (2005). Can worriers be winners? The association between worrying and job performance. *Personality and Individual Differences*, **38**, 25–31.

Perkins, A. M., & Corr, P. J. (2006). Reactions to threat and personality: Psychometric differentiation of intensity and direction dimensions of human defensive behaviour. *Behavioural Brain Research*, **169**, 21–28.

Perkins, A. M., Kemp, S. E., & Corr, P. J. (2007). Fear and anxiety as separable emotions: An investigation of the revised reinforcement sensitivity theory of personality. *Emotion*, **7**, 252–261.

Preacher, K. J., Curran, P. J., & Bauer, D. J. (2006). Computational tools for probing interaction effects in multiple linear regression, multilevel modeling, and latent curve analyses. *Journal of Educational and Behavioral Research*, **31**, 437–448.

Rasbash, J., Charlton, C., Browne, W. J., Healy, M., & Cameron, B. (2009). *MLwiN Version 2.1*. Bristol, UK: Centre for Multilevel Modelling, University of Bristol.

van Wingen, G. A., Geuze, E., Vermetten, E., & Fernandez, G. (2011). Perceived threat predicts the neural sequelae of combat stress. *Molecular Psychiatry*, **16**, 1–8.

Woodman, T., & Hardy, L. (2001). Stress and anxiety. In R. S. Singer, H. A. Hausenblas, & C. M. Janelle (Eds.), *Handbook of sport psychology* (pp. 290–318). New York: Wiley.