Routledge
Taylor & Francis Group

The development and preliminary validation of the Challenge and Threat in Sport (CAT-Sport) Scale

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This paper outlines the development and preliminary validation of a sport-specific measure of athletes' experience of challenge and threat. Three independent studies assess the content validity, factor structure, criterion validity and internal consistency of the Challenge and Threat in Sport (CAT-Sport) Scale. In study 1, a group of 25 athletes and 2 experts assessed the content validity of items derived from existing measures of challenge and threat. Participants examined a pool of 25 items, and were asked to rate the items' applicability to their experiences of challenge and threat in sport. Items failing to reach applicability of 50% were excluded from further analysis. In study 2, 197 runners completed the 21 items retained from study 1 before competition. A principal components analysis with an oblique, direct oblimin rotation yielded a 12-item, two-component solution with items indicative of athletes' experiences of challenge and threat. In study 3, 201 shooters completed the 12-item CAT-Sport before competition. Confirmatory factor analysis indicated that a 12-item 2-factor correlated model provided acceptable model fit with good internal consistency and criterion validity. Collectively these studies provide support for the CAT-Sport as a measure of athletes' experience of challenge and threat in anticipation of sport competition.

Keywords: experience; demands; emotions; sport; performance

Introduction

Athletes report a considerable array of organisational and competitive demands associated with training and competition (Arnold & Fletcher, 2012). Indeed the pressure of striving for highly valued goals, coupled with the inherent uncertainty of outcomes suggests that competing in sport itself can be stressful for many athletes. The Theory of Challenge and Threat States in Athletes (TCTSA: Jones, Meijen, McCarthy, & Sheffield, 2009), proposes that athletes can evaluate the stress of competition in either one of two ways: as a challenge or as a threat. Where individuals report high levels of self-efficacy, high levels of perceived control and adopt approach goals, challenge is purported to be elicited. On the other hand, in circumstances where self-efficacy is low, perceptions of control are diminished and avoidance goals more prevalent, threat is hypothesised to be elicited (cf. Jones et al., 2009). It is also important to note that challenge and threat only occur in a motivated performance situation, characterised by a sense of effort, uncertainty and/or danger (cf. Blascovich & Mendes, 2000). If there is nothing at stake it is unlikely that an individual will experience challenge or threat (Blascovich & Mendes, 2000).

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The TCTSA suggests that challenge and threat are *experienced* as (i) end states of this evaluation (see also Seery, 2011) and are (ii) associated with distinct cardiovascular responses. Indeed, and based upon the Biopsychosocial Model (BPSM: Blascovich & Mendes, 2000), the assessment of challenge or threat in research grounded in TCTSA is typically measured by cardiovascular indices (Blascovich, Seery, Mugridge, Weisbuch, & Norris, 2004). Specifically, according to Blascovich and Mendes (2000), challenge is associated with a cardiovascular pattern indexed by increased cardiac output (CO) and decreased total peripheral resistance (TPR), and threat is posited to be associated with a cardiovascular pattern that is indexed by a maintained or heightened CO and increased TPR.

There are advantages associated with assessing challenge and threat via cardiovascular indices. First, Blascovich and Mendes (2000) suggested that individuals may not make conscious resource and demand appraisals, and therefore may have limited ability to accurately self-report challenge and threat. Second, self-report measures may be susceptible to social desirability (Jones et al., 2009), and from this perspective athletes could be reluctant to disclose that they are feeling threatened. Moreover, the divergence between cardiovascular indices and self-report assessments of challenge and threat has led many to suggest that cardiovascular measures are a more objective way of assessing challenge and threat (cf. Blascovich & Mendes, 2000; Turner, Jones, Sheffield, & Cross, 2012).

Despite the purported advantages associated with cardiovascular indices of challenge and threat, there are at least three reasons why we believe these cardiovascular indices would be complemented by a self-report measure of athletes' *experience* of challenge and threat. First, there is inconsistency between studies about which cardiovascular markers are indicative of challenge and threat (cf. Wright & Kirby, 2003). For example, some research demonstrates that challenge is associated with an increase in CO and a decrease in TPR, whereas threat has been seen to increase CO and have a little increase or no change in TPR (Blascovich & Mendes, 2000; Tomaka, Blascovich, Kelsey, & Leitten, 1993). Similarly, the degree of change in CO is anticipated to be greater when challenged, compared to threatened. Because, the BPSM suggests that heart rate (HR) does not distinguish between challenge and threat (Blascovich, Mendes, Hunter, Lickel, & Kowai-Bell, 2001), and CO is the product of HR and stroke volume (SV), it would be anticipated that changes in SV would be exhibited between challenge and threat. However; SV may not always differentiate challenge and threat (cf. Williams, Cumming, & Balanos, 2010). In addition, where participants are placed into challenge and threat "groups", analysis of means and standard deviations and the overlap in distributions suggest that some individuals placed in a threat group may have a CO change indicative of challenge and vice versa (e.g. Turner, Jones, Sheffield, Barker, & Coffee, 2014; Study 1).

Second, CV measures are predicated on the assumption that athletes will respond with either challenge *or* threat in anticipation of competition. Although challenge *or* threat may occur for some athletes, research has also suggested that athletes can *experience* being challenged *and* threatened in the anticipation of competition (Cerin, 2003; Meijen, Jones, McCarthy, Sheffield, & Allen, 2013). Indeed the research by Cerin (2003) suggests that the experience of challenge and threat is arguably an important facet of athletes' competitive psychological state, independent of cardiovascular indices. Just as there are difficulties associated with using self-report to understand psychological processes, so too are difficulties exhibited when privileging psychophysiological indices of individuals' experience (Wiens, Mezzacappa, & Katkin, 2000).

Third, in pitting cardiovascular measures of challenge and threat against self-report measures, ostensibly "in competition" the benefits that could be accrued by a consideration of both are potentially obscured. From this perspective, it is plausible that a group of athletes could exhibit the same CV response (e.g. increase in CO and small increase or no increase in the change of TPR; threat), but experience challenge and/or threat. On the one hand, this could

simply be seen as a problem with self-report (e.g. athletes not wanting to disclose that they feel threatened). On the other however, and similar to literature on anxiety it could be that self-reported measures can complement physiological ones (Weinberger, Schwartz, & Davidson, 1979). From this vantage point, a self-report measure of athletes' experience of challenge and threat could feasibly contribute towards theory testing and development, and help to explain some findings in current literature which are inconsistent with hypotheses (Meijen, Jones, Sheffield, & McCarthy, 2013; Turner et al., 2013). More broadly, the circumstances under which there may be coherence (or lack thereof) between different facets of challenge and threat, may itself provide one avenue for further research (cf. Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). In sum, we contend that complementary to CV indices of challenge and threat, it is advantageous to understand athletes' *experience* of challenge and threat as they approach competition.[1]

Existing self-report measures of challenge and threat have questionable validity either generally or when applied to athletes specifically. For instance, individuals' *appraisals* of threat and challenge are typically assessed using the challenge and threat ratio (CAR: Tomaka et al., 1993). The CAR divides the rating of demand (e.g. stress on a scale of 1–7) by the rating of resources (e.g. coping ability on a scale of 1–7) such that scores greater than 1 are indicative of threat and scores less than 1 indicative of challenge (Feinberg & Aiello, 2010). Although this is a measure used in multiple studies examining challenge and threat (e.g. Feinberg & Aiello, 2010; Harvey, Nathens, Bandiera, & LeBlanc, 2010; Tomaka et al., 1993), it is subject to criticism. First, as Blascovich (2008) contends, when an individual evaluates sufficient or *nearly sufficient resources* to meet demands, challenge may arise as opposed to threat. Second, the same ratio score could feasibly represent very different experiences. For example, a score of 1 (1/1) might be indicative of neither challenge nor threat (i.e. low ratings of both demands and resources). Alternatively, athletes who score 1 but rate demands/resources highly (e.g. 7/7) might be associated with a quite different state. The criticisms mentioned may account, at least in part, for some of the incongruence between physiological and self-reported measures of challenge and threat. In addition, and to which we have already alluded, assessing athletes' appraisals (or evaluations) of stimuli are not commensurate with assessing athletes' *experience* of challenge and/or threat.

Specifically, where measures such as the Primary and Secondary Appraisal Scale;[2] (PASA: Gaab, Rohleder, Nater, & Ehlert, 2005), Cognitive Appraisal Scale (CAS: Skinner & Brewer, 2002) and Challenge & Threat Construal (McGregor & Elliot, 2002) do ostensibly examine facets of challenge and threat (e.g. appraisals), it is erroneous to assume that the measures named will transfer to new contexts and situations such as sport (cf. Hagger & Chatzisarantis, 2009), as the existing items have not been developed within the context of sport.

In sum, we assert that there are some theoretical advantages associated with a measure of athletes' experience of challenge and threat that could complement existing cardiovascular indices of challenge and threat. In addition, the measures of challenge and threat that are available to sport and exercise psychologists have questionable applicability to athletes. To date, there has been no systematic attempt to develop and validate a measure of athletes' experience of challenge and threat, and accordingly, this paper reports three studies describing the development and preliminary validation of an instrument to assess athletes' self-reported experience of challenge and threat.

Study 1: item generation and content validity

The first stage in the development of the Challenge and Threat in Sport (CAT-Sport) Scale was to generate a list of items that were representative of the experience of challenge and threat, as opposed to the antecedents of, or consequences of challenge and threat. This list of items was

generated in two steps. First, items purportedly assessing challenge and threat were identified in existing measures (i.e. PASA, CAR, CAS; Skinner & Brewer, 2002; Challenge & Threat Construal, McGregor & Elliot, 2002).

Another measure that could have been examined in regards to challenge and threat is The Stress Appraisal Measures (SAM: Peacock & Wong, 1990), however items relating to threat and challenge within the SAM were redundant based on the similarity to existing items (e.g. finding the situation threatening). This process generated a list of (25) items (see Table 1). Drawing upon the process outlined by Bartholomew, Ntoumanis, Ryan and Thørgesen-Ntoumanis (2010), the second step involved assessing the applicability of items to athletes' experience of challenge and threat in sport.

Method

Participants

Twenty-five student athletes 64% male ($M_{age} = 22.5$, SD = 6.1) and 36% female ($M_{age} = 21.50$, SD = 1.79), represented a range of team and individual sports including soccer ($n = 6$), cricket

Table 1.   Applicability scores of items.

Item	Applicable (n%)	Non-applicable (n%)
1. I do not feel threatened by the situation	17 (68)	8 (32)
2. The situation is not a challenge for me	14 (56)	11 (44)
3. This situation challenges me[a]	22 (88)	3 (12)
4. This situation scares me	15 (60)	10 (40)
5. The situation is important to me	2 (8)	23 (92)
6. I do not care about this situation	5 (20)	20 (80)
7. I am focusing on the positive aspects of this situation[a]	19 (76)	6 (24)
8. I worry that I will say or do the wrong thing	17 (68)	8 (32)
9. I am thinking about what it would be like if I do well[a]	5 (20)	20 (80)
10. I am worrying about the kind of impression I will make	17 (68)	8 (32)
11. I am concerned that others will find fault with me	15 (60)	10 (40)
12. I expect that I will achieve success rather than experience failure[a]	18 (72)	7 (28)
13. I am looking forward to the rewards and benefits of success[a]	21 (84)	4 (16)
14. I am concerned what other people will think of me[a]	15 (60)	10 (40)
15. I feel I cannot overcome the difficulties in this task[a]	12 (48)	13 (52)
16. I lack self-confidence	8 (32)	17 (68)
17. A challenge situation motivates me to increase my efforts[a]	22 (88)	3 (12)
18. I am thinking about being successful in this task rather than expecting to fail[a]	20 (80)	5 (20)
19. I worry what other people will think of me, even though it won't make any difference[a]	14 (56)	11 (44)
20. I am concerned that others will not approve of me	13 (52)	10 (40)
21. I am looking forward to the opportunity to test my skills and abilities[a]	23 (92)	2 (8)
22. I believe that most stressful situations contain the potential for positive benefits	4 (16)	21 (84)
23. I worry what other people are thinking of me	16 (64)	9 (36)
24. I feel like this task is a threat[a]	14 (56)	11 (44)
25. I feel like this task is a challenge[a]	21 (84)	4 (16)

Note: Please note items 1–6 are taken from the PASA (Gaab et al., 2005), items 7–23 are taken from the CAS (Skinner & Brewer, 2002); and items 24–25 are taken from the Challenge and Threat Construal (McGregor & Elliot, 2002).
[a]Some items were revised to make them more applicable to a sports setting.

($n = 2$), swimming ($n = 5$), tennis ($n = 1$), rugby ($n = 6$), netball ($n = 3$) and basketball ($n = 2$). As we did not want to impose our understanding/definitions of challenge and threat, we asked the participants to comment on what they felt challenge and threat meant to them, and the importance of each item, in a standardised semi-structured manner.

Procedure

Ethics approval for each of the three studies was provided by the first author's institutional ethics committee and were conducted in accordance with the British Psychological Society's ethics guidelines.

The items were first scrutinised by the first and second author for any items that were seemingly not assessing challenge or threat. Both of these authors have examined the validity of existing psychometric measures, and the second author has contributed to the development of two published questionnaires. Similar to Bartholomew, Ntoumanis, and Thøgersen-Ntoumani (2010), we erred on the side of inclusivity, and thus only one item "I feel like a failure" was removed from the item pool. It was considered that this item reflected an evaluation of one's self (Mullen, Markland, & Ingledew, 1997), and although might be related to challenge or threat, was not representative of challenge and/or threat specifically.

The remaining items were presented to small focus groups of student athletes who were randomly assigned to the groups (three groups of six and one group of seven) for them to individually read through the items and think carefully about whether the item was applicable to their experience of evaluating a forthcoming sporting situation as a challenge and/or a threat. In particular, they were asked to consider "whether each item captures the types of thoughts and feelings you have when you are challenged and/or threatened in sport". To enhance inclusivity of items at this first stage, if participants were "in two minds" or uncertain about the applicability of an item to them personally, but believed it could be applicable to others' experience of challenge or threat, they were asked to rate this as applicable. Participants were also encouraged to discuss and write their own comments on the list of items, for example, if they did not understand the wording, or if they felt the phrasing could be improved. This follows questionnaire development processes previously followed within the literature, to check whether the information presented is appropriate (Barbour, 2005).

Results

Athletes' perceptions of the applicability of items are reported in Table 1. Items were eliminated based on a 50% applicability criterion (cf. Jones, Lane, Bray, Uphill, & Catlin, 2005). That is, more than half (13 out of 25) respondents considered these items as not applicable.

The five items eliminated were: item 5 "This task is important to me", item 6 "I do not care about this situation", item 9 "I am thinking about what it would be like if I do well", item 16, "I lack self-confidence" and item 22 "I believe that most stressful situations contain the potential for positive benefits." Of the remaining items all had more than 50% applicability criterion, more than half (13 out of 25) respondents considered the items as applicable.

Across three of the focus groups athletes felt that the item "This situation scares me" (item 4) resonated with their experience, could be seen as relevant, but was perhaps worded too strongly to be something that was typical of their experience of challenge and threat. Based on athletes' perception that it could be relevant, but perhaps in circumstances of particular import or duress, it was decided that the item would remain within the questionnaire, but an additional item reflecting a less "intense" experience "I find this situation daunting" would be added.

Summary

This study generated a pool of items and examined the content validity of these items based on academics' and athletes' ratings. The pragmatic approach adopted (i.e. generating an item pool based on existing measures, rather than generating items "from scratch"), is similar to other studies developing questionnaires (e.g. Jones et al., 2005) and drawing on athletes' assessments of the applicability of items, helps to maintain theoretical integrity and demonstrate the appropriateness of items to the population. Results suggest that the final pool of 21 items (see Table 2) possess content that is both representative of the construct under scrutiny, and importantly has meaning to the prospective respondents to the questionnaire (Hagger & Chatzisarantis, 2009).

Study 2: principal components analysis

To explore the manner in which items in this nascent questionnaire were constellated, this study comprised a principal components analysis (PCA) with an oblique, direct oblimin rotation, which allowed components to correlate (Tabachnick, Fidell, & Osterlind, 2001).[3] The decision to allow components to correlate was based on evidence of an association between challenge and threat (Cerin, 2003; Meijen, Jones, McCarthy et al., 2013).

Method

Participants

Participants comprised 197 competitive runners, 29% female (M_{age} = 35.9, SD = 13.9) and 69% male (M_{age} = 38.4, SD = 10.5); 2% did not report their gender. All participants routinely took part (once a month) in long distance running events at regional level.

Table 2.   Items retained for further analysis.

Items
1. I do not feel threatened by the situation
2. The situation is not a challenge for me
3. This situation challenges me
4. This situation scares me
5. I am focusing on the positive aspects of this situation
6. I worry that I will say or do the wrong things
7. I am worrying about the kind of impression I will make
8. I am concerned that others will find fault with me
9. I expect that I will achieve success rather than experience failure
10. I am looking forward to the rewards and benefits of success
11. I am concerned what other people will think of me
12. I feel I cannot overcome the difficulties in this task
13. A challenging situation motivates me to increase my efforts
14. I am thinking about being successful in this task rather than expecting to fail
15. I worry what other people will think of me, even though it won't make any difference
16. I am concerned that others will not approve of me
17. I am looking forward to the opportunity to test my skill and abilities
18. I worry about what other people are thinking of me
19. I feel like this task is a threat
20. I feel like this task is a challenge
21. I find this situation daunting

Procedure

The race organisers of two competitive long distance running events were contacted, provided with a copy of the questionnaire and asked if it was possible to distribute the questionnaire at the events. The decision to utilise a running sample for this study was based on the fact it was a highly competitive event in which questionnaires could be distributed and completed within a naturalistic environment before a race. The questions were measured on a Likert scale from 1 to 6, 1 being totally disagree to 6 being totally agree. A 1–6 Likert scale was adopted as this was the original scale used with the PASA and the CAS. On race day, runners were approached by the researchers at the race registration, and informed about the nature of the study and were asked if they would be prepared to complete the questionnaire at a time convenient for them. Participants voluntarily completed the questionnaire between 1 hour and 15 minutes of the event starting.

Data analysis

Suitability for data analysis was assessed by examining (a) Kaiser–Meyer–Olkin (KMO) measure of sampling and Bartlett's test of Sphericity. The data suggested that a PCA was suitable to analyse the data (KMO = .87; Bartlett's test of Sphericity; $p < .01$). Component extraction was based upon (a) eigenvalues greater than 1.0, (b) a minimum of 5% explained variance per component and (c) unique loadings of .40 and above and at least .10 cross-loading differences (cf. Kline, 1998; Tabachnick et al., 2001). In addition the scree plot was examined to help inform a decision about the number of factors to retain.

Results

PCA analysis revealed a presence of four components solution with eigenvalues exceeding 1, explaining 62% of the variance 33.2%, 15%, 8.5% and 5%, respectively. An inspection of the scree plot revealed a clear break after the third component. Based on these results and the pattern matrix, it was decided to retain a two-component solution for further PCA analysis. This is because the third and fourth components comprised two items each deemed inappropriate to measure a construct with fewer than four items (Raubenheimer, 2004), see Table 3 for excluded items.

Items 1, 2, 3, 4, 5, 12, 16, 20 and 21 were removed because they did not fit one of the above criteria. The two-component solution explained a total of 66% of the variance; with Component 1 (threat) contributing to 44.5% and Component 2 (challenge) contributing to 21.5% of the variance (see Table 4), Cronbach's alpha coefficients suggested that each dimension possessed good

Table 3. Items excluded from the CAT-sport scale.

Items excluded after initial PCA
1. I do not feel threatened by the situation
2. The situation is not a challenge for me
3. This situation challenges me
4. This situation scares me
5. I am focusing on the positive aspects of this situation
12. I feel I cannot overcome difficulties in this task
16. I am concerned that others will not approve of me
20. I feel like this task is a challenge
21. I find this situation daunting

Table 4.   Items for the CAT-sport scale.

Items				
	Mean	SD	Skewness	Kurtosis
Component 1 (Threat)				
6. I worry that I will say or do the wrong things	2.04	1.35	1.30	.903
7. I am worrying about the kind of impression I will make	2.11	1.29	1.12	.440
8. I am concerned that others will find fault with me	1.94	1.28	1.39	1.18
11. I am concerned what other people will think of me	2.29	1.39	.80	−.484
15. I worry what other people will think of me, even though it won't make any difference	2.35	1.51	.897	−.288
18. I worry about what other people are thinking of me	1.93	1.17	1.24	.705
19. I feel like this task is a threat	1.92	1.25	1.46	1.48
Component 2 (Challenge)				
9. I expect that I will achieve success rather than experience failure	4.71	1.19	−1.06	1.35
10. I am looking forward to the rewards and benefits of success	4.95	1.11	−1.35	2.16
13. A challenging situation motivates me to increase my efforts	5.05	1.09	−1.58	2.98
14. I am thinking about being successful in this task rather than expecting to fail	5.14	1.04	−1.61	3.02
17. I am looking forward to the opportunity to test my skill and abilities	5.22	.97	−1.58	1.58

internal consistency (threat, $\alpha = .92$; challenge, $\alpha = .84$, respectively) and there was a small negative correlation between the two factors ($r = −.27$).

Summary

This study supports a two-component solution that reflects athletes' experience of challenge and/or threat prior to competition. Items retained in the PCA reflect the notion that (a) challenge is characterised by an experience that is associated with looking forward to demonstrate abilities, skills and success and (b) threat is characterised by an experience that is reflected in worries about competition (cf. Blascovich et al., 2004).

The two-component solution provides some interesting hypotheses in relation to theory on challenge and threat. For example, the only categorical difference in the antecedents of challenge and threat in the TCTSA is based on approach and avoidance goals (see Jones et al., 2009). It is also proposed that there are differences in levels (i.e. in degree) of perceptions of control and self-efficacy. This two-component solution could offer the possibility that experience of challenge and threat could be characterised by distinct antecedents. For example, it might be speculated that athletes who often reappraise the significance of events (cf. Uphill, Lane, & Jones, 2012) may be more likely to exhibit challenge than threat. Similarly, understanding athletes' experience of challenge and threat is important practically, particularly if CV indices of challenge and threat do not always reliably influence performance (Turner et al., 2013).

In sum, the PCA provides some support for a two-component solution that assesses athletes' experience of challenge and threat in anticipation of competition. However to examine the construct validity further, it is important to test this factor structure in an independent sample.

Study 3: confirmatory factor analysis and criterion validity

The aim of this study was to conduct a confirmatory factor analysis (CFA) to test the component structure obtained in study 2, with data collected from an independent athlete sample. Developing

a sound scale is a time consuming and difficult process and represents a process of refinement over time (cf. Anastasi & Urbina, 1997). Although it would be desirable to administer the CAT-Sport to a large representative sample of the entire athletic population that it could be applied to (cf. Lundqvist & Hassmén, 2005), and assess the measurement invariance across different samples, it is recognised that the factor structure of a questionnaire is only one index of a sound measurement instrument. Therefore, we also examined the predictive validity of the CAT-Sport in a more controlled, laboratory-like situation in which previous experiences of the competitive task could not unduly influence participants' responses. This study was undertaken as part of a larger study examining predictors of target shooting performance.

Method

Participants

Respondents were 201 novice target shooters, 25% female ($M_{age} = 25.15$, SD = 8.80) and 75% male ($M_{age} = 27.39$, SD = 10.38), recruited from a student population.

Procedure

Following institutional approval, participants were asked to participate in a shooting competition, where a cash prize was offered (i.e. £100 for the winner), as part of the procedure, which included a display of participants' scores, to elicit a motivational environment (Moore, Vine, Wilson, & Freeman, 2012). Participants using a replica rifle were given 18 shots at a target and results were recorded via infrared. The highest each shot was worth was 10.9 in line with professional shooting competitions. In addition participants were required to complete the Sport Emotion Questionnaire (SEQ: Jones et al., 2005), to examine the predictive validity of the constructs. It is hypothesised within the TCTSA (Jones et al., 2009) that if an individual is experiencing a challenge, they are more likely to experience positive emotions compared to that of threat. When threatened, the TCTSA predicts that anxiety will be experienced at a higher intensity in this state.

Data analysis

CFA using EQS V5 (Bentler, 1992; Bentler & Wu, 1995) was used to test the 12-item, 2-factor model of the CAT-Sport Scale developed in study 2, Byrne (2013) suggests that CFA is the best statistical procedure for testing a hypothesised factor structure. Although results of study 2 support a correlated model we also examined an uncorrelated model to improve confidence that the hypothesised model provided the best fit.

Following the recommendations of several authors (e.g. Hoyle, 1995; Kline, 1998), a range of fit indices were used to judge model adequacy, that is, whether the model fits the data. Although the χ^2 statistic has frequently been chosen as one index, with large samples the χ^2 statistic may be too sensitive and contribute to rejection of models that do, in fact, fit the data (Byrne, 2013).

As a further guard against any influence of a comparatively small sample size, the Robust Comparative Fit Index (RCFI: Bentler, 1992) was examined, RCFI values of >.90 are considered representative of a well-fitting model (Bentler, 1992). The non-normed fit index (NNFI) was also used rather than the normed fit index as a major drawback to this index is that it is sensitive to sample size, underestimating fit for samples less than 200 (Bentler, 1990; Mulaik et al., 1989), and is thus not recommended to be solely relied on (Kline, 2005). The criterion value of 0.90 or greater is associated with an acceptable model fit (Hu & Bentler, 1999) therefore this criterion was utilised in interpretation of results.

The root mean square error of approximation (RMSEA: Steiger, 1990) was also used. A RMSEA value of up to .05 indicates a good fit; MacCallum, Browne, and Sugawara (1996) have suggested that a cut-off point ranging from values .08–.10 indicate a mediocre fit. The standardised root mean residual (SRMR: Hu & Bentler, 1998) was also utilised, values of less than .08 indicate an adequate fit. Finally, alpha coefficients (Cronbach, 1951) were conducted to assess the internal consistency of each subscale with values of >.7 indicative of acceptable internal consistency.

Initially, the full data set was screened to ensure that univariate and multivariate assumptions had been fulfilled. Mardia's coefficient indicated that the assumption of multivariate normality had not been met ($p < .01$), and following Terry, Lane, and Fogarty (2003), the Satorra–Bentler χ^2 was used to compensate for non-normality. The Satorra–Bentler χ^2 is a statistic that includes a downward correction for degree of observed kurtosis (Satorra & Bentler, 1994) and was used to test the model fit for the sample. With the variance of the factor fixed at 1, the model specified that items were related to their hypothesised factor.

Results

The two-factor correlated model was tested of the CAT-Sport Scale consisting of 12 items, with the factors labelled as challenge and threat (see Table 5) the uncorrelated was also examined, showing poor fit indices.[4]

The CAT-Sport Scale showed good levels of internal consistency (threat, $\alpha = .90$; challenge, $\alpha = .83$). Overall, fit indices were indicative of a acceptable level of fit of the data to the hypothesised model; (S-B$\chi^2 = 83.57$, RCFI = 0.92, NNFI = 0.95, RMSEA = 0.07, SRMR = 0.05) and collectively the results alongside the data reported in studies 1 and 2, support a correlated, two-factor model assessing athletes' self-reported experience of challenge and threat.

Criterion validity

To explore the criterion validity of the CAT-Sport Scale,[5] emotions were also measured within the study, via the SEQ (Jones et al., 2005). A significant positive association was observed between

Table 5.   Factor loadings and error variances for the 12 item CAT-sport scale.

Subscale items	Factor loading	Error variance
Threat		
Item 1. I am worrying that I will say or do the wrong things	.751	.086
Item 2. I am worrying about the kind of impression I will make	.763	.065
Item 3. I am concerned that others will find fault with me	.624	.086
Item 6. I am concerned what other people will think of me	.658	.083
Item 9. I worry what other people will think of me, even though it won't make a difference	.632	.090
Item 11. I am worrying about what other people are thinking of me	.625	.092
Item 12. I feel like this task is a threat	.532	.095
Challenge		
Item 4. I expect that I will achieve success rather than experience failure	.724	.095
Item 5. I am looking forward to the rewards and benefits of success	.852	.091
Item 7. A challenging situation motivates me to increase my efforts	.725	.085
Item 8. I am thinking about being successful in this task rather than expecting to fail	.852	.072
Item 10. I am looking forward to the opportunity to test my skills and abilities	.536	.077

challenge and excitement intensity ($r = .22$, $p < .05$) and a significant negative correlation with anxiety ($r = -.16$, $p < .05$). Threat had a positive correlation with anxiety ($r = .39$, $p < .05$). The findings are the expected direction of relationships hypothesised with the TCTSA (Jones et al., 2009). More specifically, challenge is associated with positive emotions (e.g. excited) and threat is associated with increased negative emotions such as anxiety. Anger (Mean = .18, SD = .36) and dejection (Mean = .28, SD = .15) were excluded from analysis due to very low mean scores reported by participants.

Summary

Examination of fit indices suggested that overall the two-factor correlated model represented an acceptable model fit. In addition, this study provides some evidence of criterion validity insofar as excitement and anxiety are predicted in line with theory. Collectively, with the accompanying data reported in studies 1 and 2, we propose the CAT-Sport instrument as an initially reliable and valid measure of athletes' experience of challenge and threat, albeit one which requires further scrutiny.

General discussion

This paper reports three inter-related studies describing the development and preliminary validation of an instrument to measure athletes' self-report of challenge and threat experience. Evidence has been provided to suggest that the CAT-Sport questionnaire assesses athletes' experience of challenge and threat in anticipation of competition and, as such, represents a unique measure in the domain of sport. The development of the CAT-Sport questionnaire has been catalysed by the proliferation of recent research on challenge and threat in sport that collectively signals a need to better capture athletes' experience of challenge and threat (Cerin, 2003; Meijen, Jones, Sheffield et al., 2013). From a compositional standpoint, the instrument is the first that grounds the self-report of challenge and threat in the experiences of athletes and may help to further test and explain some of the ambiguous findings in the literature (Turner et al., 2013). For example, it may be that there are individuals who display similar cardiovascular reactivity (e.g. threat) yet experience that very differently. Such a contention has conceptual, theoretical and practical implications.

Conceptually, challenge and threat have typically been measured – and are distinguished from each other – using cardiovascular indices (Blascovich & Mendes, 2000). However, Lazarus and Folkman (1984) suggested that challenge and threat may be characterised by different appraisal patterns, whilst Cerin (2003) emphasised that athletes' experience of challenge and threat may differ. Collectively, differences in physiology, cognitions (i.e. appraisal patterns) and experience suggest that challenge and threat may be multicompontial, and the extent to which these responses may cohere arguably warrants examination (cf. Mauss et al., 2005).

Theoretically, a multicomponential characterisation of challenge and threat could yield some interesting hypotheses. For instance is there a difference in performance for those athletes who exhibit a CV response of threat but who report experiencing challenge, compared to athletes who exhibit a CV response of threat and report experiencing threat? Practically, understanding the factors that precipitate the experience of challenge and threat could yield some novel interventions to help athletes approach competition in an experientially adaptive manner.

For now questions such as the above remain speculative, and it is important to recognise limitations in the studies reported. First, compared to some studies that have generated items from the "bottom-up" based on athletes' descriptions of the content domain (Morgan, Fletcher, & Sarkar, 2013), a pragmatic approach was adopted whereby items from existing measures were used, and athletes then rated the applicability of items to their experience. While the former approach

typically uses academics as the experts to decide what is applicable to theory, this latter approach attaches greater emphasis to the "athlete as expert" in deciding which items are applicable to their experience. Consulting athletes within the study design while drawing on items that academics believe are associated with challenge and threat was considered advantageous in a domain where the developed theory is fairly recent (cf. Jones et al., 2009).

There are also limitations regarding the size and homogeneity of the samples across the studies in that they are small and narrow, respectively. Partly related to the sample sizes, the interpretation of the fit indices used to assess the hypothesised factor structure could be perceived as "liberal" based on Hu and Bentler's (1999) more recent suggestions. However, in acknowledging the iterative process between measurement, theory-testing and theory-development, it is perhaps better at this stage to tentatively support a measure that can be subject to further scrutiny, as opposed to reject an instrument that would simply be consigned to the file drawer based on a slightly more conservative set of criteria. Indeed, a larger sample in and of itself, would not necessarily guarantee better fit, nor would it enhance the theoretical basis on which it is founded. Certainly, these studies would be complemented by examining the factor structure in larger samples and testing its invariance across different samples, sports, gender and cultures (Duda & Hayashi, 1998). In conclusion, collectively these studies provide support for a self-report measure assessing challenge and threat experience reported in an athletic population.

Notes

1. We recognise the concern of one reviewer who highlights the discord between theoretical approaches (such as the BPSM) that conceptually differentiates challenge and threat at a physiological level and the rationale for a measure of athletes' experience of challenge and threat. By *definition*, a measure that assesses individuals' experience of challenge and threat has no place in either helping to confirm or refute a model that operationally differentiates challenge and threat physiologically. Yet there is, as we contend above, a reasonable body of evidence suggests the examination of athletes' experience of challenge and threat is important, and may yield valuable benefits. Moreover, although space precludes a thorough consideration, others have recognised the appeal associated with *integrating* experiential and physiological levels (cf. Blascovich & Berry Mendes, 2010), and accordingly we contend that this is a timely and appropriate development.
2. In a CFA of the PASA, Rossato, Uphill, Coleman, and Swain (2012) reported that the instrument did not possess satisfactory psychometric qualities in terms of fit indices or alpha reliabilities.
3. It is acknowledged that an alternative approach to factor extraction, principal axis factoring could have been undertaken. However, where items have something meaningful in common under most circumstances the approaches reach the same conclusion, and the distinctions between them can typically be overlooked with few adverse consequences (De Vellis, 2012). In addition, the proposed third study, in the sequence would afford the opportunity to confirm the factor structure of the questionnaire.
4. A uncorrelated model was also run, however these results did not yield a better fit, S-B$X^2 = = 253.61$, RCFI $= 0.61$, NNFI $= 0.60$, RMSEA $= 0.07$, SRMR $= 0.20$).
5. The CAR was utilised however there were no statistically significant associations with the SEQ ($p > .05$).

References

Anastasi, A., & Urbina, S. (1997). *Psychological testing* (7th ed.). Upper Saddles River, NJ: Prentice Hall.

Arnold, R., & Fletcher, D. (2012). Psychometric issues in organizational stressor research: A review and implications for sport psychology. *Measurement in Physical Education and Exercise Science*, 16, 81–100.

Barbour, R. S. (2005). Making sense of focus groups. *Medical Education*, 39, 742–750.

Bartholomew, K. J., Ntoumanis, N., & Thøgersen-Ntoumani, C. (2010). The controlling interpersonal style in a coaching context: Development and initial validation of a psychometric scale. *Journal of Sport and Exercise Psychology*, 32, 193–216.

Bentler, P., & Wu, E. (1995). *EQS for Macintosh user's guide*. Encino, CA: Multivariate software.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*, 238–246.

Bentler, P. M. (1992). On the fit of models to covariances and methodology to the bulletin. *Psychological Bulletin*, *107*, 400–404.

Blascovich, J. (2008). Challenge and threat. In A. J. Elliot (Ed.), *Handbook of approach and avoidance motivation* (pp. 431–445). New York, NY: Psychology Press.

Blascovich, J., & Berry Mendes, W. B. (2010). Social psychophysiology and embodiment. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *The handbook of social psychology* (5th ed., pp. 194–227). New York, NY: Wiley.

Blascovich, J., & Mendes, W. B. (2000). Challenge and threat appraisals: The role of affective cues. In J. P. Forgas (Eds.), *Feeling and thinking: The role of affect in social cognition* (pp. 59–82). Paris: Cambridge University Press.

Blascovich, J., Mendes, W. B., Hunter, S. B., Lickel, B., & Kowai-Bell, N. (2001). Perceiver threat in social interactions with stigmatized others. *Journal of Personality and Social Psychology*, *80*, 253–267.

Blascovich, J., Seery, M., Mugridge, C., Weisbuch, M., & Norris, K. (2004). Predicting athletic performance from cardiovascular indexes of challenge and threat. *Journal of Experimental Social Psychology*, *40*, 683–688.

Byrne, B. M. (2013). *Structural equation modeling with EQS: Basic concepts, applications, and programming*. London: Routledge.

Cerin, E. (2003). Anxiety versus fundamental emotions as predictors of perceived functionality of pre-competitive emotional states, threat, and challenge in individual sports. *Journal of Applied Sport Psychology*, *15*, 223–238.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*, 297–334.

De Vellis, R. F. (2012). *Scale development: Theory and applications* (L. Bickman & D. J. Rog (Eds.), pp. 115–158). Chapel Hill, NC: Sage.

Duda, J. L., & Hayashi, C. T. (1998). Measurement issues in cross-cultural research within sport and exercise psychology. In J. L. Duda (Ed.), *Advances in sport and exercise psychology measurement* (pp. 471–483). Morgantown, WV: Fitness Information Technology.

Feinberg, J. M., & Aiello, J. R. (2010). The effect of challenge and threat appraisals under evaluative presence. *Journal of Applied Social Psychology*, *40*, 2071–2104.

Gaab, J., Rohleder, N., Nater, U. M., & Ehlert, U. (2005). Psychological determinants of the cortisol stress response: The role of anticipatory cognitive appraisal. *Psychoneuroendocrinology*, *30*, 599–610.

Hagger, M. S., & Chatzisarantis, N. (2009). Assumptions in research in sport and exercise psychology. *Psychology of Sport and Exercise*, *10*, 511–519.

Harvey, A., Nathens, A. B., Bandiera, G., & LeBlanc, V. R. (2010). Threat and challenge: Cognitive appraisal and stress responses in simulated trauma resuscitations. *Medical Education*, *44*(6), 587–594.

Hoyle, R. H. (1995). *Structural equation modeling: Concepts, issues, and applications*. London: Sage.

Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitive to unparameterized model misspecification. *Psychological Methods*, *3*, 424–453.

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

Jones, M., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and threat states in athletes. *International Review of Sport and Exercise Psychology*, *2*, 161–180.

Jones, M. V., Lane, A. M., Bray, S. R., Uphill, M., & Catlin, J. (2005). Development and validation of the sport emotion questionnaire. *Journal of Sport and Exercise Psychology*, *27*, 407–431.

Kline, P. (1998). *Principles and practice of structural equation modelling*. New York, NY: The Guildford Press.

Kline, R. (2005). *Principles and practice of structural equation modeling* (3rd ed.). New York, NY: The Guildford Press.

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. New York, NY: Springer Publishing.

Lundqvist, C., & Hassmén, P. (2005). Competitive State Anxiety Inventory-2 (CSAI-2): Evaluating the Swedish version by confirmatory factor analyses. *Journal of Sports Sciences*, *23* (7), 727–736.

MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, *1*(2), 130–149.

Mauss, I. R., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior and physiology. *Emotion*, *5*(2), 175–190.

McGregor, H. A., & Elliot, A. J. (2002). Achievement goals as predictors of achievement-relevant processes prior to task engagement. *Journal of Educational Psychology*, *94*, 381–395.

Meijen, C., Jones, M. V., McCarthy, P. J., Sheffield, D., & Allen, M. S. (2013). Cognitive and affective components of challenge and threat states. *Journal of Sports Sciences*, *31*, 847–855.

Meijen, C., Jones, M. V., Sheffield, D., & McCarthy, P. J. (2013). Challenge and threat states: Cardiovascular, affective, and cognitive responses to a sports-related speech task. *Motivation and Emotion*, *38*, 252–262.

Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology*, *49*, 1417–1425.

Morgan, P. B. C., Fletcher, D., & Sarkar, M. (2013). Defining and characterizing team resilience in elite sport. *Psychology of Sport and Exercise*, *14*, 549–559.

Mulaik, S. A., James, L. R., Van Alstine, J., Bennett, N., Lind, S., & Stilwell, C. D. (1989). Evaluation of goodness-of-fit indices for structural equation models. *Psychological Bulletin*, *105*, 430–445.

Mullen, E., Markland, D., & Ingledew, D. (1997). A graded conceptualization of self-determination in the regulation of exercise behavior: Development of a measure using confirmatory factor analysis. *Personality and Individual Differences*, *23*, 745–752.

Peacock, E. J., & Wong, P. T. P. (1990). The stress appraisal measure (SAM): A multidimensional approach to cognitive appraisal. *Stress Medicine*, *6*, 227–236.

Raubenheimer, J. E. (2004). An item selection procedure to maximize scale reliability and validity. *South African Journal of Industrial Psychology*, *30*, 59–64.

Rossato, C. J. L., Uphill, M. A., Coleman, D. A., & Swain, J. (2012). *The Validity of the Primary and Secondary Appraisal Scale (PASA) for use with Athletes*. International convention on science, education & medicine in sport. Glasgow, UK.

Satorra, A., & Bentler, P. M. (1994). Corrections to test statistics and standard errors on covariance structure analysis. In A. von Eye & C. C. Clogg (Eds.), *Lantent variables analysis* (pp. 399–419). London: Sage.

Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews*, *35*, 1603–1610.

Skinner, N., & Brewer, N. (2002). The dynamics of threat and challenge appraisals prior to stressful achievement events. *Journal of Personality and Social Psychology*, *83*, 678–692.

Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate Behavioral Research*, *25*, 173–180.

Tabachnick, B. G., Fidell, L. S., & Osterlind, S. J. (2001). *Using multivariate statistics* (4th ed.). New York, NY: Allyn & Bacon.

Terry, P. C., Lane, A. M., & Fogarty, G. J. (2003). Construct validity of the Profile of Mood States – Adolescents for use with adults. *Psychology of Sport and Exercise*, *4*, 125–139.

Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective, physiological, and behavioral effects of threat and challenge appraisal. *Journal of Personality and Social Psychology*, *65*, 248–260.

Turner, M., Jones, M., Sheffield, D., Slater, M., Barker, J., & Bell, J. (2013). Who thrives under pressure? Predicting the performance of elite academy cricketers using the cardiovascular indicators of challenge and threat states. *Journal of Sport and Exercise Psychology*, *35*, 387–397.

Turner, M. J., Jones, M. V., Sheffield, D., Barker, J. B., & Coffee, P. (2014). Manipulating cardiovascular indices of challenge and threat using resource appraisals. *International Journal of Psychophysiology*, *94*, 9–18.

Turner, M. J., Jones, M. V., Sheffield, D., & Cross, S. L. (2012). Cardiovascular indices of challenge and threat states predict competitive performance. *International Journal of Psychophysiology*, *86*, 48–57.

Uphill, M. A., Lane, A. M., & Jones, M. (2012). Emotion regulation questionnaire for use with athletes. *Psychology of Sport and Exercise*, *13*, 761–770.

Weinberger, D. A., Schwartz, G. E., & Davidson, R. J. (1979). Low-anxious, high-anxious, and repressive coping styles: Psychometric patterns and behavioral and physiological responses to stress. *Journal of Abnormal Psychology*, *88*, 369–380.

Wiens, S., Mezzacappa, E. S., & Katkin, E. S. (2000). Heartbeat detection and the experience of emotions. *Cognition & Emotion*, *14*, 417–427.

Williams, S. E., Cumming, J., & Balanos, G. M. (2010). The use of imagery to manipulate challenge and threat appraisal states in athletes. *Journal of Sport and Exercise Psychology*, *32*, 339–358.

Wright, R. A., & Kirby, L. D. (2003). Cardiovascular correlates of challenge and threat appraisals: A critical examination of the biopsychosocial analysis. *Personality and Social Psychology Review*, *7*, 216–233.