# Re-examining the association between pre-season challenge and threat states and performance across the season

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## Abstract

Challenge and threat (C/T) states have been shown to predict sport performance under pressure. Nevertheless, only one study (Blascovich et al., 2004) has examined whether pre-season C/T states are associated with season-long performance, yielding promising findings. Despite promising findings, this work is not without limitations which warrant addressing. We aimed to address these limitations and contribute to the scarce literature which tests the effect of anticipatory C/T states on longer term performance. Thirty-eight amateur cricketers prepared and delivered two counterbalanced speeches; a control speech and a speech about an important cricket batting situation approximately 16 weeks prior to the start of their competitive season. Regression analysis showed that cardiovascular reactivity in anticipation of delivering a speech about an important cricket batting scenario the next season did not predict season-long batting performance. The findings have potential to challenge the role C/T states play in predicting longer-term performance in the sport domain.


**Key Words:** Stress response; performance under pressure, long-term effects

## Introduction

The psychophysiological challenge and threat (C/T) response to stressors has become a well-established predictor of sport performance under pressure (Cooke & Ring, 2019). Several studies have explored this association and most support the benefits of a challenge state in yielding positive performance outcomes when faced with stressors (c.f. Behnke & Kaczmarek, 2018; Hase et al., 2019), although more recent studies have drawn mixed conclusions (e.g., Jewiss et al., 2023). Within the C/T literature, the majority of studies view C/T states as situational responses to task specific stressors (e.g., Turner et al., 2013). To date, only one study (Blascovich et al., 2004) has examined anticipatory C/T responses on season-long sport performance. Although Blascovich et al. reported promising findings, there are limitations to this work which warrant addressing. Consequently, the aim of this study is to re-examine the effects of pre-season anticipatory C/T states on season-long sport performance.

Theoretical perspectives on C/T states such as the Biopsychosocial Model (BPSM; Blascovich & Mendes, 2000) draws from the cognitive components of Lazarus and Folkman's (1984) transactional model of stress, and Dienstbier's (1989) model of physiological toughness and weakness. It specifies that in the presence of goal pursuit and task engagement, C/T states emerge through a cognitive appraisal process. Here, when individual coping resources (e.g., knowledge of abilities and skill) outweigh task demands (e.g., perceived required effort) a challenge state will emerge, whereas a threat state results when demands outweigh resources (Blascovich & Mendes, 2000). In this article we adopt the BPSM's conceptualisation of C/T states which views them opposite endpoints on a single bipolar continuum. However, we acknowledge this conceptual approach deviates from that outlined by Lazarus and Folkman in their transactional model of stress and more recent, currently untested, theoretical approaches such as the Theory of Challenge and Threat States in Athletes-Revised (TCTSA-R; Meijen et al., 2020) and the Evaluative Space Approach to C/T (ESACT; Uphill et al., 2019) which conceptualises C/T states as occurring during opportunities for growth/harm and treats C/T as independent, bivalent and co-activated states.

A downstream effect of the cognitive appraisal process is that demand and resource evaluations trigger a predictable pattern of cardiovascular changes. In challenge, increased sympathetic-adreno-medullary (SAM) activity releases catecholamines triggering epinephrine release from the adrenal medulla causing vasodilation in skeletal beds (Brownley et al., 2000; Seery, 2011). A product of these neuroendocrine changes are increases in cardiac output (CO) and reductions in total peripheral resistance (TPR). Conversely, in threat, increased hypothalamic-pituitary-adrenal (HPA) activity counteracts vasodilatory effects of epinephrine through the release of cortisol, triggering attenuations or stabilization in CO and increases in TPR (Brownley et al., 2000; Seery, 2011).

Most of the research which has tested the association between C/T states and sport performance conceptualises C/T states as situation specific anticipatory responses to a meaningful performance task, where task performance immediately follows the recording of anticipatory C/T responses. This literature largely supports the idea that a challenge state yields superior performance outcomes than a threat state. In their meta-analysis of the C/T state-sport performance literature, Behnke and Kaczmarek (2018) reported small-moderate performance effects for raw and derivative cardiovascular markers of C/T states. More specifically, Turner et al. (2013) reported that cardiovascular markers of C/T states recorded in anticipation of a cricket batting task were significantly associated with batting performance performed immediately afterwards, with challenge outperforming threat. In addition, Brimmell et al. (2018) reported that a challenge state recorded in anticipation of a penalty shooting task was associated with superior immediate task performance when compared to threat. Similarly, Dixon et al. (2020) found that challenge reactivity prior to a soccer game was significantly associated with coach and player ratings of match performance. Similar findings are reported in other sports, such as golf (Moore et al., 2013), netball (Turner et al., 2012) when performance directly follows C/T state recording. It is noteworthy however that some research has not found such positive associations between C/T states and sport performance (e.g., Behnke et al., 2020; Jewiss et al., 2023). For instance, Jewiss et al. (2023) found that anticipatory C/T states were not predictive of performance under pressure in a pressurised golf-putting task once past performance had been controlled for in a within-subject design. In addition, research which explores the purported underlying mechanisms which drive divergent performance outcomes in C/T states remain largely equivocal (e.g., Arthur et al., 2019; Wood et al., 2018)

Despite a research focus on exploring how anticipatory C/T states determine sport performance, it appears that little work has tested the effect of anticipatory C/T states on season-long performance. The value of such work has practical implications which are of interest to sport psychologists, sports coaches and wider networks within a sport science team; it might be possible to predict and identify individuals likely to progress through academy and youth systems, and it may be possible to identify individuals who are likely to thrive, be challenged, manage anxiety, and thus perform optimally in critical moments throughout the course of a season (Blascovich et al., 2004). Furthermore, it may be possible to identify individuals who may require additional psychological support to facilitate the emergence of challenge states in critical performance situations.

One promising study to examine whether C/T states can predict performance over the course of a season was conducted by Blascovich and colleagues (2004). In their study, Blascovich et al. asked 27 baseball and softball athletes to prepare and deliver two counter-balanced speeches, prior to the start of the baseball/softball seasons, whilst recording cardiovascular markers of C/T states. After, and alongside team membership and baseline variable level, a speech about the qualities of a good friend was entered in Step 1 of regression analysis to control for C/T response caused by speech giving in general, in Step 2 of the predictive model cardiovascular reactivity recorded during a sport specific speech was entered and was found to be significantly associated with season-long baseball/softball performance above variance explained in Step 1. Specifically, participants who responded with cardiovascular reactivity indicative of challenge performed better throughout the duration of the season indexed via runs created by batter throughout the duration of the season, than those who exhibited cardiovascular reactivity reflective of threat.

The appropriateness of using a speech task was rationalised by Blascovich et al. (2004) on the premise that there is a direct relationship between athlete's C/T responses while imagining and giving a speech about playing their sport and the result of their performance during the subsequent season. This is speculated to be the case as demand and resource evaluations, which result in anticipation of athletic performance, will likely be evoked during a less metabolically demanding task (e.g. anticipating and delivering a speech). Thus, a speech about performance will elicit identical demand and resource evaluations, and subsequent C/T states, as actual performance itself. However, recent work which has also used a speech task to assess task specific anticipatory C/T has questioned its efficacy predicated on the assumption that cardiovascular reactivity to the task may not be solely caused by having to talk about it (Meijen et al., 2014). For instance, it may also be determined by imagery ability and imagery controllability (Beevor et al., 2023). The implications drawn from Blascovich and colleagues' work, albeit from one study, indicate that it might be possible to identify individuals likely to thrive in high pressure, goal-oriented moments to maximise individual and team success in motivated performance situations.

Despite significant contributions to the literature, Blascovich et al.'s research is not without limitations which are worthy of addressing prior to anticipatory C/T states being adopted by sports teams and utilised within the sport domain. For instance, although the conclusions drawn suggest that cardiovascular markers of C/T states were associated with season-long performance only one of the two raw cardiovascular markers of C/T states were associated with season-long performance. Specifically, despite the way TPR and CO are inversely related (Seery et al., 2010), TPR reactivity was associated with season-long performance, but CO reactivity was not ($p > 0.05$). More substantively, past performance was not controlled for, despite Blascovich et al. noting that future performance under pressure may often be predicted from past performance. Controlling for past performance is important in isolating the contribution made by C/T states on future performance beyond what can be attributed to past performance capabilities (Jewiss et al., 2023). Indeed, recent research (e.g., Jewiss et al., 2023; Turner et al., 2021) has demonstrated that performance under pressure is largely predicted by past performance reflected. A further limitation of Blascovich et al.'s research was that psychological task engagement, which is a pre-requisite to the emergence of C/T states, was recorded at the group rather than individual level, meaning participants who did not display task engagement may have been erroneously included in data analysis (Hase et al., 2020).

This study used Blascovich et al.'s research as a template to add to the limited existing literature, which makes it difficult to draw firm conclusions, on the impact of C/T states on season long performance. Specifically, we examine whether anticipatory C/T states predict cricket batting performance across the course of a season whilst simultaneously addressing contemporary suggestions in the C/T literature (e.g., controlling for past performance and ensuring task engagement at an individual level). In addition, this study adhered to recent calls in the C/T-state literature and ensured psychological task engagement at an individual level using HR reactivity (Hase et al., 2020) and controlled for past performance to elucidate the impact of C/T states on performance under pressure above past performance capabilities (Jewiss et al., 2023). Consequently, this study is the first to ensure psychological task engagement at the individual level and control for past performance to elucidate on the contribution of C/T states on predicting performance under pressure whilst assessing the longer-term performance effect yielded by C/T. It was hypothesized that past performance would be significantly related to subsequent performance over the course of a season, and C/T states would significantly contribute to predicting performance throughout the season on top of the contribution made by past performance. Specifically, it was anticipated that a challenge state indexed by increased CO and reduced TPR would be associated with better performance over the course of the season reflected by a higher batting average.

# Method

## Participants

An a-priori power analysis with an effect size set at 0.40 (which was derived from Blascovich et al.'s study because it is the only other known study to look at the effect of anticipatory C/T states on longer-term performance outcomes), desired statistical power set at 0.80, number of predictor variables set at three, and an α-level of 0.05, suggested the minimum required sample size was 32. Thirty-eight amateur male cricketers (23 ± 5 years), playing in a cricket league on the south coast of the UK, participated in the current study. All participants reported being in good health, normotensive with no cardiovascular concerns. No incentive was offered to participants for taking part. Ethical approval was granted by the University ethics committee and written individual informed consent was gained prior to data collection. All participants were asked to refrain from heavy exercise and from consuming caffeine and alcohol 24 hours prior to testing as this is known to influence resting cardiovascular measures as per Quintana et al. (2013).

## Measures

### Cardiovascular Markers of C/T States

C/T states were indexed via their cardiovascular correlates due to their reported superiority to self-reported metrics, for instance, cardiovascular markers are not influenced by some of the biases associated with self-report data (Seery, 2011). Cardiovascular measures of heart rate (HR), CO and TPR were recorded using a Finometer PRO (Finapres Medical Systems, BV, Arnhem, the Netherlands). The Finometer records these cardiovascular markers using plethysmography underpinned by volume-clamp and physiocal criteria (Penaz, 1973; Wesseling, 1995). An infrared sensor located in an appropriately sized finger cuff placed on the index fingers of the non-dominant hand records changes in the diameter of the arterial wall continuously and non-invasively. In using plethysmography, we acknowledge that the methods used in this paper to record cardiovascular markers diverge from those employed by Blascovich et al. In addition, we acknowledge that a host of stable and transient variables, such as age and gender, smoking behaviour, habitual levels of alcohol consumption, oral contraceptive pill intake, food intake, caffeine intake and engagement in physical activity (Laborde et al., 2017) may determine cardiovascular reactivity when faced with intermittent stressors and may contribute to the findings in this study.

### Performance (dependent variable)

Season-long batting performance, marked by participant batting average (calculated by taking the total number of runs scored divided by number of times the participant lost their wicket) the season directly after assessment, was used as our dependent variable. Season-long batting performance was sourced from a publicly available website (www.play-cricket.com) known for holding cricket performance metrics.

### Past Performance (control variable)

Season-long batting performance, the season directly before participating in the current study, was used as our marker of past performance. Past performance data was sourced from www.play-cricket.com.

### Anticipatory C/T states

Anticipatory C/T responses were recorded during the preparation and delivery of two counterbalanced speeches. In line with previous work (e.g., Blascovich et al., 2004; Meijen et al., 2014; Seery et al., 2010), the first speech asked participants to explain the qualities of a good friend and the second was a sport-specific speech about the upcoming cricket season. Participants were afforded two-minutes to prepare and two minutes to deliver each counterbalanced speech, during which cardiovascular data was continually recorded, with a three-minute rest period between each speech. The duration used to prepare and deliver their speech aligned with the duration employed by Seery et al. (2010), but was shorter than Blascovich et al. (2004, 2-min prep and 5-min rest) and Meijen et al. (2014, 3-min prep and 10 min rest). Per previous work (Blascovich et al., 2004; Meijen et al., 2014) cardiovascular data recorded in the friend speech was used as a control variable to isolate C/T responses which were due to competitive performance and not speech giving in general.

#### Speech One

Participants were instructed to mentally prepare (two minutes) and deliver (two minutes) a speech outlining the qualities which they considered to be characteristics of a good friend. Participants were prompted with pre-determined topics (such as encouraging participants to describe the behaviour of a good friend and outline the top three characteristics their best friend possessed) to encourage the participants to continue speaking if they stopped talking for five-seconds during speech delivery.

#### Speech Two

Participants were instructed to mentally prepare (two minutes) and deliver (two minutes) a speech discussing an important and contextually relevant batting scenario they envisaged facing in the upcoming cricket season. For example, an opening batter may imagine preparing to face the first ball of the innings, whereas a tailender may imagine preparing to face their first delivery and planning to get their partner on strike. Participants were instructed to consider behavioural, cognitive and emotional responses to their envisaged batting scenario. Participants were prompted with pre-determined topics (such as asking participants to outline their thoughts/emotions/behaviours as the bowler approached the batting crease) to encourage the participants to continue speaking if they stopped talking for five-seconds during speech delivery. The context of the sport-specific speech diverged slightly from Blascovich et al. (2004) who prescribed a specific batting scenario all participants should imagine, to reflect the numerous batting positions in cricket each with unique situational demands to ensure the imagined important batting scenario was individually and contextually relevant in the context of each participants batting role.

## Procedures

### Laboratory Setup

An email was sent to club captains at adult cricket clubs in a cricket league on the south coast of the UK asking that the study information and lead researcher’s contact details were circulated. All cricketers who displayed an interest in the study were encouraged to respond via the details provided. Cardiovascular data collection took place in a sound-proof Psychology laboratory during the cricket off-season approximately four months before the start of the upcoming season. Prior to attending their single individual testing session participants were informed they would be asked to complete two tasks considered as evaluative social stressors.

### Participant Preparation

Participants were prepared for data collection in accordance with previous literature to use the Finometer PRO (Finapres Medical Systems, BV, Arnhem, The Netherlands). A finger cuff was attached to the index finger on the non-dominant and a rica-rocci blood pressure cuff was attached around the bicep of the same arm. To reduce white coat syndrome all participants were provided with a short description about the sensation of the finger and blood pressure cuff. Participants were informed that two minutes into baseline data recording the Finometer would initiate a return-to-flow systolic calibration (which lasts for one-minute). After the systolic calibration participants were informed that the remaining seven-minutes of baseline data recording would continue. After the 10-minute baseline data collection period participants were instructed that experimental phases would begin.

### Cardiovascular Data Collection

Cardiovascular markers indicative of C/T states were recorded throughout a 10-minute baseline period (e.g., Meijen et al., 2014), which was an initial longer rest period than the timeframes used by Blascovich et al. (2004). Baseline data recording used resting rather than vanilla baseline principles, and participants were instructed to remain wakeful and to sit silently with their feet positioned on the floor (Jennings et al., 1992). During the 10-minute baseline period the experimenter was present to initiate the return-to-flow calibration but left the testing room once this process had begun to observe from a sound-proofed laboratory next door. Once baseline data recording was complete the experimenter re-entered the room.

Participants were then informed that they would be asked to prepare for and deliver two counterbalanced speeches: a friend speech and a sport specific speech. In line with previous C/T literature (e.g., Jewiss et al., 2023), participants received task instructions and were simultaneously invited to prepare their speech because anticipatory cognitive and emotional changes are likely to occur at the onset of participants receiving new information. This lasted a total of two-minutes and formed the preparation phase. At the end of the two-minutes participants were asked to deliver their speech for a further two-minutes. After the first speech was completed participants were afforded a three-minute recovery prior to beginning the second speech. A three-minute recovery period was considered appropriate to allow for cardiovascular measures to return to baseline levels and avoid any residual carry over effects due to the nature of the static non-metabolically demanding task. See Figure 1.1. for an overview of the experimental procedure. To facilitate task engagement, participants were instructed that for each speech they were being video recorded, that a second researcher was rating how well they performed each speech, and the rating of their performance would be placed onto a leaderboard to allow for social comparison with other participants. These types of instructions have been widely used within C/T previous research as a competitive stressor (e.g., Turner et al., 2013).

**Analytic Strategy**

Data were checked to ensure it met assumptions of linearity, multicollinearity, homoscedasticity, and had normally distributed residuals prior to completing a regression analysis. At this stage a total of seven participants were excluded from analysis: the data from two participants violated statistical assumptions, and five participants had missing cardiovascular or batting performance data. At this stage, the 31 remaining participants had no missing cardiovascular data and had batting performance, indexed by a full seasons batting average, for the season before and after cardiovascular recording. Psychological task engagement for both speech tasks was then checked at an individual level. To conduct this necessary check, HR reactivity was calculated by subtracting average HR in the final minute of baseline from average HR in the two-minute instruction and preparation phase for both speeches. Here, HR reactivity > 0 indicated psychological task engagement. At this stage, one participant was excluded from data analysis due to displaying psychological task disengagement in anticipation of both speech tasks. The final sample size was 30 participants which was marginally underpowered in relation to our a priori power analysis.

To index C/T states, CO and TPR reactivity data were calculated by subtracting raw cardiovascular values recorded in the final minute of baseline from average cardiovascular values recorded during the two-minute instruction and preparation phase. This diverges from Blascovich et al.'s work (2004) by using the instruction and preparation phase to reflect anticipatory C/T responses, whereas Blascovich and colleagues used the two-minute speech delivery phase to reflect anticipatory C/T. The rationale that underpinned this decision was that using the instruction and preparation phase minimised the opportunity for cognitive re-appraisal which may have occurred during speech delivery as participants reflect on and receive feedback about their speech performance (Vine et al., 2016). In addition, using the instruction and preparation phase minimised the risk of capturing movement artefact in cardiovascular data, which is common in tasks, like speech giving, where hand gestures are commonly used.

Next, as is common in the C/T state field, CO and TPR reactivity were combined to create the challenge and threat index (CTI). The CTI was created by standardising CO and TPR reactivity, multiplying CO reactivity by +1 and TPR reactivity by -1 and summing the two weighted variables. Subsequent multiple hierarchical regression analyses were conducted in three steps. Participants batting average achieved the season after C/T states were recorded was the dependent variable. Participants batting average the season prior to C/T state recording was entered in Step one. In Step two, friend speech cardiovascular reactivity scores were entered independently, and sport specific speech reactivity scores were independently entered in Step three (separate regression analyses for CO, TPR and CTI).

## Results

### Task Engagement

All 30 participants in our sample demonstrated psychological task engagement in anticipation of both speech tasks. In line with previous literature, two paired-samples t-tests were conducted to test for group task engagement by comparing the average HR in the final minute of baseline with the average HR during the two-minute instruction and mental preparation phase. For both the friend speech (88 ± 16 bpm, t(29) = 4.95, $p < .001$) and the sport specific speech (88 ± 13 bpm, t(29) = 7.11 $p < .001$) there were statistically significant increases in HR from baseline (79 ± 10 bpm) to the preparation phase.

### Relationship Between C/T States and Performance

Prior to conducting hierarchical linear regression analysis, correlational analysis revealed that all cardiovascular variables were non-significantly related to season-long performance (see Table 1.1).

In Step one, a significant proportion of batting average was accounted for by the previous season's batting average, $R^2 = 0.25$, $p <. 01$. A higher batting average the season before testing was associated with a higher batting average the season after testing ($b = .34$, $\beta = .50$). The addition of CO reactivity recorded in anticipation of the friend speech in Step two, accounted for a non–significant proportion of additional accumulated variance in batting average, $\Delta R^2 = 0.01$, Total $R^2 = 0.26$, $p > .05$, $b = -.42$, $\beta = -.05$. The addition of CO reactivity recorded in anticipation of the sport-specific speech in Step three also accounted for a non-significant proportion of additional accumulated variance, $\Delta R^2 = 0.01$, Total $R^2 = 0.27$, $p > .05$, $b = -1.12$, $\beta = -.11$. For TPR, friend speech TPR reactivity in Step two accounted for a non–significant proportion of additional accumulated variance in batting average, $\Delta R^2 = 0.06$, Total $R^2 = 0.31$, $p > .05$, $b = .02$, $\beta = .33$. The addition of sport-specific speech TPR reactivity in Step three accounted for a non-significant proportion of additional accumulated variance, $\Delta R^2 = 0.01$, Total $R^2 = 0.32$, $p > .05$, $b = -.01$, $\beta = -.14$. For the CTI, friend speech CTI entered in Step two accounted for a non-significant proportion of additional accumulated variance in batting average, $\Delta R^2 = 0.04$, Total $R^2 = 0.29$, $p > .05$, $b = -1.07$, $\beta = -.21$. In Step three, the addition of sport-specific speech CTI accounted for a non-significant proportion of additional accumulated variance, $\Delta R^2 = 0.00$, Total $R^2 = 0.29$, $p > .05$, $b = .15$, $\beta = .03$. The only significant predictor of season long performance was past performance.

## Discussion

The aim of this study was to adopt Blascovich et al.'s (2004) research as a template and contribute to the limited literature which has examined the effect of anticipatory C/T states on performance throughout the course of a season. In addition, this study sought to strengthen the methodological and analytical procedures adopted in previous work because it actions recent calls in the C/T field by ensuring psychological task engagement at an individual level (Hase et al., 2020) and controlling for past performance to elucidate the unique contribution made by C/T states in determining performance under pressure (Jewiss et al.., 2023). The main finding from this study is that cardiovascular correlates of C/T states are unrelated to batting performance throughout the duration of a cricket season when controlling for past performance. In fact, in the predictive model, past performance was the only significant predictor of subsequent performance under pressure.

Our findings partially contradict the only known study to test the effect of C/T states on performance over the course of the season (Blascovich et al., 2004) and potentially challenge the role C/T states play in determining season-long performance, although our findings should be consumed in the context of methodological limitations (e.g., the use of speech tasks to elicit C/T states). Here, Blascovich and colleagues found that TPR and CTI were significantly associated with season-long baseball performance, whereas CO reactivity was a non-significant contributor to season-long performance. Several methodological decisions may explain divergent findings reported in Blascovich et al. (2004) and this study. First, Blascovich et al. control for team membership and responses to speech giving in general, whereas this study adds past performance as an additional controlling variable. It is possible that season-long performance variance explained by C/T states in Blascovich et al. is captured within the variance explained by past performance in this study. Second, Blascovich and colleagues encouraged all participants to imagine a prescribed and fixed baseball batting scenario, whereas this study afforded participants autonomy to imagine a batting scenario familiar to them. It is possible that choice led to lower invested effort in the preparation for the tasks (Phillips et al., 2013). Third, the use of social comparison through task instructions which specified that speeches would be scored and placed on a leaderboard deviated from Blascovich et al. and may partially explain divergent findings because some participants appraisals may have been naturally facilitated by the potential of social comparison whereas other participants appraisals may have been inhibited. For instance, Mendes et al. (2001) found that cardiovascular responses indicative of C/T states varied during downward and upward social comparisons. In addition, Blascovich et al. delivered task instructions via audiotape, whereas the experimenter in this study delivered instructions verbally and research has shown that verbal instructions may contribute to different cardiovascular effects than audiotaped instructions due to social interaction, demand characteristics as well as differing pace and tone (Frings et al., 2014).

Although Blascovich and colleagues speculate that individuals who experience challenge when imagining and speaking about a goal-relevant situation are likely to experience challenge when faced with the same goal-relevant situation in game, which is likely consistent throughout the course of a season, alternative theory questions the extent to which C/T appraisals remain consistent (Jones et al., 2009; Vine et al., 2016). For instance, in the Theory of Challenge and Threat States in Athletes (TCTSA), Jones et al. (2009) propose that C/T states are dynamic and argue that demand, and resource appraisals change over time and in the presence of new information (Chadha et al., 2023; Cummings et al., 2017). For instance, Chadha et al. (2023) evidenced the dynamic nature of C/T cognitions and affective states in the lead up to competition throughout three different time points. In addition, in their Integrative Framework of Stress, Attention and Visuomotor Performance, Vine et al. (2016) propose a feedback loop where knowledge of performance may determine subsequent demand-resource evaluations in the presence of a similar performance task. Evidence for the existence of a feedback loop can be seen in Crowe et al. (2020) who found individual changes in demand and resource evaluations following individualised task performance feedback. In addition, research has demonstrated that cardiovascular reactivity to similar competitive scenarios varies from competitive event to competitive event (Dixon et al., 2020). Taken together, it is likely that individual appraisals of demands and resources in similar scenarios are likely to differ according to fluctuations caused by new information, past performance, and feedback over the course of the season. In addition, across the duration of a competitive season participants may experience major life events which may determine an individual's habitual demand and resource appraisals which may shape C/T states and performance under pressure (Moore et al., 2018).

The current study has limitations which should be considered when interpreting our findings and which should be addressed in future before any stronger inferences about the importance of C/T states for season-long performance can be made. One limitation which should be noted is that our final sample size is slightly underpowered in reference to the sample size calculation due to missing cardiovascular and performance data and individual participants not satisfying pre-requisites needed for the calculation of C/T states. In addition, subsequent research may benefit from asking participants to verbally report the specific scenario they imagined and prepared for as this could provide explanatory insights into the situations which shaped their cardiovascular reactivity. Future work may wish to allow for missing data and participants not satisfying pre-requisites in advance, although dropout rates are variable (e.g., 13% of original sample in Jewiss et al., 2023 versus 49% in Hase et al. 2019) and difficult to predict. In this study C/T states were only indexed via their cardiovascular correlates and following recommendations in the C/T literature (Hase et al., 2019), future work may wish to use self-reported metrics alongside their cardiovascular markers. Furthermore, although it satisfies theory to infer task engagement from HR reactivity, stronger conclusions may be drawn by a manipulation check. Last, recording ventricular contractility (VC) alongside HR would allow for stronger judgments of task engagement on a cardiovascular level.

Although moderators to the C/T states-performance association, such as methodological decisions like the type of performance, measurement mode, experimental design (e.g., Behnke & Kaczmarek, 2018 and variables like age and gender (e.g., Hangen et al., 2019) have been documented in the C/T field, future work may wish to consider the moderating impact of psychological strategies and techniques. One such variable worth consideration, in particular in research where encouraging participants to imagine and reflect is a core tenet, is imagery. Research has shown that the use of imagery can influence cardiovascular reactivity (e.g., Cumming & Williams, 2012) and greater capacity to produce images underpinned by task mastery could be associated with adaptive stress appraisals (Beevor et al., 2023). Consequently, recording the clarity, vividness and valence of images and further recording the extent to which this moderates C/T states is worthy of attention. In addition, future work may wish to fully explore the extent to which demographic information such as population characteristics and task demands such as the requirements of the skill determine C/T appraisals and their subsequent explanatory power. For instance, research has shown that C/T states are stronger predictors of performance in elite (e.g., Turner et al., 2013) compared to novice (e.g., Moore et al., 2015) participants and in sports where there is greater opportunity for harm such as cricket batting (e.g., Jewiss et al., 2023; Turner et al., 2013) in comparison to physically safe tasks like golf putting (Moore et al., 2015).

In conclusion, the aim of this study was to add to the limited literature which tests the effect of anticipatory C/T states on batting performance across the course of a cricket season. The study has increased methodological rigour by ensuring task engagement at an individual level and by controlling for past performance to understand the contribution made by C/T states on top of past performance capabilities. The findings of this study suggest that C/T states are not associated with performance throughout the cricket season. Consequently, the results of this study may challenge the role C/T states play in predicting longer-term performance when C/T states are elicited through speech giving and more broadly challenge the utility of speech giving as an appropriate methodology to assess anticipatory C/T responses. Consequently, before any stronger inferences can be made regarding the importance of C/T states for longer-term performance outcomes, further research is required.

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