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Predicting Pressurised Competitive Trampoline Gymnastics Performance with Challenge and Threat Evaluations

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Abstract

Excellence in trampoline gymnastics involves executing highly complex figures in a stressful competitive setting that punishes even small errors. Such competitive settings provide an ideal environment to study the theoretical predictions of the Biopsychosocial Model of Challenge and Threat. The model predicts that cognitive evaluations consistent with a challenge (versus a threat) state relate to better performance. We aimed to examine whether a cognitive challenge and threat measure taken before the start of the season predicts elite-level trampoline gymnastics performance at one highly pressurised competition 37.7 days on average later in the season. Using a prospective design with 50 preadolescent-to-adult elite-level trampoline gymnasts, we predicted first- and second-routine performance at the highly pressurised competition with pre-season cognitive challenge and threat (i.e., personal coping resources minus situational demands) evaluations regarding this competition. The main analyses partially supported the hypothesis that a challenge evaluation relates to better performance than a threat evaluation. Cognitive evaluations reflective of a challenge (versus a threat) state predicted better first routine performance (adjusting for age, sex, and average season performance). In the second routine, a subset of athletes reported relatively more challenge evaluations, but performed significantly worse by failing to complete their routine. These findings provide novel insights into the predictions and boundary conditions of the biopsychosocial model of challenge and threat and emphasise the importance of routine type (mandatory, but relatively simple, first versus free-choice second routine) in predicting trampoline gymnastics performance.

Keywords: Demand-resource evaluation score, elite trampoline gymnastics, personal coping resources, pressurised competition, situational demands.

Predicting Pressurised Competitive Trampoline Gymnastics Performance with Challenge and Threat Evaluations

Sports such as competitive trampoline gymnastics require athletes to execute a well-rehearsed series of movements (also called routine) in a competition. Competitions can be very stressful for both amateur and elite athletes, as they are highly evaluative and athletes invest considerable time and energy in performing well (Blascovich & Mendes, 2000; Blascovich et al., 1999). Failure to perform up to one's potential during such events despite optimal training and preparation may be partly due to psychological factors related to the competitive stress athletes perceive. This study examined whether psychophysiological variables based on the Biopsychosocial Model of Challenge and Threat (BPSM) can predict such pressurised performance in competitive trampoline gymnastics.

The BPSM can explain performance differences between athletes in competitive situations in terms of challenge and threat (CAT) states (Blascovich & Mendes, 2000; Blascovich, 2008). Jones and colleagues extended the model with their Theory of CAT States in Athletes (Jones et al., 2009), a framework that specifically focuses on the sporting context; and this was updated with relevant research findings from the past decade (Meijen et al., 2020). Uphill and colleagues (2019) presented another theoretical development departing from the BPSM with their evaluative space approach to CAT states, which conceptualises CAT as two separate continua that can be experienced to the same degree at the same time. In this work, we conceptualised and measured CAT states as opposite poles to a single continuum consistent with the BPSM (Blascovich, 2008). The BPSM states that sport competitions are examples of motivated performance situations, which are goal-relevant (successful completion helping to attain relevant personal goals), evaluative (personal performance being evaluated), and require adequate performance to maintain personal growth and well-being (Blascovich & Mendes, 2000). For trampoline gymnasts, performing optimally at competitions requires focus, split-second decision-making, and the perfect execution of complex movements. The BPSM proposes that in this context, athletes' psychophysiological responses range on a continuum from challenge to threat. The stress athletes experience here depends greatly on how much value they attach to the competition outcome. When the outcome is perceived to be important and athletes are consequently engaged in the competition, the challenge-threat continuum predictions of the BPSM apply.

These predictions are based on the notion that athletes weigh the demands of the upcoming situation against their personal resources. In this case, situational demands comprise factors like the difficulty of executing the movements constituting one's routine in the given competition. Personal resources comprise factors like physical fitness, motor skills, and psychological characteristics like relative safety, certainty, or familiarity (Blascovich, 2008). When athletes evaluate that they can successfully deal with a situation because their personal coping resources are at least equal to the situational demands, the task is perceived as challenging. Conversely, when athletes evaluate their personal coping resources to fall short of situational demands, a threat state results. These conscious or subconscious cognitive evaluations are inherently subjective and do not necessarily reflect rational-economic calculations (Blascovich et al., 2003).

The cognitive demand-resource evaluations can trigger physiological responses that can be observed on a cardiovascular level. Precisely, engaging in a relevant task will lead to increases in heart rate (number of heart beats per minute) and ventricular contractility (the force with which the heart contracts). When a situation is experienced as challenging, a relative increase in cardiac output (litres of blood pumped per minute) as well as a relative decrease in total peripheral resistance (the degree to which peripheral blood vessels are constricted) are predicted. Conversely, a threat state features relatively little change in cardiac output and little change or relative increases in total peripheral resistance (Blascovich, 2008).

The BPSM is highly relevant for competitive athletes (e.g., baseball and softball players, golfers; Blascovich et al., 2004; Moore et al., 2013), and the field of sport psychology more generally. Literature reviews have supported the prediction that a challenge state is associated with better sport performance than a threat state. For example, two meta-analyses and one systematic review of 62, 19, and 38 studies, respectively, found that a challenge state relates to better performance than a threat state with generally low risk of bias, although the 2018 meta-analysis also highlighted a risk for publication bias (Behnke & Kaczmarek, 2018; Hase, O'Brien, et al., 2019; Hase et al., 2025). The systematic review found the superiority of a challenge state on the cognitive and physiological level to be consistent across outcome tasks and research designs (Hase, O'Brien, et al., 2019). Among the studies that did not find the predicted association between CAT states and performance, most did not involve sporting or even motor tasks (for two exceptions, see Mulvenna et al., 2023 & Sammy et al., 2017). Importantly, only a few studies focused on elite- or high-level athlete performance.

One study by Dixon and colleagues (2020) prospectively examined coach- and self-rated performance in elite football academy matches as a function of cardiovascular CAT responses and found a significant association favouring a challenge state. Another study examined elite academy athletes' performance, albeit in a laboratory-based batting test, also found superior performance was associated with a cardiovascular challenge state (Turner et al., 2013). A study by Turner and colleagues (2021) examined performance in young female netball players trialing for elite netball teams, arguably presenting a pressurised real-world performance situation. The results showed that cognitive CAT evaluations significantly predicted trial outcome (team selection versus non-selection). CAT evaluations have also been used to predict pressurised esports performance, obtaining largely consistent results (Behnke et al., 2020; Sharpe et al., 2024). Namely, Sharpe and colleagues found in two experiments that participants in a high- compared to a low-pressure condition reported more threat and performed worse. Behnke and colleagues (2020) found positive CAT-performance correlations at two timepoints, although only the first one reached statistical significance.

Moreover, three key prospective studies have examined the possibility of a pre-season CAT measure predicting official sport performance metrics. Moore and colleagues (2013) found that pre-competition self-reports of cognitive CAT evaluations predicted competitive golfers’ same-day performance at a pressurised club championship competition. Furthermore, Blascovich and colleagues (2004) found that a pre-season physiological CAT measure predicted the average number of runs scored by college baseball and softball athletes throughout the competitive season. Finally, and most recently, Jewiss and colleagues (2024) found that pre-season physiological CAT did not predict season-long cricket batting performance in a conceptual replication study of Blascovich and colleagues (2004). Given these recent mixed results, it is important to consider complex reciprocal relationships between CAT evaluations and performance over time. Even in same-day measurements, the relationships can be more complex. For example, even though Turner and colleagues (2013) found that a challenge state was generally associated with better performance than a threat state among 42 high-level cricket athletes, they identified subgroups that underperformed in a challenge or performed well in a threat state, pointing to self-efficacy and avoidance goal orientation as explanations. To clarify the relatively scarce and sometimes mixed results regarding the predictive ability of CAT states for athletic performance, the current study will provide valuable results.

Although the abovementioned research provided important insights into the relationship between CAT states and performance in the sports context, the current study addressed a research question that had not yet been answered by this research. Specifically, we focused on the potential of a pre-season CAT measure to predict performance in a single, highly pressurised sport competition in elite-level athletes during their season. If this were the case, it would provide athletes, coaches, and team staff with important knowledge to guide athletes' mental preparations for specific competitions, while holding a time-related advantage over same-day measurements. The study is conceptually similar to Blascovich and colleagues (2004) and Jewiss and colleagues (2024) in that it conceptualises CAT as a potential predictor of temporally distal outcomes (and thus a rather temporally stable construct). However, it deviates methodologically regarding the performance outcome, which was competitive trampoline gymnastics performance in one highly pressurised competition in the season rather than overall season metrics.

Individual trampoline gymnastics performance hinges on a few highly pressurised moments. A trampoline competition typically comprises performing two routines. A routine consists of 10 jumps, during each of which athletes perform a set of transversal and longitudinal body rotations that determine the difficulty of the individual jump (Fédération Internationale de Gymnastique, 2017). Typically, the jumps in the first routine are prescribed by the organising body of the competition, whereas jumps in the second routine are chosen by each athlete. Failing to complete one jump may interfere with the execution of the next jump, or even end the routine if athletes land outside of the permitted area of the trampoline, thus resulting in minor to major score deductions. Thus, the possibility of failing one's routine entirely provides another way of conceptualising and analysing trampoline performance next to comparing continuous performance scores: a dichotomous comparison of athletes who completed their routine versus athletes who did not. Meticulous precision in the execution of each jump is required from athletes not only because of potential score deductions, but also because of the risk of injury if athletes miss the trampoline and fall to the gym floor from several metres high. Thus, athletes are aware that minute mistakes are potentially costly, both for the sake of their score and personal safety.

Performance psychology has often examined (trampoline) gymnastics from a qualitative research angle (Burgess et al., 2016; Dolléans et al., 2011; Hauw & Durand, 2007; Nicholls & Levy, 2016). For example, an interview study with elite trampoline athletes identified major psychological factors to explain good versus bad performance in trampoline gymnastics (Hauw & Durand, 2007). These major psychological factors were 1) finding the best moment to begin the performance, 2) finding and maintaining sufficient engagement to successfully end it, 3) recovering sufficient sensory-motor capacity to perform after temporary difficulties, and 4) maintaining quick and effective problem-solving ability during the performance.

A study of elite gymnasts' lived stressors highlighted that aside from poor training performance, social expectations, and coach evaluations, the constant injury risk presents a significant stressor (Nicholls & Levy, 2016). Taken together, having to deliver an optimal performance in two highly pressurised moments without second chances under the scrutiny of the judges and audience provokes high psychological pressure and a risk of interference with self-focused attention leading to choking under the pressure (Baumeister & Showers, 1986). These competitions thus represent an ideal environment for CAT research. Though previous studies have presented interesting insights into the performance psychology of (trampoline) gymnastics, a quantitative study on CAT evaluations in elite trampoline gymnasts could provide valuable additional insights.

The aim of the present study was to examine whether a cognitive CAT measure taken before the start of the season predicts elite-level trampoline gymnastics performance at one highly pressurised competition later in the season. We hypothesised that a challenge cognitive evaluation would be associated with better performance than a threat evaluation at the competition, both in terms of continuous scores as well as dichotomous routine completion (complete versus incomplete). Following recent findings, we also controlled for general performance level (Jewiss et al., 2023).

Method

Participants

The sample consisted of 50 Dutch elite trampoline gymnasts (31 female, 19 male) competing at national ($N = 25$) and international level ($N = 25$)[1]. This sample size was determined by resource constraints rather than statistical power considerations (Lakens, 2022). Precisely, we tested all athletes in the collaborating trampoline

[1] Competitive level was included in sensitivity analyses but did not change the pattern of results and was therefore excluded from the main analyses for analytical parsimony.

federation's pre-season training camp who consented to participate in the study. Age ranged from 11 to 26 years, with a mean of 15.8 years (*SD* = 4.0).

Materials

Demand and Resource Evaluations

Two items assessed cognitive demand and resource evaluations (adapted from Schneider, 2008). These items have been commonly used in previous CAT research (e.g., Vine et al., 2013). Adapted to the trampoline gymnastics context, the measure prompted athletes to imagine their most important competition of the upcoming season and then presented two items: "How demanding do you expect the upcoming routine to be?" for demands and "How able are you to cope with the demands of the upcoming routine?" for resources. As participating athletes had little time available for the measurements, we opted for previously established single-item measures of demands and resources (e.g., Moore et al., 2014) to keep time requirements per participant to a minimum. Both items were translated into Dutch and scored on a 7-point Likert scale anchored by *not at all* (1) and *extremely* (7, as per Schneider, 2008). A cognitive CAT variable was created by subtracting demands from resources, meaning that possible scores ranged from -6 to 6 with higher scores representing evaluations more consistent with a challenge appraisal. As the BPSM associates the importance of a motivated performance situation with task engagement and subsequent CAT states (Blascovich, 2008), we focused on the most important competition of the upcoming season to maximize task engagement and thereby the validity of the reported CAT evaluations.

Performance

Performance (i.e., the separate first- and second-routine scores) was retrieved from the official result publications of the competitions specified as each athlete's most important competition of the season, which on average took place 37.7 days after the initial measurement (*SD* = 14.3, range: 7-70 days). As is common in competitive trampoline gymnastics, a panel of judges assessed the difficulty and execution of the individual jumps, and individual jump scores were summed to a final routine performance score, where higher scores denoted better performance (Fédération Internationale de Gymnastique, 2017). The analysis was limited to scores from individual trampoline jumping competitions to avoid confounding influences (e.g., athletes receiving a low score due to mistakes committed by their partner in a synchronised trampoline jumping competition).

In addition to the first and second routine performance scores from the self-reported most important competition of the season, a second performance measure was used as a control variable in the study (hereafter termed "season performance"). This measure comprised scores from up to six competitions that the athletes competed at during their season. These competitions were the last qualifier competition for the world championships, the world championships, the national club championships, and the first three qualifier competitions for the individual national championships. The athletes competed at an average of four out of these six competitions (*M* = 4.08; *SD* = 1.18).

Procedure

The study was approved by an institutional ethical committee. Baseline measurements took place at a national trampoline gymnastics training camp as well as at the following training sessions of some participating athletes due to time constraints or athletes' absence at the training camp. Prior to participation, athletes (and both of their parents/guardians for under 18s) provided written informed consent.

The data collection took place in a quiet room provided by the participating trampoline association and local clubs. After a five-minute resting period, the experimenter delivered the following instructions to participants:

> The rest period has now finished. Shortly, we would like to ask you to imagine your most important competition this upcoming season. Specifically, please imagine what is going to happen in the last minute before starting your routine at this competition. This is the most important part of the experiment.

Immediately afterward, the experimenter asked participants to name their most important competition of the upcoming season. Participants then reported the specific competition and were given one minute to imagine the last minute before starting their routine there. Next, the experimenter delivered the following instructions:

> Now for the next one minute, we would like you to describe out loud your feelings and thoughts during the last minute before starting your routine and how you expect to perform at your competition.

After this minute of speaking about the imagery associated with the last minute before the start of the competition (the responses were neither recorded, nor otherwise analysed), participants reported demand and resource evaluations for the competition, and the experimenter thanked them for participating. Performance scores were retrieved from the official result publications. Cardiovascular data were recorded throughout the resting, imagery, and talk aloud periods, but due to equipment problems, we do not report them here. These equipment problems most likely resulted from the Portapres not including a finger cuff small enough to measure cardiovascular data of the athletes with smaller fingers in our sample accurately. As a result, the recordings of 21 participants (42%) were missing due to signal loss or blood pressure readings and cardiac output estimates being unrealistically low and thus unsuitable for a scientific publication. For transparency, we report the smaller-sample analyses including cardiovascular CAT as well as more information regarding the physiological measurements in online supplementary material OSM 1.

Transparency and Openness

We performed all analyses in RStudio (version 2023.6.1.524, RStudio Team, 2020) using two-tailed tests with a significance level of $\alpha = .05$. We cite all data and methods used appropriately and report all instances of missing or transformed data. The reported study was part of a larger research project on the antecedents to psychophysiological stress responses in elite trampolining. The research question does not overlap with any other publication based on this project. Analysis code and/or raw data are available upon request from the corresponding author. The reported study was not preregistered. The sample size was determined by resource constraints (Lakens, 2022); that is, by the availability of elite-level trampoline gymnasts in the collaborating trampoline federation who volunteered to participate in the study.

Data Processing and Statistical Analysis

To reduce distributional problems, we winsorised outlying performance data (values more extreme than $\bar{y} \pm 3SD$; Stevens, 2009) to be 1% more extreme than the next non-outlying score (as Shimizu et al., 2011). Winsorisation is a commonly used outlier treatment option in the BPSM-based CAT literature as it allows to avoid losses in statistical power while also treating outliers (e.g., Moore et al., 2012, 2014; Hase, Gorrie-Stone, et al., 2019). On first routine performance scores, the procedure achieved an approximately normal distribution for the main analysis (described below). We kept the approach consistent for second routine performance data even though in this case, the winsorisation was insufficient to remedy the distribution problems, which is why we performed a censored analysis (see below). One outlier in the first routine data was winsorised, and nine outliers in the second routine data. The outlying nature of the latter nine data points was due to athletes' non-completion of their routines, which commonly occurs in trampoline gymnastics when athletes make a mistake too severe to allow them to continue their routine (e.g., landing outside the permitted area of the trampoline).

We tested the relationship between winsorised performance as the dependent variable and cognitive CAT as the independent variable using multiple linear regression analyses that controlled for age, sex, and season performance and entered all predictors in the same step. Analyses were conducted for each of the two routines performed in the self-reported most important competition of the season. Squared semipartial correlations were calculated as measures of effect size. The assumptions of normality, linearity, and homogeneity of variance were tested using histograms and x-y scatterplots; and were deemed approximately met for winsorised first routine performance. For winsorised second routine performance, the normality assumption was violated due to the very low scores of routine non-completers, which inflated the low end of the continuum. To take this systematic deviation from normality into account, we performed tobit regression using the crch() function of the *crch* package using a lower limit of the lowest complete-routine score for the censored dependent variable (42.485 points; Messner et al., 2014). This way, we could statistically control the systematic deviation from normality due to routine non-completion. To examine potential differences between second routine completers and non-completers, five independent samples *t*-tests compared the two groups on cognitive CAT, demand evaluations, resource evaluations, first routine performance, and age. For these tests, Cohen's *d* values were computed as effect size measures (Cohen, 1992). As only one athlete did not complete the first routine, the comparisons could not be repeated for first routine scores. We calculated post-hoc power estimates with the pwr.t.test() and pwr.f2.test() functions of the *pwr* package (Champely, 2020).

Results

Of the 50 participants, four athletes did not compete in their self-reported most important competition, and one could not be included in the main analyses due to missing season average performance data (no performance scores aside from their most important competition of the season were found). Thus, there was an effective sample of 45 in the main analyses. Table 1 reports descriptive statistics for, and correlations between, all variables. Most athletes (84%) reported the FIG trampoline world championships or the World Age Group Competitions (the equivalent for age groups 11-12, 13-14, 15-16, and 17-21 years) as the most important competition.

CAT and Competition Performance

Table 2 presents the results of the multiple linear and tobit regression analyses of first and second routine performance scores, respectively.

The first routine model explained a significant proportion of the variance in performance [$R^2_{adj} = .72$, $F(4, 40) = 29.35$, $p < .001$, post-hoc power > .99]. There were significant effects for cognitive CAT ($B = 0.47$, $t = 2.85$, $p < .01$, $sr^2 = .05$), first routine season performance ($B = 0.26$, $t = 2.76$, $p < .01$, $sr^2 = .05$), and age ($B = 0.59$, $t = 6.54$, $p < .001$, $sr^2 = .27$), such that individuals who evaluated more challenge, had better season performance, and were older performed better in the first routine. There was no significant effect for sex ($B = 0.11$, $t = 0.18$, $p = .86$, $sr^2 < .01$).

The tobit regression model for second routine performance [log-likelihood = -97.34, *df* = 6, $R^2_{\text{Cox-Snell}}$ = .49, post-hoc power > .99] showed no significant effects for cognitive CAT (*B* = -0.11, *z* = -0.42, *p* = .67, *r* = -.06), nor second routine season performance (*B* = 0.10, *z* = 1.69, *p* = .09, *r* = .24). There was a significant effect for age that replicated the first routine finding (*B* = 0.51, *z* = 4.29, *p* < .001, *r* = .54), but no significant effect for sex on second routine performance (*B* = 1.06, *z* = 1.12, *p* = .26, *r* = .16).

CAT and Second Routine Completion Status

Table 3 summarises the independent-samples *t*-tests comparing athletes who completed second routine with those who did not. The tests showed that second routine non-completers reported CAT evaluations significantly more consistent with a challenge state, corresponding to a large effect, [*t*(44) = 2.53, *p* = .02, *d* = 0.89, post-hoc power = .84]. Analysing CAT evaluations separately showed a statistically significant difference with a medium effect size on demand evaluations [*t*(44) = -2.39, *p* = .03, *d* = -0.75, post-hoc power = .70], and a non-significant difference of medium effect size on resource evaluations [*t*(44) = 1.44, *p* = .18, *d* = 0.57, post-hoc power = .47], indicating that non-completers reported less demands and more resources than completers. Cohen's *d* values indicated negligible to small effects for first routine performance. Precisely, second routine non-completers had higher first routine performance scores (i.e., better performance; *d* = 0.35, post-hoc power = .21).

Discussion

The present study tested the hypothesis that a challenge cognitive evaluation at a pre-season training camp would be associated with better trampoline gymnastics performance at the self-reported most important competition of the season than a threat evaluation. Performance was examined in different ways, but generally based on expert judge evaluations, presenting an extension to most CAT studies in sports that have used objective performance indicators (for another exception, see Dixon et al., 2020). As athletes performed two different routines with different requirements, we examined two continuous routine performance scores. Moreover, the considerable number of athletes who did not manage to complete their second routine enabled a dichotomous comparison of completers versus non-completers for this routine. The results were mixed regarding the main hypothesis and showed a complex picture of performance under pressure, where cognitive evaluations may be predictive of performance in different ways depending on the type of routine performed.

In interpreting the results, it is important to keep in mind the time-separated contexts in which CAT evaluations and performance were observed. Consistent with the integrative framework of stress, attention, and visuomotor performance (Vine et al., 2016), the average time gap of over five weeks between CAT evaluations and performance allowed for feedback loops producing continuous reappraisal of the competitive situation, which means that observing a significant relationship between pre-season evaluations and performance would suggest rather stable individual differences in CAT evaluations (e.g., Tomaka et al., 2018). However, one should also note the considerable variation in the gap between CAT evaluations and performance, whose impact future research would do well to explore. Another variable to consider would be athletes' imagery ability (e.g., Cumming & Eaves, 2018; Rhodes et al., 2024), which should become more relevant for temporally distal performance outcomes. Unfortunately, we did not include this variable in the measurements. A last interpretive caveat would be the contrast with Blascovich and colleagues' (2004) work, which, like

Jewiss and colleagues (2024), focused on overall season performance, whereas we focused on one specific competition.

The main hypothesis was supported in the regression analysis of routine 1 performance (Table 2). There was a significant positive relationship between cognitive CAT evaluations and continuous first routine (i.e., mandatory and typically slightly less demanding) performance scores, favouring a challenge over a threat evaluation. Hence, trampoline gymnasts who self-reported cognitive evaluations more consistent with a challenge state (i.e., personal resources matching or outweighing situational demands) in the pre-season measurement were more likely to obtain a higher score for their mandatory routine at the most important competition of the season than athletes reporting evaluations consistent with a threat state. This finding is consistent with the predictions of the BPSM (Blascovich, 2008), the Theory of CAT States in Athletes (Jones et al., 2009), and previous empirical findings (Hase et al., 2025; Hase, O'Brien, et al., 2019). However, this is the first study to demonstrate that it is possible to predict performance at a highly pressurised future competition by assessing cognitive evaluations with a pre-season measurement. This is similar to Blascovich and colleagues (2004), who predicted season average batting performance in softball and baseball with a physiological pre-season CAT measure. The temporal separation of the observed CAT evaluations and performance implies that there might be a relatively stable individual differences component to CAT evaluations, although the role of variation in the time gap should be explored further. In a vignette study, this component has been estimated to explain around 15% of the variance in cognitive CAT evaluations (Moore et al., 2019). Future studies in various real-world performance situations could provide further important insights into this topic (cf. Dixon et al., 2020; Moore et al., 2013; Turner et al., 2021).

Apart from theoretical convergence, this finding also holds relevance for practitioners, as a simple measure of CAT evaluations could provide early insights into athletes' preparedness to adaptively deal with the mandatory first routine in an important future competition. If necessary, it could provide time to develop and implement a challenge-promoting or stress-mitigating intervention, for example pressure inurement training (van Rens et al., 2020) or self-compassion (Mosewich et al., 2013). Even in case of limited time, this measure could allow staff to select and employ an acute sport psychological intervention to mitigate the effects of a threat state on performance. For example, one could use self-distancing (Streamer et al., 2017) or mindfulness-based stress reduction techniques (e.g., Jones et al., 2020) to reduce and reappraise performance anxiety symptoms, thereby promoting a more challenge-like perspective. Though the exact demands-resources balance at which practitioners best intervene prior to a competition needs to be studied in more detail, practitioners could begin by screening for a negative balance (i.e., demands outweighing resources) as an early warning sign for potential performance issues.

The association between cognitive CAT evaluations and performance was not replicated on the continuous second routine performance outcome. More importantly, the dichotomous second routine comparisons of routine completers versus non-completers produced a contrary result. Contrary to the hypothesis, second routine non-completers (relative to those with a complete routine) reported evaluations more consistent with a challenge state. The reason for this might be the different natures of the two routines. The first routine typically consists of mandatory jumps of moderate difficulty in a fixed order, whereas in the second routine athletes often seize the opportunity to choose a series of more complex (i.e., difficult and thereby risky) jumps. This should make first routine performance more predictable, and personal evaluations of resources relative to situational demands easier, which might strengthen the relationship between cognitive CAT evaluations and performance. In contrast, the second routine often features maximum-difficulty jumps that are risky even for the best athletes. Experienced athletes might evaluate the upcoming competition as a challenge, but still fail their second routine due to its inherent risk. It should also be noted that the cognitive CAT evaluations were only reported once for the entire competition. This could explain the unexpected findings in the analysis of second routine performance. Since we asked athletes to imagine the last minute before starting their most important competition of the season, they might likely have imagined their first routine-focused preparatory minute, which might explain the better predictive ability of CAT evaluations for first than for second routine performance.

It could also be that previously well-performing athletes, who evaluate more resources relative to demands based on previous results, are more likely to choose more difficult jumps in the second routine. This would naturally place them at greater risk of failing the routine. If this were the case, one would expect these athletes to have better first routine performance and higher intended second routine difficulty scores. This hypothesis can be scrutinised only partially here, as performance, but not intended second routine difficulty scores were available to the research team. The first routine performance difference between second routine completers and non-completers was not statistically significant (the comparison was certainly underpowered according to a post-hoc power estimate); though a small effect size suggested potential practical significance (see Table 3; Cohen, 1992). Supporting our speculation, first routine scores of second routine non-completers were slightly higher than those of second routine completers. Thus, it might indeed be that previously better-performing athletes are more likely to fail their second routine due to the self-imposed difficulty increase of the second routine. As a result, this would question the prediction that a challenge state relates to better decision-making than a threat state (Jones et al., 2009), potentially requiring more precise specification of the prediction's boundary conditions. Certainly, future research would do well to elucidate the relationship between CAT states and decision-making further to advance existing theoretical models.

Another potential explanation for the different cognitive CAT evaluations of second routine completers and non-completers would be overconfidence, meaning that the higher scores in non-completers reflect inflated resource and/or diminished demand evaluations after relatively strong first routine performance. Brimmell and colleagues (2019) reported a relevant trend toward more challenge-consistent evaluations after successful performance in a penalty shooting task, but unfortunately did not examine subsequent performance. The notion of overconfidence after successful performance might also be consistent with the "high challenge" state described by the revised Theory of CAT States in Athletes (Meijen et al., 2020), which associates it with high self-efficacy. Though initially positively related with performance, high self-efficacy has been found to have a complex relationship with performance in repeated performance contexts (Beattie et al., 2011). Thus, successful prior performance might have provoked a disrupted second performance due to overconfidence in the present study, despite high self-efficacy and challenge. In the high-stakes context of the second routine in competitive trampoline gymnastics, a relative cautiousness about one's abilities might be rather adaptive and would resonate with prior research finding that experimentally decreasing self-confidence can under some circumstances increase performance (Woodman et al., 2010). In any case, differences between second routine completers and non-completers should be interpreted with caution given the small sample sizes.

Some limitations to the study need to be noted. Due to the naturalistic study design, it was not possible to sample more participants, which would have especially benefited the statistical power of the dichotomous comparisons of second routine non-completers and completers. The study also suffered from the lack of a physiological CAT measurement, which was not available for technical reasons. This study was also limited by athletes only being asked to imagine the last minute before starting their important competition and to provide routine-unspecific CAT evaluations, as opposed to separately imagining the last minute before both their first and second routine and providing CAT evaluations separately for both routines. Doing this might have resulted in better predictive ability of cognitive CAT evaluations for second routine performance. This study's prediction of performance might have also been limited by the lack of control variables like imagery ability (Cumming & Eaves, 2018) and other relevant individual difference variables (e.g., risk-taking; Porcelli & Delgado, 2017). These conclusions can inform future CAT studies as well as theoretical models dedicated to predicting athletic performance with CAT states.

Future research could test whether the present findings generalise to other sports, especially team sports, in which the interplay between CAT states on the individual level and group-level performance is still unexplored, and likely more complex. Another gap left by this study is the content of athletes' responses to the question about their last pre-competition minute, which was not recorded or analysed.

Such data might improve the mechanistic understanding of CAT states regarding involved cognitions, emotions, attention, and motivation. As such, future studies of this topic could produce valuable conceptual and theoretical advances, for example by being the first to combine traditional CAT research with natural language processing. Finally, research could examine moderators of the cognitive CAT-performance relationship like (subjective) task difficulty and task engagement, enabling the development of interventions to improve athletes' ability to accurately assess demand and resource evaluations.

Conclusion

The present study used a cognitive CAT measure to predict performance at high-level trampoline gymnasts' self-reported most important competition of the season, which consisted of a routine with predefined performance requirements and a "free" routine with freely chosen figures. There was no consistent support for the hypothesis that a cognitive challenge evaluation relates to better trampoline gymnastics performance. On the one hand, a cognitive challenge evaluation was associated with better performance than a threat state in the analysis of first (predefined, slightly less complicated) routine performance. On the other hand, there was no relationship between CAT evaluations and second (freely chosen and usually more complicated) routine performance, and athletes who did not complete the second, arguably more pressurised, routine reported cognitive evaluations more consistent with a challenge state. These findings hold relevance for coaches, sport psychologists, and other professionals interested in predicting and optimising athletes' performance under pressure, highlighting the importance of distinguishing between first and second routine performance. They also demonstrate that in the case of first routine performance scores, an early measure of cognitive CAT evaluations may be useful as it could predict pressurised performance weeks later.

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Table 1

Descriptive Statistics and Correlation Matrix

	M	*SD*	1.	2.	3.	4.	5.	6.
1. Performance – First Routine	42.53	3.62	N/A					
2. Performance – Second Routine	46.83	3.38	**.45***	N/A				
3. Season Average Performance – First Routine	41.16	4.34	.68***	**.29**	N/A			
4. Season Average Performance – Second Routine	42.71	8.07	**.19**	**.42***	**.34**	N/A		
5. Cognitive CAT	0.09	1.88	.04	**-.33**	.11	**-.05**	N/A	
6. Age	17.04	4.12	.79***	**.59*****	.55***	**.22**	-.28	N/A

Note. $N_{min} = 45$. Significance denoted by $^{*}p < 0.05$, $^{***}p < 0.001$. Reported correlation coefficients are Pearson's *r*, except for those highlighted by boldface (Spearman's rho).

Table 2

Multiple Linear Regressions for each Routine

	First Routine					Second Routine			
Effect	*B*	*β*	*t*	Sig.	sr^2	*B*	*z*	Sig.	r^2
Cognitive CAT	0.47	.26	2.85	.01	.05	-0.11	-0.42	.67	< .01
Season Average for Respective Routine	0.26	.29	2.76	.01	.05	0.10	1.69	.09	.06
Age	0.59	.68	6.54	< .001	.27	0.51	4.29	< .001	.29
Sex	0.11	.02	0.18	.86	< .01	1.06	1.12	.26	.03
Constant	21.86		6.72	< .001		33.25	11.73	< .001	
		$R^2 = .75$, $R^2_{adj} = .72$					$AIC = 206.70$, $RMSE = 2.44$, $R^2_{Cox\text{-}Snell} = .49$		

Note. $N = 45$. Dependent variable: Winsorised performance at self-reported most important competition of the season. Due to the systematic violation of regression assumptions due to inflation of low scores, we used tobit regression to analyse second routine scores.

Table 3

t-Tests Comparing Athletes with Incomplete Second Routine Against Remaining Athletes

	Incomplete Routine			Complete Routine					
Effect	*M*	*SD*	*N*	*M*	*SD*	*N*	*t*	*p*	Effect Size (*d*)
Cognitive CAT	1.56	1.59	9	0.03	1.76	37	2.53	.02	0.89
Demands	3.78	0.83	9	4.57	1.09	37	-2.39	.03	-0.75
Resources	5.33	1.41	9	4.59	1.26	37	1.44	.18	0.57
First Routine Performance	42.81	2.77	9	41.64	3.46	37	1.08	.30	0.35
Age	15.44	2.74	9	16.00	4.33	37	-0.48	.64	-0.14

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