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The influence of self-talk on challenge and threat states and performance

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ABSTRACT

Objectives: A psychophysiological response called a challenge state has been associated with better performance than a threat state. However, to date, challenge-promoting interventions have rarely been tested. Therefore, this study investigated whether instructional and/or motivational self-talk promoted a challenge state and improved task performance.
Design: A three-group, randomised-controlled experimental design was used.
Method: Sixty-two participants (52 males, 10 females; M_{age} = 24 years, SD = 6) were randomly assigned to one of three self-talk groups: instructional, motivational, or control (verbalising trial number). Participants performed four dart-throwing tasks. Cognitive and cardiovascular measures of challenge and threat states were recorded before the first and final task.
Results: The motivational, but not the instructional group, improved their performance between the first and final tasks more than the control group. Self-talk had no effect on the cognitive or cardiovascular challenge and threat measures. However, evaluating the task as more of a challenge (coping resources match/exceed task demands) was related to better performance. Cardiovascular reactivity more reflective of a challenge state (higher cardiac output and/or lower total peripheral resistance reactivity) was more positively related to performance in the motivational than in the control group, and in the control than the instructional group.
Conclusions: Motivational self-talk improved performance more than control self-talk. Furthermore, motivational self-talk may have strengthened, whereas instructional self-talk may have weakened, the relationship between challenge and threat states and performance. Hence, athletes in a challenge state may benefit from motivational self-talk, whereas those in a threat state may profit from instructional self-talk.

1. Introduction

In elite sport, it is common to see some athletes choke, whereas others excel under pressure (Hill, Cheesbrough, Gorczynski, & Matthews, 2019). The biopsychosocial model of challenge and threat (Blascovich, 2008), and the theory of challenge and threat states in athletes (Jones, Meijen, McCarthy, & Sheffield, 2009) both provide explanations for such instances of performance variability. The theories conceptualise challenge and threat (CAT) states as distinct patterns of cognitive evaluations and physiological responses in motivated performance situations. There is overlap between the proposed effects of self-talk in the Framework for the Study and Application of Self-talk within Sport (Hardy, Oliver, & Tod, 2009) and the effects of a challenge state in the aforementioned CAT theories. Thus, this study tested whether self-talk, a widely researched phenomenon in sport, influenced CAT states.

Motivated performance situations (e.g., sporting competitions, university exams, job interviews) are characterised by their potentially stressful nature, and require an active coping effort or an instrumental cognitive and/or behavioural response, to attain an important and self-relevant goal (Blascovich, 2008). In these situations, CAT states occur on a single bipolar continuum, which can be described in terms of underlying cognitive evaluations and accompanying physiological responses (Blascovich, 2008). Due to the continuous nature of CAT states, relative rather than absolute differences in CAT are often examined. Toward the challenge end of the continuum, athletes evaluate that their coping resources match or exceed situational demands. Toward the threat end, athletes evaluate that coping resources fall short of situational demands. It should be noted that these evaluations are subjective rather than objective. The biopsychosocial model of challenge and threat posits that the balance of evaluated coping resources to situational demands engenders specific physiological responses. Both CAT states require task engagement, which is marked by increases in heart rate (number of heart beats per minute) and ventricular contractility

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(contractile state of the left ventricle). A challenge evaluation, however, is associated with a cardiovascular reactivity pattern consisting of relatively greater cardiac output (volume of blood ejected by the left ventricle per minute) and lower total peripheral resistance (degree of systemic peripheral vascular constriction), whereas a threat evaluation is linked to a pattern composed of relatively lower cardiac output and greater total peripheral resistance (Tomaka, Blascovich, Kelsey, & Leitten, 1993).

Both the biopsychosocial model of challenge and threat and the theory of challenge and threat states in athletes specify that a challenge state is related to better performance than a threat state (Blascovich, 2008; Jones et al., 2009). Although a recent meta-analysis noted that the effect may be small (Behnke & Kaczmarek, 2018), a challenge state has been associated with superior performance relative to a threat state in 74% of studies conducted across various tasks and contexts (e.g., baseball/softball, golf putting, surgery; see Hase, O'Brien, Moore, & Freeman, 2018 for a review). For example, in a sample of experienced golfers, Moore, Vine, Freeman, and Wilson (2013) found that cognitive evaluations more consistent with a challenge state were related to better performance than evaluations more indicative of a threat state (Moore et al., 2013). Thus, knowing how to promote a challenge state (or counteract a threat state) could enable the optimisation of performance during pressurized competition. Related to this notion, the theory of challenge and threat states in athletes specifies that high self-efficacy, high perceived control, and an approach focus promote more favourable cognitive evaluations and a challenge state. This theory also specifies that a challenge state leads to more efficient attention, positive emotions, and emotions being perceived as more facilitative for performance (Jones et al., 2009). In contrast, low self-efficacy, low perceived control, and an avoidance focus promote less favourable cognitive evaluations and a threat state. Finally, according to this theory, a threat state results in less efficient attention (i.e., a focus on task-irrelevant stimuli), negative emotions, and emotions being perceived as unhelpful for performance (Jones et al., 2009).

Previous laboratory-based research has successfully manipulated CAT states either directly with scripts influencing evaluations of situational demands and/or personal coping resources (e.g., verbal instructions, Moore, Vine, Wilson, & Freeman, 2012; audio instructions, Turner, Jones, Sheffield, & Barker, 2014), or indirectly via psychological interventions (e.g., arousal reappraisal, Moore, Vine, Wilson, & Freeman, 2015; quiet eye training, Moore et al., 2013; imagery, Williams & Cumming, 2012). Despite some promising findings demonstrating the successful manipulation of CAT states and performance (e.g., study 2, Feinberg & Aiello, 2010; Moore et al., 2013; Moore et al., 2015), other evidence has been more equivocal. Indeed, in one study, the manipulation only had a marginally significant effect on CAT states, and the threat group outperformed the challenge group (i.e., study 1, Feinberg & Aiello, 2010). Meanwhile, in the two other studies, the manipulation check confirmed a successful manipulation of underlying demand and resource evaluations (study 4, Feinberg & Aiello, 2010; Williams & Cumming, 2012), but there were no effects on task performance. Following these mixed findings, it is important to examine if other psychological interventions can lead to a challenge state and improved performance. One possible intervention is self-talk.

Self-talk is often used in sport to direct attention, create more positive interpretations of anxiety, and optimise performance (Hatzigeorgiadis, Zourbanos, Galanis, & Theodorakis, 2011; Wadey & Hanton, 2008). Self-talk includes spontaneously occurring automatic thoughts and verbalisations, and deliberate and strategic statements addressed to oneself (Hardy et al., 2009). Self-talk can vary in terms of content, emotional valence, and whether it is audible or silent and deliberate or automatic (Theodorakis, Weinberg, Natsis, Douma, & Kazakas, 2000; Theodorakis, Hatzigeorgiadis, & Zourbanos, 2012; Van Raalte, Vincent, & Brewer, 2016).

A recent review distinguished organic and strategic self-talk, which represent self-statements reflecting ongoing cognitive processes and cue words used for strategic purposes, respectively (Latinjak, Hatzigeorgiadis, Comoutos, & Hardy, 2019). Organic self-talk has further been divided into spontaneous and goal-directed self-talk, which represent the unintentional (automatic) and intentional responses to athletes' emotions and thoughts. The review also distinguished strategic (comprising mechanical repetition of cue words) from reflexive self-talk (in which the use of organic self-talk is discussed in a reflexive exercise, but no self-talk is used). Beyond these distinctions, two of the most common forms of self-talk are instructional (i.e., cues that direct attention and instruct regarding technical, strategic, or kinaesthetic aspects of skill execution) and motivational (i.e., cues that maximise motivation, effort, confidence, and positive mood; Hatzigeorgiadis et al., 2011). Both forms of self-talk improve performance (Tod, Hardy, & Oliver, 2011), and motivational self-talk reduces cognitive anxiety and enhances self-confidence (Hatzigeorgiadis, Zourbanos, Mpoumaki, & Theodorakis, 2009).

Furthermore, a key self-talk theoretical model, the Framework for the Study and Application of Self-talk within Sport (Hardy et al., 2009), specifies that self-talk can exert effects on attention, motivation, affect, and behaviour in ways similar to a challenge state. Specifically, self-talk is thought to improve concentration and reduce interfering thoughts, increase self-efficacy, improve anxiety and interpretations of anxiety symptoms, and optimise movement and skill execution. However, none of the abovementioned theories specify CAT states as a potential mechanism in the relationship between self-talk and performance.

As theoretical models and empirical research in the CAT and the self-talk literature propose consistent effects of a challenge state and effective self-talk (i.e., improved performance, attention, self-efficacy, and more facilitative interpretations of emotions), the present study aimed to examine the effect of three different strategic self-talk interventions on CAT states; specifically comparing instructional, motivational, and control self-talk cues. We hypothesised that in anticipation of a post-training dart-throwing task, participants in the instructional and motivational self-talk groups would report cognitive evaluations (i.e., coping resources match/exceed task demands), and exhibit cardiovascular responses (i.e., relatively higher cardiac output and/or lower total peripheral resistance reactivity), more reflective of a challenge state than those in the control self-talk group (verbalising the trial number as a neutral self-talk cue; H1). Furthermore, we hypothesised that participants in the instructional and motivational self-talk groups would perform a post-training dart-throwing task better than those in a control self-talk group (relative to pre-training performance; H2). Finally, we hypothesised that cognitive evaluations (i.e., coping resources match/exceed task demands), and cardiovascular responses (i.e., relatively higher cardiac output and/or lower total peripheral resistance reactivity), more consistent with a challenge (versus a threat) state would be related to better task performance (H3).

2. Method

2.1. Participants

A power calculation for a repeated-measures ANOVA with a between-within interaction was conducted using G*Power software version 3.1.9.2. Because no effect size could be obtained for the effect of self-talk on CAT states, a medium effect size was assumed ($d = 0.50$; Cohen, 1992). This is consistent with the average effect of self-talk on performance ($d = 0.48$; Hatzigeorgiadis et al., 2011). With an alpha level of 0.05, and 90% desired power, the power calculation produced a minimum sample size of 54 (60 for $d = 0.48$). The final sample consisted of 62 university students and members of staff (84% male; $M_{\text{age}} = 24$ years, $SD = 6$, range 18–52). Native English speakers comprised 55% of the sample. All participants reported being right-handed or ambidextrous. Two participants reported having played darts at club level, whereas the remaining participants reported not engaging in competitive darts before.

2.2. Materials

Cardiovascular data. The Portapres Model-2 (Finapres Medical Systems BV, Amsterdam, the Netherlands) was used to record three cardiovascular variables: heart rate, cardiac output, and total peripheral resistance. The Portapres bases its measurements on the arterial volume-clamp method of Peňáz (1973), and the physiological calibration criteria for the proper unloading of the finger arteries of Wesseling (1996). It also uses a height correction unit to compensate for hydrostatic pressure changes due to movement of the hand. Previous research has used the Portapres for CAT measurements (e.g., Hase, Gorrie-Stone, & Freeman, 2018; Moore, Young, Freeman, & Sarkar, 2018), and it has been validated against the Finapres and Oxford method, and was found to be accurate, reliable, and cause no more missing data due to artefacts than the latter method (Hirschl, Woisetschläger, Waldenhofer, Herkner, & Bur, 1999; Imholz et al., 1993). Data were converted and downloaded for analysis using Beatscope software version 1.1.

Demand and resource evaluations. Demand and resource evaluations were assessed via two self-report items from the Stressor Appraisal Scale (Schneider, 2008). These items have been well-established in the CAT literature, and have been used to validate CAT cardiovascular indices (e.g., Tomaka, Blascovich, Kibler, & Ernst, 1997; Tomaka et al., 1993), and in research linking cognitive evaluations, cardiovascular responses, and performance (e.g., Hase, Gorrie-Stone, et al., 2019a,b; Vine, Freeman, Moore, Chandra-Ramanan, & Wilson, 2013). Specifically, these items asked participants: "How demanding do you expect the upcoming task to be?" and "How able are you to cope with the demands of the upcoming task?". Consistent with Schneider (2008), both items were scored on a seven-point Likert scale anchored between *not at all* (1) and *extremely* (7). A cognitive CAT variable (i.e., demand resource evaluation score) was then created by subtracting evaluated demands from resources, meaning that scores ranged from −6 to 6 and higher values denoted evaluations more consistent with a challenge state (i.e., resources match/exceed demands; Moore et al., 2013).

Self-talk manipulation check. Two self-report items were used to ask participants about their self-talk use: "How often did you repeat your self-talk statement?" and "Do you believe that this procedure was helpful to you?" (Theodorakis et al., 2000). Both items were scored on a 10-point scale anchored between *not at all* (1) and *extremely* (10).

Dart-throwing performance. Participants threw darts from a distance of 2.4 m toward a dartboard of 44.8 cm diameter, with the centre (bulls-eye) 1.7 m above the floor. Unlike a traditional dartboard, the board was divided into nine concentric circles around a red bulls-eye. Landing a dart in the outermost ring was worth one point, with every more central ring worth one more point, and 10 points being awarded for landing the dart in the bulls-eye. Darts that landed outside the outermost ring scored zero points. Time to complete each task was recorded, but there was no time limit for the tasks, and completion time did not significantly differ between groups in the baseline [$F(2, 59) = 0.36$, $p = .70$, $\eta_p^2 = 0.01$], or final [$F(2, 59) = 0.44$, $p = .65$, $\eta_p^2 = 0.02$] task.

2.3. Procedure

This study was approved by the University of Essex ethics committee (SRES 1718). Upon entering the laboratory, participants were given an information sheet and provided informed consent. The information sheet explained the study and highlighted that rewards would be given to the three best performers on the two competitive dart-throwing tasks (i.e., baseline and final task combined), which each consisted of 20 throws. The order of the dart-throwing tasks was: (1) baseline task (20 throws), (2) first training block (10 throws), (3) second training block (10 throws), and (4) final task (20 throws). Before starting the baseline task, participants sat in front of a computer screen and a Qualtrics survey guided them through the study protocol. Participants first provided demographic information (e.g., age, sex, native language, previous darts experience), and then the experimenter put the Portapres on the left hand of participants (cardiovascular measurements with this device may be sensitive to laterality, which is why right-handed or ambidextrous participants were recruited), with the cuff around the middle finger and the height correction sensor around the upper arm at the height of the sternum. Resting cardiovascular data were then recorded for 3 min (as Vine et al., 2013). After that, the computer presented instructions highlighting the task rules, scoring method, and existence of rewards for the top three performers to encourage task engagement. Participants were asked to confirm that they had read the instructions, and then think about the instructions and the upcoming task for 1 min, during which cardiovascular data was recorded. Participants then reported demand and resource evaluations before standing up and performing the baseline task (20 throws). Performance was recorded for all throws.

Next, participants were randomly assigned (with a randomiser embedded in the Qualtrics survey) to the instructional, motivational, or control self-talk group, and received instructions on the screen to stand up and perform the first training block comprising 10 throws. Immediately before each of these throws, participants verbalised their self-talk cue out loud. The self-talk cues were adapted from Theodorakis et al. (2000), who used the same motivational self-talk cue (i.e., "I can"). Due to the different tasks used in their studies, we modified the instructional self-talk cue to maintain a visual attentional focus on the target of the dart-throwing task (i.e., "aim central"; aiming to promote a quiet eye; Moore et al., 2013). In the control self-talk group, the self-talk cue was "Trial *x*", where *x* stands for the number of the throw. It was emphasised that these throws were for training purposes only, and that the scores would not contribute to the final competitive score. After the first training block, participants were instructed to perform another 10 training throws in a second block, this time verbalising the self-talk cue internally before each throw. Once participants had completed the second training block, they were seated in front of the computer screen again and underwent another cardiovascular measurement with the same procedure as the first one (i.e., 3 min of rest, receipt of task instructions, and 1 min reflection after task instructions). Task instructions were the same as before the baseline task, but additionally reminded participants to use their practiced self-talk cue during the final dart-throwing task, which again counted toward their competitive score. After the cardiovascular recording had ended, participants reported demand and resource evaluations, stood up, and completed the final dart-throwing task (20 throws). Participants then sat down in front of the computer screen to complete the self-talk manipulation check items before they were debriefed and thanked.

2.4. Statistical analysis

Mean heart rate, cardiac output, and total peripheral resistance values were calculated for the final minute of the rest period and the 1 min after task instructions for both the baseline and final dart-throwing tasks. Six univariate outliers (values more extreme than three standard deviations from the mean; three on each task) were winsorised to be 1% more extreme than the next non-outlying score (as Hase, Gorrie-Stone, et al., 2018). Resting cardiac output and total peripheral resistance values were then regressed on their respective post-instruction values with the standardised residuals saved to create residualised change scores that adjusted for baseline differences (Burt & Obradović, 2013). Total peripheral resistance residualised change scores were then multiplied by −1 and summed with the cardiac output residualised change scores to create a single cardiovascular CAT index, with a higher index score representing a cardiovascular response more indicative of a challenge state (i.e., relatively higher cardiac output and/or lower total peripheral resistance reactivity).

As is common in CAT research (e.g., Vine et al., 2013), paired-samples t-tests were used to examine whether the sample as a whole were engaged in the task, by comparing resting and post-instruction heart rate on the baseline and final task, respectively. To check self-talk compliance and perceived helpfulness between the groups, two one-way between-subjects ANOVAs compared differences between the self-talk groups in terms of self-talk frequency and helpfulness. Simple contrasts with the control group as the reference group probed significant effects for self-talk group.

To test H1, two repeated-measures ANOVAs examined demand resource evaluation score and CAT index with task (i.e., baseline versus final) as the within-participants factor, and the group by task interaction as the between-participants factor and independent variable of interest. To explore significant effects, simple contrasts were used with the control self-talk group as the reference group.

H2 and H3 were tested with a generalised estimating equations analysis predicting performance with self-talk group, task (i.e., baseline versus final), demand resource evaluation score, CAT index, and the respective two-way interaction terms for task and self-talk group (i.e., group by task, group by cognitive CAT, group by cardiovascular CAT, task by cognitive CAT, and task by cardiovascular CAT). Specifically, H2 was tested with the group by task interaction effect, comparing the self-talk groups on change in performance from the baseline to the final task. Moreover, H3 was tested with the main effects for demand resource evaluation score and CAT index on performance across tasks and groups. The generalised estimating equations model was used because it enables a test of the relationships between a set of categorical and continuous independent variables (including their interactions), and a dependent variable across different time points, which is a parsimonious alternative to conducting separate analyses at each time point. All of the above analyses used a significance level of $\alpha = 0.05$.

3. Results

3.1. Preliminary analyses

One participant provided no demand resource evaluations for the final task, and the equipment did not record cardiovascular data for 10 participants due to signal problems. One participant missed baseline task data, two participants missed final task data, and seven participants missed data from both tasks. Hence, the final sample comprised 61 participants for analyses of demand resource evaluation score and 52 participants for analyses of CAT index. The paired-samples t-tests for heart rate showed increases for both competitive tasks, although the difference was only marginally significant for the baseline task [$M_{\text{Baseline}} = 1.38$ bpm, 95% CI (−0.04; 2.79), $t(53) = 1.95$, $p = .06$, $d = 0.27$; $M_{\text{Final}} = 2.24$ bpm, 95% CI (0.32; 4.16), $t(52) = 2.34$, $p = .02$, $d = 0.32$].

Tables 1 (raw cardiovascular data) and 2 (demand resource evaluation score, CAT index, performance, self-talk frequency, and self-talk helpfulness) list descriptive statistics by self-talk group and task. The ANOVA on self-talk frequency revealed no significant difference between the groups [$F(2, 55) = 0.78$, $p = .46$, $\eta_p^2 = 0.03$], with the descriptive statistics indicating that participants in all groups almost always used their respective self-talk cues (see Table 2). The ANOVA on the self-talk helpfulness variable revealed a significant difference between the groups [$F(2, 55) = 3.43$, $p = .04$, $\eta_p^2 = 0.11$]. Simple contrasts indicated that the motivational group rated their self-talk cue to be significantly more helpful than the control group (contrast value = 1.75, $p = .01$), whereas the instructional group rated their self-talk cue to be more helpful than the control group, albeit not significantly so (contrast value = 1.21, $p = .09$). Changing the reference group revealed that the motivational and instructional self-talk groups did not significantly differ in self-talk frequency or helpfulness.

3.2. Main analyses

H1. Effects of self-talk manipulations on CAT states. Table 3 summarises the two repeated-measures ANOVAs on demand resource evaluation score and CAT index. There were no significant effects for self-talk group by task on demand resource evaluation score [$F(2, 58) = 0.97$, $p = .39$, $\eta_p^2 = .03$], or CAT index [$F(2, 49) = 1.59$, $p = .21$, $\eta_p^2 = .06$]. Despite the lack of statistical significance, these baseline-to-final task changes represented small and medium effect sizes, respectively.

H2. Effects of self-talk manipulations on performance. Table 4 presents parameter estimates for the generalised estimating equations analysis predicting performance relevant to H2 and H3. There was a significant group by task interaction effect (Wald $\chi^2 = 6.11$, $p = .05$). The parameter estimates for this effect showed that the performance of the motivational group improved more from the baseline to the final task than the performance of the control group ($B = -11.76$, Wald $\chi^2 = 5.52$, $p = .02$), but there was no significant difference in performance change from the baseline to the final task between the instructional and control groups ($B = -3.36$, Wald $\chi^2 = 0.38$, $p = .54$).

H3. Effects of CAT states on performance. There was a significant main effect for demand resource evaluation score (Wald $\chi^2 = 13.33$, $p < .01$). Furthermore, there were significant interaction effects for CAT index by group (Wald $\chi^2 = 11.54$, $p < .01$), and for CAT index by task (Wald $\chi^2 = 4.84$, $p = .03$). Parameter estimates for the demand resource evaluation score main effect showed that a demand resource evaluation score more consistent with a challenge state (i.e., coping resources match/exceed task demands) was associated with better performance ($B = 2.64$, Wald $\chi^2 = 4.37$, $p = .04$). The parameter estimates for the CAT index by group interaction effect showed group differences in the way CAT index related to performance. Specifically, CAT index was significantly more negatively related to performance for the instructional group than the control group ($B = -4.62$, Wald $\chi^2 = 6.35$, $p = .01$). In contrast, CAT index was marginally more positively related to performance for the motivational group than the control group ($B = 2.01$, Wald $\chi^2 = 3.74$, $p = .05$). Hence, a CAT index more consistent with a challenge state (i.e., relatively higher cardiac

Table 1
Raw cardiovascular variables by self-talk group and task.

Baseline Task	Instructional Self-Talk				Motivational Self-Talk				Control Self-Talk			
	Rest		Post-instructions		Rest		Post-instructions		Rest		Post-instructions	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1. Heart Rate (bpm)	77.49	13.30	80.87	13.98	81.91	14.72	82.30	14.97	78.76	10.15	79.30	9.65
2. Cardiac Output (lpm)	5.44	1.96	5.78	1.81	6.03	2.46	6.46	2.31	5.83	1.40	5.90	1.80
3. Total Peripheral Resistance (mmHg.s/ml)	1.02	0.37	0.92	0.23	0.92	0.49	0.86	0.37	0.94	0.36	0.93	0.32
Final Task	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
4. Heart Rate (bpm)	77.54	12.84	81.35	13.50	81.31	12.67	82.79	14.59	77.48	9.31	79.14	11.91
5. Cardiac Output (lpm)	5.83	1.73	5.89	1.46	6.09	2.20	6.13	2.29	5.43	1.40	5.98	1.71
6. Total Peripheral Resistance (mmHg.s/ml)	0.96	0.38	1.01	0.50	0.95	0.49	0.98	0.61	0.91	0.20	0.91	0.19

Table 2
Variables of interest by self-talk group and task.

	Instructional Self-Talk				Motivational Self-Talk				Control Self-Talk			
	Baseline Task		Final Task		Baseline Task		Final Task		Baseline Task		Final Task	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
1. Performance	114.25	16.35	121.95	14.98	118.45	21.41	127.68	22.14	127.10	17.35	129.70	13.93
2. Demand resource evaluation score	1.90	2.00	2.40	2.25	2.66	1.74	2.89	2.14	2.53	1.85	2.85	1.66
3. CAT index	0.18	2.04	−0.25	1.02	0.27	1.50	−0.14	2.02	−0.55	1.73	0.44	1.88
4. Self-Talk Frequency	N/A	N/A	7.58	2.59	N/A	N/A	8.55	1.96	N/A	N/A	8.16	2.71
5. Self-Talk Helpfulness	N/A	N/A	6.16	1.83	N/A	N/A	6.70	2.11	N/A	N/A	4.95	2.41

Note. CAT = Challenge and threat.

Table 3
Mixed-model ANOVAs on demand resource evaluation score and CAT index data by self-talk group.

	Demand Resource Evaluation Score				CAT Index			
	Mean Square	*F*	*p*	η_p^2	Mean Square	*F*	*p*	η_p^2
Task	2.02	3.31	.07	.05	0.00	0.00	< .99	.00
Self-Talk Group	0.59	0.97	.39	.03	5.52	1.59	.21	.06
Error	0.61				3.46			

Note. CAT = Challenge and threat.

output and/or lower total peripheral resistance reactivity) was more favourable for the motivational group than the control group, and in turn for the control group than the instructional group. Finally, the parameter estimate for the CAT index by task interaction effect showed that CAT index was more positively related to performance in the baseline task than in the final task ($B = 2.61$, Wald $\chi^2 = 4.84$, $p = .03$).

4. Discussion

This study examined the effects of self-talk on CAT states and performance during a competitive dart-throwing task. We specified three hypotheses: that the instructional and motivational self-talk groups would exhibit cognitive evaluations and cardiovascular responses more indicative of a challenge state compared to the control group (H1); that the instructional and motivational self-talk groups would perform the final task better (relative to baseline) than the control group (H2); and that both cognitive evaluations and cardiovascular responses more indicative of a challenge state would be related to better performance (H3). H1 was not supported, but there was partial support for H2, as participants in the motivational self-talk group improved their performance from the baseline to the final task more than participants in the control group. There was also partial support for H3, as demand and resource evaluations more consistent with a challenge state were related to better performance. Hence, this study provides initial insight into the relationships between self-talk, CAT states, and task performance.

Instructional and motivational self-talk, as practiced in this study, did not significantly affect CAT states, assessed at both the cognitive and cardiovascular level. Indeed, the differences in how the groups changed from baseline to final task represented small (demand resource evaluation score) and medium (CAT index) effects, which was smaller than (demand resource evaluation score) and similar to (CAT index) the effect size assumed in the power calculation. As this study is the first to investigate this relationship, there is no previous evidence regarding the association between self-talk and CAT states. However, previous research and theory has linked instructional and motivational self-talk

Table 4
Generalised estimating equations analysis of dart-throwing performance data - parameter estimates.

Effect	Comparison	*B*	Wald χ^2	*p*
Main Effects				
Self-Talk Group				
	IST – CST	−9.62	2.70	.10
	MST – CST	−7.94	1.14	.29
Task				
	BL – FT	−0.21	0.00	.96
Demand Resource Evaluation Score	N/A	2.64	4.37	.04
CAT Index	N/A	−0.31	0.18	.67
Interaction Effects				
Self-Talk Group by Task				
	$(IST_{BL} – CST_{BL}) – (IST_{FT} – CST_{FT})$	−3.36	0.38	.54
	$(MST_{BL} – CST_{BL}) – (MST_{FT} – CST_{FT})$	−11.76	5.52	.02
Demand Resource Evaluation Score by Self-Talk Group				
	Demand Resource Evaluation Score $_{IST}$ - Demand Resource Evaluation Score $_{CST}$	−1.89	1.17	.28
	Demand Resource Evaluation Score $_{MST}$ - Demand Resource Evaluation Score $_{CST}$	1.37	0.63	.43
CAT Index by Self-Talk Group				
	CAT Index $_{IST}$ - CAT Index $_{CST}$	−4.62	6.35	.01
	CAT Index $_{MST}$ - CAT Index $_{CST}$	2.01	3.74	.05
Demand Resource Evaluation Score by Task				
	Demand Resource Evaluation Score $_{BL}$ - Demand Resource Evaluation Score $_{FT}$	0.37	0.18	.68
CAT Index by Task				
	CAT Index $_{BL}$ - CAT Index $_{FT}$	2.61	4.84	.03
Intercept		126.59	605.86	.00

Note. BL = Baseline task. FT = Final task. CST = Control self-talk. IST = Instructional self-talk. MST = Motivational self-talk. CAT = Challenge and Threat. N/A = No applicable comparison due to the continuous nature of the variable.

with constructs that have also been linked with CAT states including performance, attentional focus, goal orientation, and interpretations of anxiety symptoms (e.g., Hardy et al., 2009; Hatzigeorgiadis, Zourbanos, Mpoumpaki, & Theodorakis, 2009; Hatzigeorgiadis et al., 2011; Jones et al., 2009; Latinjak, Torregrossa, Comoutos, Hernando-Gimeno, & Ramis, 2019; Vine, Moore, & Wilson, 2016). The current findings indicate that effective self-talk does not directly influence CAT states, despite this apparent consistency.

Motivational self-talk, as practiced in this study, was found to enhance dart-throwing performance. Specifically, the motivational self-talk group demonstrated greater improvements in performance from the baseline to the final task than the control group. This trend was also present for the instructional group, but it did not reach statistical significance. As such, these results are not fully consistent with the findings of systematic reviews and meta-analyses, which have found that both instructional and motivational self-talk benefit performance (Hatzigeorgiadis et al., 2011; Tod et al., 2011). A theoretically supported explanation for the differences between the experimental groups (relative to the control group) is the perceived helpfulness of the self-talk cue. The motivational, but not the instructional group, rated their cue to be more helpful than the control group, which is consistent with the idea that efficacy beliefs about self-talk can moderate the relationship between self-talk and task performance (Hardy et al., 2009). However, another explanation is that motivational self-talk is simply superior to instructional strategic self-talk for dart-throwing.

The control group in this study differed from some control groups in previous studies. For instance, some control groups have received no self-talk instructions at all (i.e., no-verbalisation controls; e.g., Hatzigeorgiadis et al., 2009). In contrast, this study used a control self-talk cue to impose similar cognitive load on participants and to prevent organic self-talk, which may occur in no-verbalisation controls (e.g., Hardy, Hall, Gibbs, & Greenslade, 2005). Although such a condition could theoretically function as a negative intervention (i.e., hampering adaptive organic self-talk use), it appears that this was not the case in this study, as demand resource evaluation score and CAT index data (Table 2) suggested that the control group exhibited a trend toward cognitive evaluations and cardiovascular responses more consistent with a challenge state than the instructional and motivational self-talk groups.

In this study, cognitive evaluations more indicative of a challenge state (i.e., coping resources match/exceed task demands) were related to better performance. This is consistent with the predictions of the biopsychosocial model of challenge and threat and theory of challenge and threat states in athletes (Blascovich, 2008; Jones et al., 2009), and the findings of a recent systematic review, in which 76% of the reported effects found that a challenge evaluation was associated with better performance than a threat evaluation (Hase, O'Brien, et al., 2018). In contrast, CAT index had no significant effect on task performance. This lack of association is inconsistent with the predictions of the biopsychosocial model of challenge and threat and theory of challenge and threat states in athletes, and the findings of recent reviews (e.g., Behnke & Kaczmarek, 2018), although some studies assessing both cognitive and cardiovascular measures of CAT states have also found divergent effects (e.g., Moore et al., 2018; Vine et al., 2013). Correlations between cognitive and cardiovascular measures of CAT states are usually weak to moderate (e.g., Moore et al., 2018; Vine et al., 2013), and the correlation between demand resource evaluation score and CAT index in this study was not significant, raising concerns about the propositions of the biopsychosocial model of challenge and threat.

This study observed an interaction effect between CAT index and self-talk on task performance. Specifically, CAT index was less positively related to performance in the instructional than in the control self-talk group. Instructional self-talk could have promoted a more optimal attentional focus on the target, which is similar to one of the proposed mechanisms through which a challenge state is thought to operate (see Vine et al., 2016). For example, the theory of challenge and threat states in athletes proposes that "in a challenge state the focus of attention is on appropriate cues, whereas in a threat state attention is also directed to task irrelevant stimuli that could cause harm" (Jones et al., 2009, p. 173). Hence, the direction of attention towards the target in the instructional group should not have helped those in a challenge state (who focused on the target anyway), but helped those in a threat state (who would have focused on task-irrelevant cues without the help of the instructional self-talk cue). As a result, CAT index would have impacted performance less strongly in the instructional than in the motivational self-talk group. Although theory-based, we acknowledge that this explanation is speculative and requires further scrutiny.

In addition to the result noted above, there was a more positive relationship between CAT index and performance in the motivational than in the control self-talk group, although this effect only approached significance. This trend indicates that the motivational self-talk cue was most beneficial to those who responded to the task with a cardiovascular response more indicative of a challenge state (i.e., relatively higher cardiac output and/or lower total peripheral resistance reactivity). A possible explanation for this result, which requires further investigation in future research, is that motivational self-talk encouraged more liberal use of available energy by increasing effort, which is compatible with the more efficient energy mobilisation observed in the challenge cardiovascular pattern (due to greater cardiac activity and/or vasodilation, Blascovich, 2008), but conflicts with the threat cardiovascular pattern (due to less efficient energy mobilisation).

Some limitations should be noted. First, the strategic self-talk interventions were very brief and had a low self-determination component (Hardy, 2006). Ideally, the selection of self-talk cues should have been determined by assessing individual needs and preferences (e.g., whether to verbalise cues aloud or internally; Hatzigeorgiadis, Zourbanos, Latinjak, & Theodorakis, 2014), selecting individually matching cues, and adapting, internalising, and automatizing cues in training (Hardy, 2006). Also, the self-talk cues were only aimed at a subset of the functions covered by more complete interventions of the same type (e.g., "*I can*" targets confidence, but not effort or arousal control; "*Aim central*" directs attention, but does not introduce technical information or influence decision-making). Future research could therefore test how prolonged and reflexive self-talk affects CAT states in multiple testing sessions.

Second, it is difficult to infer whether the baseline-to-final task performance improvements were attributable to practice effects, an effect of all three self-talk cues, or both. This could be remedied by a no-verbalisations control group; or by instructing all groups to use control self-talk in the baseline task, and then continuing as per the present study in the training and final tasks. Furthermore, the control self-talk cue impacted organic self-talk, and thereby CAT states and performance. Although there was no negative impact on CAT states (see Table 2), future research should include both a control self-talk and a no-verbalisations condition, and obtain reports of cognitive load and organic self-talk use to provide conclusive evidence to answer this question. Similarly, the manipulation check used in this study did not assess organic self-talk, which might have been assessed in parallel to the strategic self-talk that participants used (Latinjak, Hatzigeorgiadis, et al., 2019).

Third, in the baseline task, task engagement was relatively weak, as evidenced by the marginally significant increase in heart rate. Future research might prevent this by verbally and emphatically delivering task instructions, and/or provoking elevated pressure by highlighting social comparison (e.g., being filmed, mentioning a scoreboard) or performance-contingent punishments (e.g., being interviewed for poor performance; Moore et al., 2015). Other studies that have observed greater increases in heart rate, however, have compared a quiet rest period to a more metabolically demanding period (e.g., a speech; Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004). Thus, the silent task visualisation in this study should have produced cardiovascular data less reflective of speech production and/or other confounding factors. Finally, the statistical analyses conducted in this study did not account for multiple statistical comparisons. Although the generalised estimating equations analysis reduced the number of statistical tests performed at the separate time points, the results should still be interpreted with caution.

5. Conclusion

This study examined the effect of self-talk on CAT states and performance during a competitive dart-throwing task. Self-talk did not impact CAT states, but motivational self-talk improved performance more than control self-talk. Thus, self-talk may be a useful psychological strategy, but not exert its beneficial effects on performance by influencing CAT states. In addition, a cognitive evaluation more reflective of a challenge state (coping resources match/exceed task demands) was related to better performance. Finally, the findings relating to the cardiovascular reactivity patterns of CAT states were more complicated, and suggested that instructional self-talk may weaken, whereas motivational self-talk may strengthen, the relationship between a challenge-like cardiovascular response (higher cardiac output and/or lower total peripheral resistance reactivity) and performance, compared to control self-talk. Hence, motivational self-talk may offer more benefit to athletes experiencing a challenge state, while instructional self-talk might be more advantageous to athletes in a threat state.

Declarations of interest

None.

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