Cognitive appraisals and team performance under stress: a simulation study

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LC and MJ conceived and designed the study, EB, MS and MT provided substantial contributions to psychological aspects of the study design, LC, PLI and JF collected the data, FC and EB performed the statistical analysis, LC, MJ, PLI, JF, EB and MT drafted and revised the manuscript. All authors reviewed and approved the final manuscript. All authors agreed to be accountable for all aspects of the work, ensuring questions related to accuracy and integrity of any part are appropriately investigated and resolved.

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The study protocol was reviewed by the relevant institutional ethical board (Comitato Etico Interaziendale Novara) who granted an exemption letter (protocol n. CE 41/18).

Abstract

Objective: The present study explored how challenge and threat responses to stress relate to performance, anxiety, confidence, team identity and team characteristics (time spent training and postgraduate experience) in a team-based medical simulation competition.

Design: Cross-sectional data were collected prior to three days of competition.

Setting: The study was conducted during a national simulation-based training event for residents, the SIMCUP Italia 2018. SIMCUP is a simulation competition where teams of four compete in simulated, medical emergency scenarios.

Subjects: 95 participants from 24 teams.

Measurements and Main Results: Each day prior to the competition, participants completed brief self-report measures which assessed demands and resources (which underpin challenge and threat responses to stress), cognitive and somatic anxiety, self-confidence and team identification. Participants also reported time (hours) spent practicing as a team and years of postgraduate experience. A team of referees judged each scenario for performance and assigned a score. We built a linear mixed model using demands and resources to model performance. The data showed that both demands and resources have a positive effect on performance (31 [11 - 50.3] $p<0.01$ and 54 [25 - 83.3], $p<0.01$ percentage points increase for unitary increases of demands and resources respectively), which however is balanced by a negative interaction between the two [demands * resources interaction coefficient = -10 [-16 - -4.2]. A high level of resources is associated with better performance until very high demands. Cognitive and somatic anxieties were found to be correlated with demands (Pearson's $r=0.51$, $p<0.01$ and 0.48, $p<0.01$ respectively). Time spent training was associated with greater perceptions of resources (Pearson's $r=0.36$, $p<0.01$).

Conclusions: We describe a model of challenge and threat that allows estimation of performance according to the perceived demands, resources and the interaction between the two. Higher levels of resources and lower demands were associated with better performance.

Introduction

Medical teams work in demanding situations that are often uncertain, changeable and require accurate decision-making, skilled movement and co-ordinated action. How teams perform matters for patient outcomes (1). In addition to medical expertise, how individuals and the team collectively respond and manage the psychological stress of the situation has a significant impact on performance (2, 3). One approach, which attempts to explain the facilitating and debilitating effects stress can have on performance is the biopsychosocial (BPS) model of challenge and threat (4).

A challenge state occurs when personal resources meet or exceed situational demands, whereas threat occurs when demands exceed resources (4). To illustrate, consider an unexpected cannot-ventilate cannot-intubate situation: in a challenge state, an individual perceives sufficient resources to cope with the demands of the situation, but the converse is true in a threat state. Challenge states have been consistently associated with improved performance in a range of environments and activities (5, 6). These include word search tasks (7), mental arithmetic tasks (8), pattern-recognition and number-categorisation tasks (9) and in high-pressure sport performance (10). Challenge and threat states have also been associated with performance in medical settings, with a challenge state associated with better performance (11). The challenge state represents an attempt to mobilize energy for action, whereas the threat state is a “distress system”, associated with perceptions of actual or physical harm. In a challenge state it is proposed that performance is improved as a result of increased task engagement, improved decision-making, decreased likelihood of conscious control (often called ‘paralysis by analysis’) over skilled motor movements that are typically better performed automatically (12).

Of interest in stressful situations is the emotional response of participants. In particular anxiety which is characterized by feelings of apprehension and tension along with activation or arousal of the autonomic nervous system (13). In competitive environments, such as sport, research has considered how the cognitive (e.g., feelings of apprehension) and physiological (e.g., increased activation of the autonomic nervous system) aspects of anxiety relate to performance differently. For example, the Multidimensional Theory of Competitive State Anxiety (MAT)(14) proposes that cognitive anxiety (psychological) has a negative linear relationship with performance while somatic anxiety (physiological) has an inverted-U relationship with performance. Self-confidence, considered to be orthogonal to cognitive anxiety, is proposed to have a positive linear relationship with performance and also forms part of MAT. Theoretically it has been proposed that emotional responses in challenge and threat states can be similar, although when challenged anxiety is seen as a helpful stimulus for performance (12). There is some support for this proposition (15) although there is also data showing challenge states being similar to threat states on anxiety and perceptions of helpfulness of anxiety (16), while in some studies challenge states have also been associated with both lower levels of anxiety and more facilitative interpretations of anxiety (17).

While individual resources are important in determining the nature of the stress response, social aspects also matter. In particular responses to stress may be influenced by how connected a person feels to their team and leader. To illustrate, participants receiving instructions from a person prior to a demanding task that they see as being from an out-group (i.e. not like them) responded with a threat response (18). This illustrates the importance of leaders having a strong relational identity with their team. In addition to the leader, responses may also be influenced by how connected a person feels with their team, organisation or profession more broadly. Group membership not only provides a sense of belonging but says

something about who we are; it provides us with a social identity. Social identity, such as membership of a team (team identity) is proposed to be positively associated with performance in a number of ways including increased discretionary effort, such as greater practice time(19, 20). Social identity has also been shown to impact challenge and threat responses in stressful situations(21).

The present paper reports an exploration of the psychological factors associated with performance in teams participating in a medical simulation competition. The primary aim of the study is to explore how challenge and threat states link to performance. Secondary aims addressed in the paper include exploring how psychological variables, specifically cognitive anxiety, somatic anxiety, self-confidence and team identity, and team characteristics, specifically time spent training and years of postgraduate experience, link to challenge and threat. Simulation competitions generate stress in participants (22) and provide a controlled environment in which to assess psychological responses, team functioning and overall performance. Thus, such competitions provide a unique environment to explore predictors of team performance, which may have implications for refining and optimising the training of medical emergency teams.

Materials and Methods

Participants

Participants were recruited during a national simulation-based event for residents, the SIMCUP Italia 2018. SIMCUP Italia was open to residents from any Italian residency program and from any level of training. Four residents composed each team (except for one team of three due to a participant drop-out) and multidisciplinary teams were encouraged. The study protocol was reviewed by the relevant institutional ethical board (Comitato Etico Interaziendale Novara) who granted an exemption letter (protocol n. CE 41/18). Participation in the study was on a voluntary basis; all participants provided informed consent prior to study enrolment.

Procedure

Participating teams were involved in a consecutive series of simulations, involving clinical, psychomotor and relational skills. Day 1 (D1) was a preliminary qualification round and each team participated in three simulation scenarios, Day 2 (D2) was a qualification round and each qualified team participated in seven simulation scenarios and Day 3 (D3) was the final, where each qualified team participated in one scenario. First and second days were structured using an Objective Structured Clinical Examination (OSCE)-like system. At the end of D1 which consisted of 3 different simulations per team (N=95 participants, 24 teams), the ten highest ranking teams moved on to D2 (7 simulations per team, n=40 participants, 10 teams). After the second day the six highest ranking teams moved on to the finals, D3 (one simulation per team, n=24 participants, 6 teams). Finals were held using a classical SimWars style (23) . The finalists performed their simulation in front of the audience consisting of those teams who did not qualify for the finals, the faculty, and the judges. At the start of each day, before competing, participants were asked to complete a questionnaire that included brief

measures of challenge and threat (assessed by self-reported appraisals of demand and resources), cognitive anxiety, somatic anxiety, self-confidence and team identity. On the first day, participants also reported the amount of time they had practiced for the competition as a team (in hours) as well as their post-graduate year. All measures were translated into Italian by one of the authors (LC).

Measures

Performance. Each scenario was rated for technical and non-technical skills. The case designers developed a technical skill scoring tool for each simulation scenario with a predetermined maximum score. These scoring sheets were checklists scored as 0 (no), 2 (yes), or 1 (yes, but incomplete). Non-technical skills were measured using the Italian version of the Ottawa global rating scale (GRS), which includes six items ranging from 0 to 7 with a maximum possible score of 42 (24). The final score is the average of all scores obtained in each station, weighted evenly for the two tools and expressed as percentage. All raters were experts in critical and emergency care. Each station was rated by a minimum of two to a maximum of three raters per assessment tool (one team dedicated to technical skills and one for the non-technical skills). The group of raters had to arrive at an agreement before providing one single assessment sheet per tool per team after each scenario. All raters were simulation instructors, with technical content and non-technical skills experience, familiar users of the assessment tools and all participated in a pre-event briefing regarding assessment procedures. A more in-depth description of the principles of the format, its educational rationale and the assessment tools used can be found in Ingrassia et al (25), the full list of simulation stations and scenarios can be found in the supplementary appendix. All scoring during SIMCUP was collected and processed using the STAT59 system (www.stat59.com, Edmonton, Canada).

Challenge and Threat. Participants completed the Demands and Resources Evaluation Scale (DRES) which has been commonly used to assess challenge and threat (26). A challenge state occurs when resources meet or exceed situational demands, whereas threat occurs when demands exceed resource. Demand evaluations were assessed by asking "How demanding do you expect the competition to be?" and resource evaluations by asking "How able are you to cope with the demands of the competition?" The items were rated using a 6-point Likert scale from 1 (*not at all*) to 6 (*extremely*). In the past, researchers have used the scores from these items to create a discrepancy value (27) in which positive scores indicate challenge and negative scores indicate threat ($DRES_d$), or have created a ratio (28) in which scores greater than 1 reflect threat and scores less than 1 reflect challenge ($DRES_r$). We calculated both of these scores for the analyses in this study. The DRES has been shown to predict performance in medical tasks, albeit with novice participants (11).

Anxiety and Self-Confidence. The Mental Readiness Form-Likert (29) was used to measure state anxiety on 2 bipolar scales corresponding to cognitive anxiety and somatic anxiety. It was chosen as it is a brief measure and assesses the three components of MAT. To assess cognitive anxiety participants rated the extent to which they felt worried (1 = *not worried* to 11 = *worried*), and to assess somatic anxiety participants rated the extent to which they felt tense (1 = *not tense* to 11 = *tense*). Self-confidence was also self-reported using a bipolar scale from 1 (*confident*) to 11 (*scared*). The Mental Readiness Form-Likert was chosen as it is a brief measure, comprising three single items, to assess the three components of MAT. The Competitive State Anxiety Inventory-2 (CSAI-2) (14) was originally used to assess the components of MAT and (29) revealed correlations between the Mental Readiness Form-Likert and the CSAI-2 subscales of .76 for cognitive anxiety, .69 for somatic anxiety and -.68 for self-confidence (The negative correlation reflects that high scores on CSAI-2 confidence

and low scores on the MRF confidence subscales both reflect high confidence). The MRF-Likert has been linked to fluctuations in competitive sport performance(30).

Team Identity. Participants' self-reported identity with the team (31) over four items related to feelings of being part of a group. Participants were required to respond to statements such as "*I identify with other members of this group*" and "*I am pleased to be a member of this group*" on a 7-point Likert scale from "*Do not agree at all*" to "*Completely agree*". Responses were averaged across the four items to create a team identity scale. This measure has demonstrated strong internal consistency reliability (0.93 in the work of van Dick et al)(32). In terms of validity, measures of team identity have been positively associated with greater personal and collective effort exerted by team members(33). In the present study the internal consistency reliability of the scale, measured using Cronbach's alpha was good across all three timepoints (D1 = .89; D2 = 0.92; D3 = 0.88). A copy of the complete study questionnaire is available in the supplementary appendix.

Statistical Analysis

All psychometric evaluations were performed using data from the scales which have been treated as quantitative real values. Categorical variables were reported as a proportion and percentile. Continuous variables were reported as a mean ± standard deviation (SD) and compared using unpaired t test.

As our primary analysis, we used a linear mixed effect regression to analyze the impact of cognitive appraisal on performance over the competition days, with fixed effects of demands, resources and the interaction between demands and resources. Since performance was evaluated at a team level, this analysis was carried out with team level values averaging the demands and resources of all team members to create a team level value.

Secondary exploratory analyses of DRES indexes and other psychological variables were performed by means of simple correlation for measures taken at day 1 and repeated measures correlation for measures taken over the whole event (34). Since psychological evaluation was performed individually, this analysis was carried out with individual level values. All statistical analysis has been performed using R 3.6.1, [R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.] A p value < 0.05 was considered significant.

Results

Ninety-five participants from 24 teams were included in the study. Participants were, on average, 29.9 years of age (SD=2.1), and the majority (62%) were female. Demographic details including post-graduate experience are presented in table 1. The distribution of participants by post-graduate year per team is presented in graphical form in the supplementary appendix.

Challenge, threat and team performance

Cognitive appraisal of psychological resources was consistently higher in teams who were successful during the various steps of the event, while demands were perceived to be similarly high in both groups. DRES indexes (both discrepancy and ratio) showed a trend moving towards a challenge perception of the events for those teams qualifying to the next level of the event during each day of the competition, with a statistically significant difference only during day 2. Details about demands, resources, DRES discrepancy and ratio, as well as overall performance results, technical and non-technical skill assessment and other cognitive and psychological variables are presented in Table 2.

Using a linear mixed model, a significant effect of both demands (coefficient = 31 [11 - 50.3], p<0.01) and resources (coefficient = 54 [25 - 83.3], p<0.01) on performance was found. The interaction between demands and resources (coefficient = -10 [-16 - -4.2], p<0.01) was also significant. Equation 1 describe the model results in a mathematical form.

$$performance = -99 + 31 * demands + 54 * resources - 10 * (demands * resources)$$

Coefficients should be interpreted as follows: a unitary increase of the dependent variable (demands or resources) will lead to a change in performance equal to the coefficient. As an

example, a one-point increase in demands should lead to a 31 points increase in performance (i.e. 31 percentage points). Usually coefficients are independent (i.e. the 31 points increase in performance due to a single point increase in demands is valid at every levels of resources). The presence of the interaction term, however, ties together the effects of both demands and resources. Hence, the effect of a one-point increase in demands will lead to (31 -10 * resources) change in performance.

A graphical representation of the model, with the predicted performance for different levels of demands given a very high, or very low, level of resources is presented in figure 1.

The relationship between challenge and threat and cognitive anxiety, somatic anxiety, self-confidence, training, postgraduate experience and team identity over the competition.

As for the secondary aim of the study, on day 1 we found a moderate correlation between cognitive anxiety and demands (Pearson's r 0.51, <0.01) but not with resources (Pearson's r 0.18, p=0.08). The same was found regarding somatic anxiety and demands (Pearson's r 0.48, p<0.01) but not with resources (Pearson's r 0.03, p=0.76). Confidence was weakly correlated with demands (Pearson's r 0.23, p=0.03) and moderately correlated, in a negative fashion, with resources (Pearson's r -0.42, p <0.01) and DRES indexes (DRESd Pearson's r -0.47, p <0.01, DRESr Pearson's r 0.48 p <0.01). This negative relationship is due to the nature of the tool used to measure confidence, where the strongest confidence was expressed with the lowest value on the scale. Team identity of day 1 was not correlated with cognitive appraisal (DRESd Pearson's r 0.07, p=0.48). Finally, training was weakly correlated with resources (Pearson's r 0.36, p<0.01) as well as with DRES indexes (DRESd Pearson's r 0.25 p=0.01~~37~~, DRESr Pearson's r -0.29 p=~~=~~<0.01) but not with demands (Pearson's r 0.06, p=0.53) and post-graduate experience was weakly correlated with resources (Pearson's r -0.22, p=0.02) but not with

demands (Pearson's r -0.11, p=0.27) nor the DRES indexes (DRESd Pearson's r -0.11 p=0.26, DRESr Pearson's r 0.06 p=0.58).

For repeated measures over the competition there was no correlation between cognitive anxiety, somatic anxiety or confidence and demands, resources or DRESd and DRESr. A moderate correlation was found between team identity and demands (repeated measures r 0.43, p**=<0.01**) and resources (repeated measures r 0.40, p**=<0.01**) but not with the relative DRES indexes. The full correlation coefficients are presented in table 3.

Discussion

The present study is the first to explore the relationship between challenge and threat responses, team identity, anxiety, self-confidence and team performance in a team based medical simulation competition.

The main findings of the present study are contained in the mixed linear model.

Using the direct measurements of demands and resources instead of one of the more commonly used indexes (DRESd, DRESr) permitted us to explore how demands and resources influence performance in a more nuanced way than by simple subtraction or ratio, as the model suggest that having high resources or low demands is not enough to predict performance. The model showed that both demands and resources have a positive effect (positive coefficients) on performance; however, performance is also mediated by the interaction of the two variables, which in the model has a negative effect.

The presence of the interaction term in the model means that the effect of one independent variable (demands or resources) on performance depends on the values of the other independent variable. This important result implies that an increase in resources has a different effect on performance on different levels of demands and vice versa.

A high level of resources is associated with better performance until very high demands. At this stage performance is unrelated to perceived resources, and it is at this stage that we would expect to see skill breakdown. This happens when resources are at a similar level to demands and suggests that, in this medical simulation competition at least, personal resources need to exceed, not just meet demand for performance benefits.

The relationship between demands and resources supports previous research comprising interviews with intensive care members in which team members faced a situation where the resources were less than expected, and when the demands on them were

increasing, individual distress was detected and contagious. Collective distress was then perceived as disruptive for team work (35). It is worth noting that the ability to manipulate demands and resources which underpin challenge and threat states could affect team performance and thus could have an impact in team training. For example, designing specific training to allow individuals and teams to modify their cognitive appraisal might translate in improved performance(28).

For educators this information could aid in the design of the simulation experience, avoiding (or deliberately planning, according to the specific learning goal) situations of excessive demands which could hinder the effect of perceived resources on performance.

As for the secondary outcome our aim was to perform a simple exploration of which factors might be associated with the participants' cognitive appraisals, to provide thoughts for future experimental studies aiming at explaining a causal relationship between them. While higher confidence was associated with a higher challenge (greater score on the DRES index), there was no relationship between anxiety levels or team identity and perceptions of challenge or threat. Greater levels of training were associated with greater perceptions of challenge.

It is not surprising that confidence was positively associated with challenge, and that anxiety was not associated with challenge or threat, as both are in line with theory(12). It is particularly interesting that the intensity of the emotional response to a competition did not differ even though for some teams the competition was seen as more of a challenge and this is line with some previous research (15, 16). It is hypothesised that anxiety states may be seen as more helpful in those who appraise a scenario as challenging but in our study we did not collect data on participants' perceptions of emotional states.

That training plays a role in challenge responses under stress supports previous literature. In a recent study, where medical teams were randomised to pre-event planning versus no planning before a high stakes medical simulation, although there were no differences in perceived level of anxiety among the two groups, cognitive appraisal ratios shifted from threat towards challenge for those who were allowed a pre-event planning time. The authors concluded that this shift might have influenced clinical performance in the simulated scenarios (36).

Historically team performance has been investigated with respect to two aspects of performance: team perspective and centrality of authority (2). Previous research, although describing underlying processes of effective teams, did not provide insights into factors that enhance or impair the development of a shared mental model or of the aspects that influence the performance a team under pressure (37). The implications of the present study are that medical team training programs aiming at developing and improving healthcare team work and performance in high stake environments could consider interventions aimed at measuring and modifying team-members perception of demands and resources. Potential interventions that can act on cognitive appraisal in high-stakes environment are those that will enhance the individual's ability to interpret demanding events as challenges rather than threats. One can impact cognitive appraisal by changing the perceived demands of the task or by altering the actual or perceived demands resources of the individuals (38). Future research could investigate which aspects of team training has a direct effect in modifying the resource pathways and perceived demands that underpin challenge and threat states. The interaction between these two appraisals is key and, at least in a simulated medical competition, high resources and low demands is associated with better performance.

Understanding if similar relationships transfer to actual medical care is a focus for future research.

Limitations

Our study has a number of important limitations that should be considered. Participants were post-graduate trainees (residents), and although many of them were of high seniority, resuscitation teams are often led, or composed of, attending physicians. It is difficult to predict if these results would apply to attending physicians. However, residents and fellows do represent a significant population among medical providers and do play an important role within these teams. The same applies to the fact that most teams are interprofessional, while our teams were composed exclusively of physicians.

We averaged each team member individual cognitive appraisal to an arithmetic mean cognitive appraisal, representing the team and allowing analysis on a team level. This might not fully be representative of the individual perception of team members and should be considered when interpreting the present results. We do not think however it is an unreasonable approach to consider that the final result of a team taking part in a task is the composition of the strength and weaknesses of all team members.

We explored correlations between demands and resources and other psychological variables but did not explore nor build any causal models of the effect that other psychological variables or demographics could have on performance. This was not the objective of the present study and will be explored in future works.

The psychological data were comprised solely of self-report data and future research could augment these data with physiological data to give a more rounded view of the stress response (39, 40). Further it is also worth noting that while the DRES is considered by researchers to reflect demands vs. resources, it could be argued that item two of the DRES

indicates coping rather than resource dominance. Contemporary challenge and threat theory (4, 15) does not include coping (emotion focused and problem focused) as outlined by Lazarus (41) and as such theorists should more closely consider the role of coping in challenge and threat states. While the link between training and a challenge state was interesting it is also worth noting that team training was not investigated in-depth, and we do not know the nature of the training or whether a mentor was involved in guiding the training.

It is also worth noting that for our measures, this was the first time they had been used with medical professionals, although the DRES has been shown to predict performance in a simulated medical task (laparoscopic surgery) albeit with novice participants (11). As such the validity of these instruments in this population has not been confirmed.

A final limitation resides in the nature of the competition itself: we could only collect repeated measurements of successful teams. This could potentially have led to selection bias.

Conclusion

This was an exploratory study assessing the relationship between challenge and threat states, prior training, team identity, anxiety responses and performance in a team based medical simulation competition. We provide a model that described how demands and resources interact to provide performance, in a simulated stressful environment. We found that both demands and resources have a positive effect on performance, but that the interaction between the two is significant and has a negative effect. Further research should build on this work and explore if similar relationships are observed in actual care, aim to develop evidence-based individual and team-based interventions to improve critical care team performance, and to ultimately improve patient outcomes.

References

1. Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JD, van Wijk KP. Interventions to improve team effectiveness: a systematic review. Health Policy. 2010;94(3):183-95.

2. LeBlanc VR. The effects of acute stress on performance: implications for health professions education. Acad Med. 2009;84(10 Suppl):S25-33.

3. LeBlanc VR, McConnell MM, Monteiro SD. Predictable chaos: a review of the effects of emotions on attention, memory and decision making. Adv Health Sci Educ Theory Pract. 2015;20(1):265-82.

4. Blascovich J, Tomaka J. The biopsychosocial model of arousal regulation. Advances in experimental social psychology. 28: Elsevier; 1996. p. 1-51.

5. Behnke M, Kaczmarek LDJIJoP. Successful performance and cardiovascular markers of challenge and threat: A meta-analysis. 2018;130:73-9.

6. Hase A, O'Brien J, Moore LJ, Freeman PJS, Exercise,, Psychology P. The relationship between challenge and threat states and performance: A systematic review. 2018.

7. Mendes WB, Major B, McCoy S, Blascovich J. How attributional ambiguity shapes physiological and emotional responses to social rejection and acceptance. J Pers Soc Psychol. 2008;94(2):278-91.

8. Tomaka J, Blascovich J, Kibler J, Ernst JM. Cognitive and physiological antecedents of threat and challenge appraisal. J Pers Soc Psychol. 1997;73(1):63-72.

9. Blascovich J, Mendes WB, Hunter SB, Salomon K. Social "facilitation" as challenge and threat. J Pers Soc Psychol. 1999;77(1):68-77.

10. Turner MJ, Jones MV, Sheffield D, Slater MJ, Barker JB, Bell JJ. Who thrives under pressure? Predicting the performance of elite academy cricketers using the cardiovascular indicators of challenge and threat states. J Sport Exerc Psychol. 2013;35(4):387-97.

11. Vine SJ, Freeman P, Moore LJ, Chandra-Ramanan R, Wilson MR. Evaluating stress as a challenge is associated with superior attentional control and motor skill performance: testing the predictions of the biopsychosocial model of challenge and threat. J Exp Psychol Appl. 2013;19(3):185-94.

12. Jones M, Meijen C, McCarthy PJ, Sheffield D. A theory of challenge and threat states in athletes. International Review of Sport and Exercise Psychology. 2009;2(2):161-80.

13. Spielberger CD. Theory and research on anxiety. Anxiety and behavior. 1966;1(3).

14. Martens R, Burton D, Vealey RS, Bump LA, Smith DE. Development and validation of the competitive state anxiety inventory-2. Competitive anxiety in sport. 1990:117-90.

15. Trotman GP, Williams SE, Quinton ML, Veldhuijzen van Zanten J. Challenge and threat states: examining cardiovascular, cognitive and affective responses to two distinct laboratory stress tasks. Int J Psychophysiol. 2018;126:42-51.

16. Meijen C, Jones MV, McCarthy PJ, Sheffield D, Allen MS. Cognitive and affective components of challenge and threat states. J Sports Sci. 2013;31(8):847-55.

17. Moore LJ, Vine SJ, Freeman P, Wilson MRJIJoS, Psychology E. Quiet eye training promotes challenge appraisals and aids performance under elevated anxiety. 2013;11(2):169-83.

18. Slater MJ, Turner MJ, Evans AL, Jones MV. Capturing hearts and minds: The influence of relational identification with the leader on followers' mobilization and cardiovascular reactivity. The Leadership Quarterly. 2018;29(3):379-88.

19. Boehm SA, Dwertmann DJ, Bruch H, Shamir B. The missing link? Investigating organizational identity strength and transformational leadership climate as mechanisms that connect CEO charisma with firm performance. The Leadership Quarterly. 2015;26(2):156-71.

20. Haslam A. Psychology in organizations: The social identity approach. 2004.

21. Derks B, Scheepers D, Van Laar C, Ellemers NJJoESP. The threat vs. challenge of car parking for women: How self-and group affirmation affect cardiovascular responses. 2011;47(1):178-83.

22. Ghazali DA, Darmian-Rafei I, Nadolny J, Sosner P, Ragot S, Oriot D. Evaluation of stress response using psychological, biological, and electrophysiological markers during immersive simulation of life threatening events in multidisciplinary teams. Aust Crit Care. 2018;31(4):226-33.

23. Okuda Y, Godwin SA, Jacobson L, Wang E, Weingart S. SimWars. J Emerg Med. 2014;47(5):586-93.

24. Franc JM, Verde M, Gallardo AR, Carenzo L, Ingrassia PL. An Italian version of the Ottawa Crisis Resource Management Global Rating Scale: a reliable and valid tool for assessment of simulation performance. Intern Emerg Med. 2017;12(5):651-6.

25. Ingrassia PL, Franc JM, Carenzo L. A novel simulation competition format as an effective instructional tool in post-graduate medical education. Adv Simul (Lond). 2018;3:17.

26. Tomaka J, Blascovich J, Kelsey RM, Leitten CL. Subjective, physiological, and behavioral effects of threat and challenge appraisal. Journal of personality and social psychology. 1993;65(2):248.

27. Moore LJ, Vine SJ, Wilson MR, Freeman P. Examining the antecedents of challenge and threat states: the influence of perceived required effort and support availability. Int J Psychophysiol. 2014;93(2):267-73.

28. Moore LJ, Vine SJ, Wilson MR, Freeman P. The effect of challenge and threat states on performance: an examination of potential mechanisms. Psychophysiology. 2012;49(10):1417-25.

29. Krane V. The mental readiness form as a measure of competitive state anxiety. The Sport Psychologist. 1994;8(2):189-202.

30. Butt J, Weinberg R, Horn T. The intensity and directional interpretation of anxiety: Fluctuations throughout competition and relationship to performance. The Sport Psychologist. 2003;17(1):35-54.

31. Doosje B, Ellemers N, Spears R. Perceived intragroup variability as a function of group status and identification. Journal of experimental social psychology. 1995;31(5):410-36.

32. Van Dick R, Lemoine JE, Steffens NK, Kerschreiter R, Akfirat SA, Avanzi L, et al. Identity leadership going global: Validation of the Identity Leadership Inventory across 20 countries. Journal of Occupational

Organizational Psychology. 2018;91(4):697-728.

33. Høigaard R, Boen F, De Cuyper B, Peters DM. Team identification reduces social loafing and promotes social laboring in cycling. J International Journal of Applied Sports Science. 2013;25(1):30.

34. Bland JM, Altman DG. Calculating correlation coefficients with repeated observations: Part 1--Correlation within subjects. BMJ. 1995;310(6977):446.

35. Piquette D, Reeves S, LeBlanc VR. Stressful intensive care unit medical crises: How individual responses impact on team performance. Crit Care Med. 2009;37(4):1251-5.

36. Evain JN, Perrot A, Vincent A, Cejka JC, Bauer C, Duclos A, et al. Team planning discussion and clinical performance: a prospective, randomised, controlled simulation trial. Anaesthesia. 2019;74(4):488-96.

37. Lingard L, Espin S, Evans C, Hawryluck L. The rules of the game: interprofessional collaboration on the intensive care unit team. Crit Care. 2004;8(6):R403-8.

38. Harvey A, Nathens AB, Bandiera G, Leblanc VR. Threat and challenge: cognitive appraisal and stress responses in simulated trauma resuscitations. Med Educ. 2010;44(6):587-94.

39. LeBlanc VR, MacDonald RD, McArthur B, King K, Lepine T. Paramedic performance in calculating drug dosages following stressful scenarios in a human patient simulator. Prehosp Emerg Care. 2005;9(4):439-44.

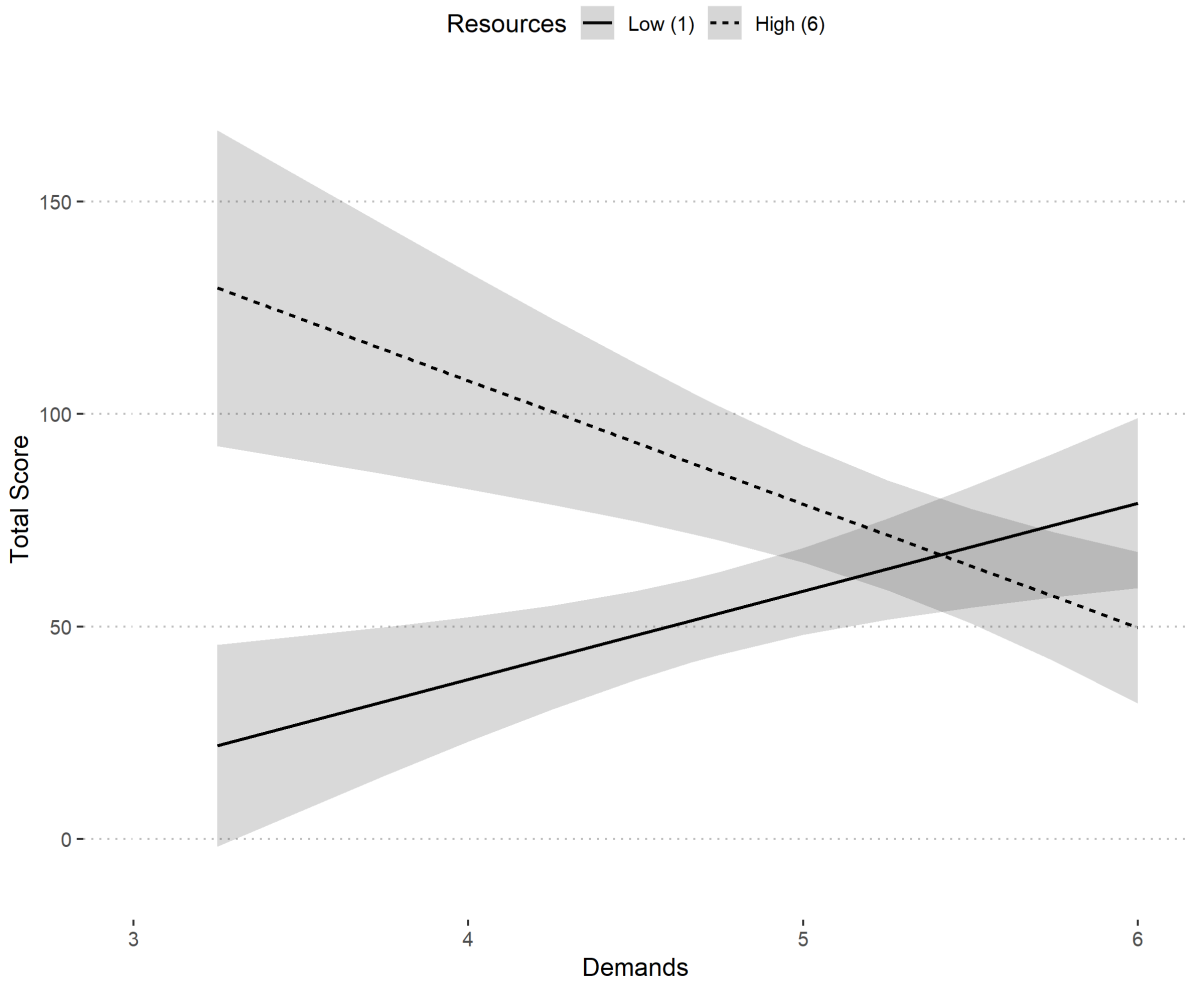
40. Leblanc VR, Regehr C, Tavares W, Scott AK, Macdonald R, King K. The impact of stress on paramedic performance during simulated critical events. Prehosp Disaster Med. 2012;27(4):369-74.

41. Lazarus RS. Emotion and adaptation: Oxford University Press on Demand; 1991.

Figure Legend

Figure 1.

Graphical representation of the linear mixed model. Performance predictions according to varying level of demands at a sample very high and very low resources level.


Resources
Low (1)
High (6)
150
100
50
0
Total Score
3
4
5
6
Demands