Instr Sci (2015) 43:401–426
DOI 10.1007/s11251-014-9333-6

Team regulation in a simulated medical emergency: An in-depth analysis of cognitive, metacognitive, and affective processes

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Received: 10 April 2014 / Accepted: 18 October 2014 / Published online: 5 November 2014
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Abstract This study examined the nature of cognitive, metacognitive, and affective processes among a medical team experiencing difficulty managing a challenging simulated medical emergency case by conducting in-depth analysis of process data. Medical residents participated in a simulation exercise designed to help trainees to develop medical expertise, effective leadership, and team management skills. Purposive sampling was used to select one team for case study based on overall performance. Video and audio data were collected from the simulation and debriefing session and a follow-up interview was conducted with the team leader. Performance measures were also collected from expert raters (i.e., experienced staff physicians). Video data were reviewed and coded for cognitive, metacognitive, and emotional events exhibited by team members during the simulation. Interview and debriefing transcripts were coded for themes related to these regulatory processes. Results from quantitative and qualitative analyses revealed that the team exhibited lower-order cognitive and metacognitive process (e.g., summarizing, providing information) more often than higher-order processes (e.g., evaluation, reasoning). Furthermore, team members expressed negative emotions (e.g., anxiety) more often than positive emotions (e.g., enjoyment). Chi square analyses of the team leader revealed that negative emotions were significantly more frequently preceded by lower-order processes

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compared to higher-order processes. Qualitative thematic analyses provided further corroboration of these findings. The findings suggest that medical trainees (particularly teams experiencing difficulty managing a challenging case) may require further scaffolding in their use of regulatory processes within medical emergencies. The results from this study are discussed in terms of implications for theories of self-regulation, methodological advances, and instructional design for medical education.

Keywords Emotion · Cognition · Metacognition · Regulation · Medicine · Simulation training

Introduction

When confronted with an emergency case, medical professionals are required to make critical decisions that directly impact patient safety and long-term health outcomes. If the patient's health is deteriorating at a rapid pace, the urgency and intensity of the situation is exacerbated. The critical condition of the patients and their symptoms (e.g., irregular heartbeat, blocked airways) combined with the novelty and complexity of these types of cases requires, leadership, adaptability, and coordination of medical knowledge, resources, and team communication to effectively stabilize the patient (Salas et al. 2007). Within these high-stakes environments, a diverse range of cognitive, metacognitive, and affective processes may also serve to hinder or enhance performance (Brydges and Butler 2012; Zimmerman and Schunk 2011). For instance, if a team leader enters the room in a relatively calm state, this may reduce cognitive load and allow for higher-order cognitive and metacognitive processes, such as continuous monitoring for fixation errors and effective communication of critical thinking (Pekrun 2006, 2014). On the other hand, if leaders are feeling overly anxious, they may be less likely to engage in flexible problem-solving or effective communication (Pekrun 2006, 2014).[1] As such, medical professionals and residents must learn to monitor and regulate their thoughts, feelings, and behaviors, because of the potentially deleterious effects that dysregulation may have on the ability to successfully care for the patient. Moreover, it is also important that medical trainees learn to enact these changes and adapt on-the-fly given that medical emergency cases afford little time for team formation and selection compared to other group contexts (Kanaga Kossler 2011; Wildman et al. 2012).

Given these considerations, and recent calls to examine self-regulation within medical education (Brydges and Butler 2012; Sandars and Cleary 2011), the present research contributes to the literature by providing an in-depth case study on the nature of cognitive, affective, and metacognitive (CAM) processes as they unfold for a medical team experiencing difficulty managing a highly challenging medical emergency simulation. This type of scenario is important from an educational perspective as it can help to illuminate problem areas that may require additional scaffolding. As such, findings from this research provide a foundation to improve the design and delivery of team-based simulation training, as well as learning outcomes for medical professionals. In the following sections we provide an overview of medical emergency training, as well as a description of theories of self-regulation and achievement emotions that were used to ground this research. The introduction closes with the purpose and research questions of the current study.

[1] It is also possible that a reciprocal relationship exists between these processes.

Medical emergency training

Medical emergencies (e.g., cardiac arrest) present a challenge for medical professionals because they are demanding in terms of both the medical knowledge needed to plan effective interventions and the regulatory skills required to effectively manage the team. During medical emergencies, potentially life-threatening errors and adverse events commonly occur (Rothschild et al. 2005) given that the complexity and frequency of invasive interventions for critically ill patients present greater opportunities for error (Bion and Heffner 2004). Research has revealed that there are several cognitive errors in clinical decision-making that can occur due to diagnostic uncertainty, case novelty, and frequency of distractions unique to medical emergencies (Bond et al. 2004; Croskerry 2003). Medical errors can also occur as a result of communication difficulties (Leonard et al. 2004; Lingard et al. 2008; Manser and Foster 2011). Adverse medical events affect nearly 1 out of 10 patients (de Vries et al. 2008), and up to 98,000 deaths per year are attributed to medical errors in the United States alone (Kohn et al. 1999).

To help address these issues, *crisis resource management* training programs have been developed to foster dynamic decision-making, interpersonal skills, and team management (Cheng et al. 2012; Gaba et al. 1994; Gaba 2010). Implementing this type of training within simulation settings, in particular, allows medical professionals to gain experience and learn from errors without harm to patients (Greenberg et al. 2011; Salas et al. 2008b; Ziv et al. 2005). This type of training also provides an opportunity to develop team-based competencies (e.g., leadership, performance monitoring, closed loop communication, mutual trust, adaptability), which can in turn help to improve decisions-making, patient safety, and care (Salas and Cannon-Bowers 2001; Salas et al. 2008a, b; Salas et al. 2005). Effective teamwork is critical given that medical emergencies typically involve two or more inter-related medical professionals that interact, share common goals, and coordinate actions and information to function as a unit and achieve a desired outcome (Salas et al. 2007, 2008a, b). Despite the potential benefits of these high-fidelity training experiences, there is a need for further research to examine the nature of learning and performance within simulation environments (Greenberg et al. 2011; McGaghie et al. 2010), particularly as they occur in real-time *during* team training (Salas and Cannon-Bowers 2001; Salas et al. 2008a). One approach is to apply theories of self- and co-regulation. As Sandars and Cleary (2011, p. 975) have argued, regulation theories offer an “exciting potential” to improve achievement and clinical performance.

Self- and co-regulation

Theories of self-regulation (e.g., Boekaerts 2011; Pintrich 2000; Winne and Hadwin 1998, 2008; Zimmerman and Schunk 2011) have commonly been employed as a guiding framework within educational psychology to understand learning and performance within achievement settings. Broadly speaking, self-regulation refers to the self-initiated management of thoughts, feelings, and behaviors that are used to achieve specific goals (Zimmerman 2001, Zimmerman and Schunk 2011). High levels of self-regulation involve setting effective goals, employing adaptive strategies, and successfully monitoring and assessing progress (Zimmerman and Schunk 2008).

According to Pintrich’s (2000, 2004) social-cognitive framework, there are four phases of self-regulation: (1) forethought, (2) monitoring, (3) control, and (4) reaction. These phases are considered cyclical and encompass different areas or components of regulation, such as cognition and metacognition (e.g., critical thinking, assessing strategy use), as well as affect (e.g., emotions), which can be deployed throughout each phase in a dynamic manner. For example, forethought may involve planning and goal-setting, as well as activation of prior knowledge and perceptions of task-value and control. Monitoring may involve metacognitive awareness of the amount of effort invested, the time used, and changes in task conditions. Control may involve selecting cognitive strategies, such as critical thinking or summarizing. Reaction may involve assessment of outcomes, effectiveness, and emotional responses. Collectively, this framework describes how cognitive, affective, and metacognitive (CAM) processes may occur across various phases of self-regulation. Researchers have argued that one way to measure these processes is to treat self-regulation as event-based rather than a largely static trait or aptitude, and as such, they make the fundamental assumption that cognitive, metacognitive, and affective processes can be detected and traced in real time (Azevedo 2014; Azevedo et al. 2013; Winne and Azevedo 2013; Winne and Perry 2000).

Within the domain of medicine, researchers have acknowledged the importance of self-regulation for effective clinical practice and have called for further work to better understand how to promote adaptive self-regulation (e.g., Artino et al. 2012; Butler and Brydges 2013; Brydges and Butler 2012; Sandars and Cleary 2011; Sandars 2013; White 2007). Although several studies in medical education can be couched within a self-regulation framework (see Brydges and Butler 2012), calls have been made for more explicit and systematic application of these theories (Sandars and Cleary 2011) using measures that capture self-regulation processes as they unfold in real time (Durning et al. 2011).

In addition to self-regulation frameworks, which treat the individual as the focal point, scholars have explored how coregulation can occur within group settings (Azevedo 2014; Molenaar and Järvelä 2014). Coregulation incorporates social factors (e.g., peer interaction) that occur during group problem-solving activities (Brydges and Butler 2012; Hadwin and Oshige 2011; Volet and Summers 2013; Volet et al. 2009). Coregulation moves beyond the individual to measure how group members interact (Hadwin and Oshige 2011; Volet et al. 2009). Social-cognitive models of self- and co-regulation frameworks are particularly relevant for group dynamics that occur within medical team settings. However, one major shortcoming of these frameworks is that the role of affect is largely underrepresented (Ben-Eliyahu and Linnenbrink-Garcia 2013). Similarly, within medicine, researchers have typically focused on cognitive processes (e.g., reasoning, problem-solving) and metacognitive processes (e.g., planning, monitoring) while affective processes (e.g., emotions) have typically been assessed in terms of psychological health and emotional intelligence (e.g., Chew et al. 2013; Pedersen 2009) rather than their functional role in learning and performance. Recently, calls have been made to address these gaps (Artino 2013; Artino et al. 2012) as it has been noted that there is a need for medical educators to better understand the role of emotions and apply this knowledge to clinical training (Croskerry et al. 2008; McConnell and Eva 2012). In the following section, we discuss research and theory on emotions in achievement settings.

Achievement emotions

Emotion is considered to be a subset of affect and has been described as “a feeling that is often short-lived, intense, and specific” (Artino 2013, p. 1062). Achievement emotions refer to emotions that are directly linked to achievement activities or outcomes (Pekrun 2006; Pekrun et al. 2011; Pekrun et al. 2002). According to Pekrun and colleagues (Pekrun et al. 2002, 2011; Pekrun 2006), achievement emotions can be classified based on several dimensions, including: valence (positive vs. negative), physiological arousal (activating vs. deactivating), and object-focus (outcome-related vs. activity-related) Using combinations of the arousal and valence categories, achievement emotions can be organized into the following four groups: *positive activating* (e.g., enjoyment, hope, pride), *positive deactivating* (e.g., relief), *negative activating* (e.g., anger, anxiety, shame), and *negative deactivating* (e.g., boredom, hopelessness).

Control-value theory of achievement emotions (Pekrun 2006) provides a useful social-cognitive framework to examine the structure and function of emotions in achievement settings by explaining reciprocal links between antecedents, emotions, and their effects. According to control-value theory, appraisals of subjective control and value are fundamental to the elicitation of emotions (Pekrun et al. 2007; Pekrun 2006). For example, if individuals positively value an activity and feel personally in control, they would be expected to experience enjoyment, whereas if individuals do not feel in control of the situation, they would be expected to experience frustration (Pekrun 2006). Once elicited, emotions can, in turn, hinder or enhance regulatory processes and performance (Mega et al. 2014; Pekrun 1992, 2006; Pekrun et al. 2002, 2011).

As research has shown, positive emotions are related to more flexible and creative modes of thinking, such as elaboration and critical thinking strategies, as well as other regulatory processes, such as planning, monitoring, and evaluation. In contrast, negative activating emotions (e.g., anger, anxiety) are linked with more rigid modes of thinking, such as rehearsal strategies (Isen 2000; McConnell and Eva 2012; Pekrun et al. 2002, 2011). In addition, negative emotions are generally negatively related to achievement whereas positive emotions are positively related to achievement (Pekrun et al. 2002, 2011).[2] In one of the few studies examining emotions within medical education, Artino et al. (2010) found that, among medical residents, enjoyment was positively related to achievement, whereas anxiety and boredom were negatively related to achievement. However, both positive and negative emotions can place a strain on cognitive resources and lead to task-irrelevant thinking by redirecting attention toward the object of the emotion rather than the task at hand (Meinhardt and Pekrun 2003; Pekrun 2006). As such, although they may be subjectively experienced as pleasant or unpleasant based on valence, whether or not a particular emotion is considered *adaptive* is more variable and dependent upon the context (Pekrun 2006). For instance, anxiety may produce negative outcomes when faced with significant time constraints yet positive outcomes when additional time is afforded (Pekrun 1992). Similarly, anger may cause individuals to become distracted by ruminating about shortcomings in their abilities, or it may spur them to invest more effort (Pekrun 1992).

Despite these advances in research, to our knowledge no studies to date have examined how emotional states relate to other facets of self-regulation and performance among medical residents. Recently, calls have been made for theory-based research to examine the nature of emotions using control-value theory and multiple methodologies (including real-time assessments) across diverse phases and contexts of medical education (Artino et al. 2012). Thus, further empirical work is needed, including research that focuses on training outside the classroom, in settings that more closely approximate clinical practice, such as simulations.

Present study

Due to the paucity of research in this area, the purpose of the present study was to examine the nature of cognitive, affective, and metacognitive (CAM) processes within the context of a high-fidelity simulation session designed to equip medical residents with medical content expertise (i.e., medical knowledge and skills) and crisis resource management skills (i.e., effective leadership and team management). To optimize training opportunities, it is

[2] Negative activating emotions (e.g., anxiety) appear to have a more variable relationship with achievement (Pekrun et al. 2011; Pekrun 1992).

important to identify areas in need of improvement by studying teams that experience a high degree of difficulty managing a medical emergency. Therefore, we conducted a case study using a purposive sampling approach typically employed in qualitative research (Creswell 2006) based on two criteria: (1) a lower performing team (2) a highly challenging medical case. This approach, referred to as extreme case sampling, was chosen given that our goal was to analyze the most obvious example or clear-cut pattern of CAM processes—in this case, for a team experiencing difficulty managing the case based on performance ratings.

Accordingly, we aimed to address the following research question: (1) What is the nature of cognitive, affective, and metacognitive processes within a medical team experiencing difficulty with a challenging medical emergency simulation? To address this question, we included data from multiple sources (e.g., behavioral, verbal, facial expressions, self-report) to provide an in-depth analysis. We also developed and applied theory-based coding schemes for each of these regulatory processes by reviewing the literature from relevant disciplines (e.g., educational psychology). Although hypotheses are tentative given the paucity of research in this area, we argue that effective performance (i.e., effective application of medical expertise and crisis resource management skills) requires team members to monitor and control (i.e., regulate) their emotions and thought processes so that they can effectively plan and implement medical interventions (e.g., administer medications, perform EKG). Thus, we expect that difficulties with case management will be related to persistence in negative emotions and less effective deployment of cognitive and metacognitive processes. In the following section we describe the methodology, including a description of the simulation training, medical case, data sources, and coding process.

Methodology

Participants

Participants were first- to third-year postgraduate medical trainees (i.e., residents) enrolled in a core internal medicine program at a large Canadian university. All residents in this program were required to participate in a yearly Crisis Resource Management half-day training session at a Canadian Medical Simulation Centre during their 3 years of core internal medicine training. For this case study, we selected one team consisting of six internal medical residents ($N = 5$ females; $N = 1$ male).[3] Four residents participated in the simulation while two observed. The average age of this team was 26 ($SD = 1.87$). The majority of the residents within this team were in their first year of residency (60.0 %) and the remaining were in their second year (40 %); no team members were in their third year of residency. We selected this team based on expert ratings that indicated the leader had more difficulty managing this case compared to other teams participating in this training session.[4]

[3] This study is part of a larger research program on crisis resource management simulation training. For the purposes of this case study, we selected one team and one case from a sample of 3 teams ($N = 17$ residents) that each participated in 3 case simulations (hyperkalemia, pulmonary embolism, upper gastrointestinal bleed) during a half-day training session.

[4] Medical expert ratings for the leader were lower ($M = 1.42$) compared to the average across all leaders for this case ($M = 2.05$, $SD = 0.59$). CRM ratings for the leader were lower ($M = 3.13$) compared to average across all leaders for this case ($M = 4.76$, $SD = 1.53$). The team also reported lower prior CRM skills ($M = 2.00$, $SD = 0.71$) compared to the average across teams ($M = 2.27$, $SD = 0.70$) and lower post-training CRM skills ($M = 2.26$) compared to the average across all teams ($M = 3.20$, $SD = 0.86$), which indicates less effective CRM skills.

Simulation training environment

The crisis resource management (CRM) simulation exercise is designed to train internal medicine residents in skills needed to effectively manage resuscitation efforts (i.e., stabilize a critically ill patient who is in imminent danger of death). Successful resuscitation requires mastery of medical content expertise (e.g., correct diagnosis) and CRM skills (e.g., effective communication and leadership). As a team effort, this requires coordination and participation from each member to successfully plan and execute medical interventions (e.g., administer medication, insert tube into trachea to maintain open airway). The simulation room was equipped with video cameras, microphones, medical equipment and a high-fidelity mannequin (simulated patient, see Fig. 1). Team members' actions (e.g., administering medication, ordering tests) impacted the mannequin's reactions and outcomes (e.g., verbal responses and vital signs), which were controlled by a technician from the control room. Limited patient information was provided prior to the simulation and dynamically during the simulation at the residents' request.

Research protocol

During the 11-min simulation, two debriefers (experienced staff physicians) observed from the control room behind a one-way mirror. After completion of the simulation, debriefers independently completed rating scales and checklists about the leader's performance (crisis resource management and medical expertise) and facilitated a 20-min debriefing session. At the end of the simulation session, residents attended a medical expertise presentation explaining the case. Afterward, residents completed feedback questionnaires and had the option to participate in a follow-up interview to discuss their experiences and emotions during the simulation.

Case description: pulmonary embolism

We selected the pulmonary embolism simulation for analysis because it was considered to be the most challenging of the cases developed for the simulation training session (based on agreement among case developers and expert staff physicians). The patient in this medical case was a pregnant woman with a massive pulmonary embolism, which is a large blood clot in the blood vessel of the lung. This clot causes both lung and heart failure and is potentially fatal. Appropriate management of this case included: (1) assessment (e.g., ordering blood tests, chest X-ray, electrocardiogram, and echocardiogram); (2) making the diagnosis of massive PE based on assessment results; (3) supporting the heart using intravenous fluids and medications that help to elevate blood pressure; (4) helping the patient's breathing, including intubation and use of mechanical ventilation; and (5) administering a thrombolytic—a potent medication that dissolves blood clots—to unblock the blood vessels in the patient's lungs.

Materials/measures

Simulation and debriefing

Video and audio recordings were collected during the simulation and debriefing to capture verbal and nonverbal behavior (e.g., facial expressions, body language). These data were used to code for cognitive, metacognitive, and affective events as described in further detail below.

Fig. 1 High fidelity mannequin within the simulation room

Performance measures

The Medical Expert Checklist and the Ottawa Crisis Management Skills Global Rating Scale (Kim et al. 2006, 2009) were completed by debriefers to assess the leader's medical expertise and team-management skills, respectively. The CRM Global Rating Scale is designed to assess competence in crisis resource management skills and contains a question for each category of CRM as follows: communication, leadership, problem-solving, situational awareness, resource utilization, and overall CRM performance. This Likert scale ranges from 1 to 7 and includes anchored descriptions attached to each rating (e.g., "remains calm and in control for entire crisis; makes prompt and firm decisions without delay; always maintains global perspective"). Lower scores indicate weaker CRM skills. The same scale was used across all cases as CRM skills required to manage critically ill patients are expected to be generalizable across medical emergency scenarios. Construct validity and acceptable levels of reliability have previously been established for this rating scale (see Kim et al. 2006, 2009). The Medical Expert Checklist is designed to assess medical knowledge and skills (e.g., which medication to use, how to insert a central line) and is adapted for each case. This Likert scale ranges from 0 = not done to 3 = done very well. A sample item for the pulmonary embolism checklist includes: "Recognizes clinical hypoperfusion (i.e. correlates blood pressure results with physical findings such as altered mental status and decreased urine output)." In terms of validity, the content of this checklist was developed by subject matter experts (case developers and expert medical professionals, specializing in emergency care) and informed by empirical and review papers from the medical literature describing effective diagnosis, treatment, and management of pulmonary embolism during pregnancy (e.g., Ahearn et al. 2002; Baurjeily 2010; Torbicki et al. 2008; Turrentine et al. 1995; Wood 2002). Debriefers were trained how to use these scales in an orientation session led by the case developers prior to participating in the simulation. To calculate inter-rater reliability for these scales, intraclass correlation coefficients were obtained based on debriefers' ratings of scale items across all teams and cases for the Medical Expert Checklist ($\rho = 0.89$) and CRM rating scale ($\rho = 0.78$). Furthermore, for the pulmonary embolism case in particular, debriefers reached 100 % agreement for the ordinal rankings of teams for both scales (i.e., rank order of team-performance from highest to lowest based on overall ratings of each scale).

Demographics and feedback questionnaire

Demographic data (e.g., year of residency, gender) and questions related to participants' satisfaction with the training session were collected.

Follow-up interview

Follow-up interviews were audio recorded and transcribed verbatim. These data allowed us to further probe team leaders about their experiences and emotions during the simulation. Sample questions included: "Do you think you were you able to effectively monitor your emotions during the simulations?" "Was there a particular strategy or set of strategies behind the way you approached this medical case?"

Coding

Simulation coding

Coding schemes (see Table 4 Appendix) were developed to identify cognitive, metacognitive, and affective events/processes exhibited by the team (medical residents) during the simulation. We reviewed the literature to identify relevant coding schemes and theoretical frameworks to apply to this context; however given limitations with approaches used in previous work, we opted to develop and test coding schemes through an iterative process that involved applying theoretical frameworks to generate categories for the coding scheme and revising after assessing their suitability. During this process, two trained coders applied the taxonomies by reviewing videos, identifying relevant segments, and coding independently. Disagreements were identified and discussions led to refinement of the coding scheme. In some instances, definitions were adapted after initial coding to increase relevance for this medical context and to incorporate additional data channels as necessary (e.g., paralinguistic and body language cues for emotions).

The metacognitive coding scheme was guided by Schraw and colleagues' framework (Schraw and Dennison 1994; Schraw 1998, 2010) for metacognitive monitoring and control, which includes the following three categories: (1) planning (setting subgoals, forming an action plan, allocating tasks/roles), (2) monitoring (checking understanding, monitoring task performance), and (3) evaluation (assessing effectiveness of approach/technique/strategy). To ensure the definitions and categories were relevant for a medical scenario, we also drew from Lajoie and Lu's (2009) metacognitive coding scheme. The cognitive coding scheme was informed by basic working memory and information processing models of cognition (see Winne and Hadwin 1998). It included the following three categories: (1) collecting/providing information (selecting, attending to, eliciting, and sharing new information), (2) summarization and repetition (communication of previously covered information or knowledge by verbalizing it verbatim or by reorganizing it in one's own words), and (3) reasoning (manipulating and/or combining knowledge to arrive at conclusions based on that information). Segments of cognitive and metacognitive events were identified, segmented, and coded based on dialogue moves between residents. The emotion coding scheme was guided by taxonomies described by Pekrun and coauthors (1992, 2002, 2006, 2011) and capture emotions that arise in learning and achievement contexts, which is relevant for the simulation scenario. This includes the following positive and negative emotions: *enjoyment*, *hope*, *pride*, *relief*, *gratitude*, *relaxation*, *contentment*, *frustration*, *sadness*, *disappointment*, *anger*, *anxiety*, *shame*, *hopelessness*, and *boredom*. Given the nature of an emergency care environment (high stress, life-threatening), we also consulted Ekman's six basic emotion taxonomy (Ekman 1992; Ekman and Friesen 1978) to complement Pekrun's taxonomy. Specifically, *disgust* and *surprise* were added to the coding scheme. Videos were reviewed to determine if emotions other than those in Ekman and Pekrun's taxonomies were experienced, and reviewers identified *compassion* and *neutral*. Emotions were identified in the video based on four different types of available data channels: dialogue, facial expression, body language, and paralinguistics. Discrete emotional states were segmented by the presence or shift in emotion. Each team member was coded individually.

Two coding schemes were used (emotion and cognitive/metacognitive); coders independently coded for emotions first, followed by coding of both cognitive and metacognitive events. To calculate inter-rater reliability, two coders independently coded the leader and identified any disagreements in codes (segments were agreed on beforehand). For the cognitive and metacognitive coding scheme, agreement was 92 %. For emotions, coding scheme agreement was 89 %. The results from simulation analyses (presented below) include codable segments based on analyses using these coding schemes. Uncodable segments were typically due to audio/video quality (e.g., participant inaudible or out of frame) or inability to reliably determine a category based on the available data channel.

Debriefing session and interview coding

Audio recordings of the debriefing session and the follow-up interview were transcribed verbatim and coded for cognitive, metacognitive, and affective responses using qualitative approach (i.e., content/thematic analyses; Creswell 2006). Relevant segments were identified and categorized according to these cognitive, metacognitive, and affective processes. Responses were grouped into themes according to whether the speaker's response referred to an effective or ineffective regulatory process. To calculate inter-rater reliability, an independent coder re-coded the debriefing transcripts; (88 % agreement was established between the two coders. Overall, these data served as self-report measures as team members were able to discuss thoughts and emotions that may not have been verbalized or overtly expressed during the simulation.

Results

Simulation session

For each CAM process, we calculated frequency proportions (i.e., percentage of instances that an event occurred based on number of codes divided by total number of codes) and duration proportions (i.e., percentage of time that an event occurred based on seconds of code length divided by total code lengths in seconds).[5] These statistics were calculated separately for (1) the leader and (2) remaining team members as a collective group (average).

[5] Percentages represent the frequency and amount of time (s) that a particular category occurred (e.g., duration of monitoring) compared to the total number of events or duration of events that occurred for the process (e.g., total duration of metacognitive events).

Metacognitive processes

Analyses revealed that of the metacognitive processes, the leader most commonly exhibited *planning* in terms of frequency (72.00 %) and duration (75.53 %), followed by *monitoring* (28.0 % frequency; 24.47 % duration). However, further analysis of the leader's dialogue at the microlevel revealed that during 47.3 % of task allocation (considered to be a type of planning event) the instructions from the leader were indirect (e.g., "let's start an IV"; "we need to know") rather than direct assignment of a task to a specific team member (e.g., "Sam, you're in charge of intubation"). In contrast with the leader, remaining team members engaged in *monitoring* more frequently (81.25 %) and for the longest duration (77.87 %), followed by *planning* (16.67 % frequency; 21.31 % duration), and lastly *evaluation* (2.08 % frequency; 0.82 % duration). *Evaluation* was not demonstrated by the leader. See Table 1 and Fig. 2 for frequency and duration of metacognitive processes.

Cognitive processes

In terms of cognitive processes, the leader most commonly exhibited *summarization/repetition* in terms of frequency (38.46 %) and duration (42.47 %) followed by *collecting/providing information* (34.62 % frequency; 27.40 % duration), and lastly *reasoning* (26.92 % frequency; 30.14 % duration). Compared to the leader, remaining team members exhibited *collecting/providing information* most frequently (75.47 %) and in longest duration (74.85 %), followed by *summarization/repetition* (22.64 % frequency; 24.56 % duration), and lastly *reasoning* (1.89 % frequency; 0.58 % duration). For raw scores of cognitive processes (frequency and duration), see Table 2 and Fig. 3.

Emotions

Analyses of emotions revealed that the leader displayed a *neutral* state most frequently and for the longest duration during the simulation (54.90 % frequency; 57.21 % duration), followed by *anxiety* (27.45 % frequency; 29.81 % duration), *frustration* (7.84 % frequency; 4.33 % duration), *disappointment* (3.92 % frequency; 4.81 % duration), and lastly *hopelessness* (5.88 % frequency; 3.85 % duration). In contrast to the negative emotions, the leader did not exhibit any positive emotions during the simulation (i.e., *compassion*, *relief*, *pride*, *hope*, *gratitude, relaxation, contentment*, and *enjoyment*). Analyses also revealed that *shame*, *anger*, *sadness*, *boredom*, *disgust*, and *surprise* were not exhibited by the leader during the simulation. Consistent with the leader, on average the remaining team members exhibited a *neutral* stance most frequently (75.27 %) and for the longest duration during the simulation (83.71 %), followed by *anxiety* (6.59 % frequency; 5.00 % duration), *frustration* (7.14 % frequency; 4.61 % duration), *hopelessness* (5.88 % frequency; 2.06 % duration), *compassion* (2.20 % frequency; 1.86 % duration), *shame* (2.20 % frequency; 0.98 % duration), *surprise* (2.20 % frequency; 0.88 % duration), *relief* (0.55 % frequency; 0.39 % duration), *anger* (0.55 % frequency; 0.29 % duration), and *hope* (0.55 % frequency; 0.20 % duration). Again, similar to the leader, remaining team members did not experience most positive emotions (*pride, enjoyment, gratitude, contentment*, or *relaxation*). They also did not exhibit *disappointment*, *sadness*, *boredom*, or *disgust*. For raw scores of affective processes (frequency and duration), see Table 3 and Fig. 4.

Table 1 Durations for metacognitive events

Category	Agent	Duration
Planning	TL	75.53 % (71.00 s)
	TM	21.31 % (8.67 s)
Monitoring	TL	24.47 % (23.00 s)
	TM	77.87 % (31.67 s)
Evaluating	TL	0 %
	TM	0.82 % (0.33 s)

TL team leader; *TM* team members

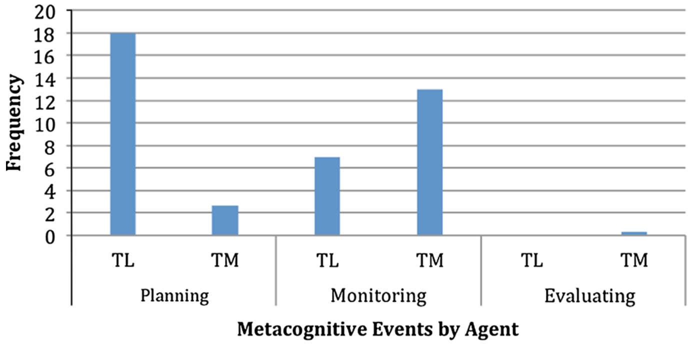

Fig. 2 Frequencies for metacognitive events. *TL* team leader, *TM* team members

Table 2 Duration for cognitive events

Category	Agent	Duration
Collecting/providing information	TL	27.40 % (20.00 s)
	TM	74.85 % (42.67 s)
Summarization and repetition	TL	42.47 % (31.00 s)
	TM	24.56 % (14.00 s)
Reasoning	TL	30.14 % (22.00 s)
	TM	0.58 % (0.33 s)

TL team leader; *TM* team members

To further examine the context surrounding the deployment of negative emotions, we conducted a (post hoc) Chi square analysis of the states in the 10 s preceding incidents of negative emotion as exhibited by the leader. These events were grouped as lower-order cognitive/metacognitive events (summarization/repetition, collecting/providing information, and planning[6]), higher-order cognitive/metacognitive events (reasoning, evaluation, and monitoring), or other (no cognitive or metacognitive event deployed during 10-s interval prior to onset of negative emotion). Results from the Chi square analysis revealed a significant difference in the frequency distribution of events that preceded emotions, with lower-order events occurring significantly more frequently and higher-order events

[6] Planning was considered lower-order given that the follow-up analyses of its quality revealed that in almost half of the cases, it was not executed effectively.

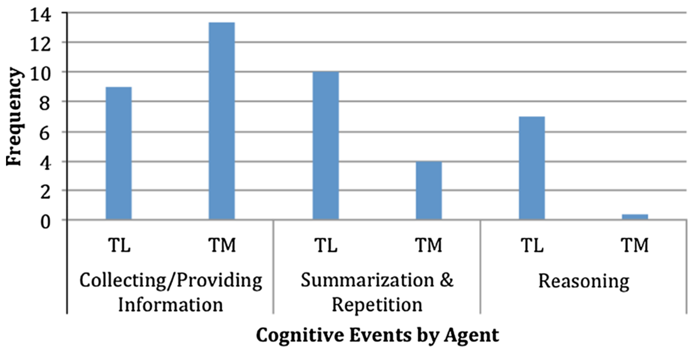

Fig. 3 Frequencies for cognitive events. *TL* team leader, *TM* team members

occurring significantly less frequently than expected by chance: χ^2 (2, $N = 22$) = 8.27, $p < 0.05$.

Debriefing session and follow-up interview[7]

Qualitative content analyses revealed that the discussion during the debriefing session focused on key issues related to crisis resource management (e.g., breakdown/dysregulation in communication), as well as suggestions to improve regulatory strategies and prevent confusion in future cases. Overall, although the handling of the simulated medical emergency was considered relatively unsuccessful from a medical perspective (unable to stabilize the patient), the team members and leader exhibited a great deal of metacognitive knowledge while reflecting upon the sources of their difficulties.

One of the key areas of difficulty addressed during debriefing was task allocation and role assignment. While the leader had assigned team members specific roles before the simulation, the case nurse was not informed of the roles and was uncertain as to who he should be taking orders from: "I was kind of looking and like, 'where's my next order coming from?'" Similarly, another team member stated: "But [you need] to say that you're the team leader, because we all knew it, but I'm not sure that [the nurse] knew who the case leader was." The medical expert also noted that this was not clear: "I thought [the other team member] was in charge. And then I heard a voice giving orders… I didn't know who it was, so a few of us were confused." Team members' responses during the debriefing session also indicate that as the simulation progresses, the leader does not clearly delegate new tasks to other team members: "At the beginning we did sort of, we had an idea that we were supposed to be doing different things. For example, after I'd taken med history and taken the physical exam, then it became a little bit more nebulous." Feedback from observing residents suggested that this lack of role assignment was related to poor task allocation: "I think maybe airways [could have] been managed by one person, and then when she felt uncomfortable she could have asked for help… You [pointing to another team member] could have done something else." Another team member added: "Sometimes [the leader] would ask for something and I would try to go through the crash cart. But obviously [the nurse] could find it a lot easier than I did… And then I sort of didn't have

[7] Names from quotations have been replaced with the individual's role during the simulation to protect anonymity.

Table 3 Duration for emotion events

Category	Agent	Duration
Compassion	TL	0 %
	TM	1.86 % (6.33 s)
Relief	TL	0 %
	TM	0.39 % (1.33 s)
Pride	TL	0 %
	TM	0 %
Hope	TL	0 %
	TM	0.20 % (0.67 s)
Enjoyment	TL	0 %
	TM	0 %
Gratitude	TL	0 %
	TM	0 %
Relaxation	TL	0 %
	TM	0 %
Contentment	TL	0 %
	TM	0 %
Neutral	TL	57.21 % (119.00 s)
	TM	83.71 % (284.33 s)
Surprise	TL	0 %
	TM	0.88 % (3.00 s)
Anxiety	TL	29.81 % (62.00 s)
	TM	5.00 % (17.00 s)
Frustration	TL	4.33 % (9.00 s)
	TM	4.61 % (15.67 s)
Disappointment	TL	4.81 % (10.00 s)
	TM	0 %
Hopelessness	TL	3.85 % (8.00 s)
	TM	2.06 % (7.00 s)
Shame	TL	0 %
	TM	0.98 % (3.33 s)
Anger	TL	0 %
	TM	0.29 % (1.00 s)
Sadness	TL	0 %
	TM	0 %
Boredom	TL	0 %
	TM	0 %
Disgust	TL	0 %
	TM	0 %

TL team leader; *TM* team members

anything else to do." It may be the case that these issues in task allocation were related to uncertainties the leader held about the direction of the case (i.e., planning): "I think that [my lack of communication] was more reflective of my own thought processes that I was very clear in the beginning, and then once I got to a certain point it became very difficult

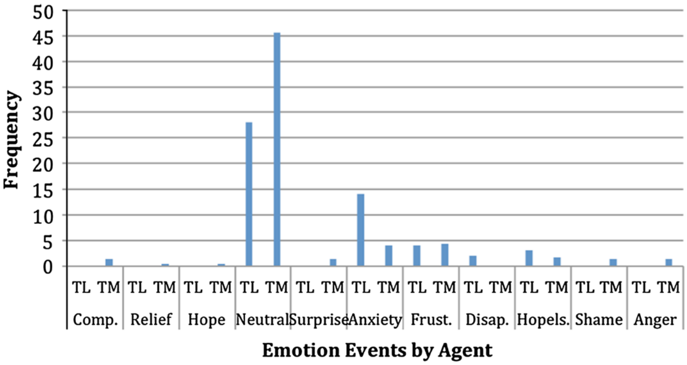

Fig. 4 Frequencies for emotion events. *TL* team leader, *TM* team members

and I wasn't quite sure where I was going. And I was just trying to keep things stable while trying to figure out the next step."

Another issue was the lack of summarization. Specifically, team members expressed that they often were unsure of what was being performed and whether certain tasks had been completed: "It's often difficult to know what's already been done and what's actually happening when you're trying to focus on [one thing]. I wasn't sure whether the IV heparin was running or not, so I guess sort of announcing what's happening, you know, and what we had accomplished or summarizing." Another team member added: "I think at the beginning you were summarizing the situation, but then as it was going on we didn't get that summary of what was happening and where we were heading… so maybe telling us a little bit more."

The medical experts also identified lack of evaluation as problematic. They noted that the leader did not evaluate the changing state of the patient frequently enough and the lack of consistent evaluation may have contributed to overfixations on tasks that were not longer helpful or relevant. For example, as one debriefer commented: "Also, keep an eye on the evolution of things. I think you were trying… bagging, ready to intubate, but then an O_2 stat [oxygen saturation] was 94, and she was better, so it's always adjusting to new findings." The nurse also commented on this: "Always remember to get back to the 're-evaluate and reassess' because we got really fixated as a group on that desaturation episode. We poured all our resources in on it and as that's going on, as we're laying the patient down to deal with the desaturation we kind of lost sight of the really big picture."

In contrast to the previous areas for improvement, it was acknowledged by one team member that the leader effectively set goals, which helped the team members to stay focused in a highly stressful case: "I thought it helped [the level of stress]… that she sort of went, 'Ok, no, let's not focus on the baby, let's focus on the mom.' She said that repeatedly over… when anybody said the vitals of the baby, she would be like, no, we're focusing on the mom. It focused us, because you have so many problems in this kind of situation, so we're trying to think for two people. It helped prioritize and I think she did that very well."

While the team members and medical experts focused on cognitive and metacognitive coregulatory strategies that could have been used for a more successful outcome (as described above), the responses during the follow-up interview suggested that the leader focused on the inability to regulate emotions. When asked what types of emotions were experienced during the simulation, the leader identified stress and fear. These affective states were attributed to the lack of experience with medical protocol for this particular case and the lack of outside medical resources as depicted in the following quote: "[It was] stressful. It was clear right away, the problem. The solution is very murky to me. So this is a woman who's in distress, who's compromised from a PE and is pregnant. And I just, you know, my normal routines of how I usually would deal with a code [medical emergency], in this situation, I was completely off of it." Similarly, the leader commented on the novelty and emotionally charged nature of this particular case: "I was very stressed and I was very scared through the whole thing because I could see myself losing the baby; I could understand that I wasn't in enough control." In the following section, we discuss how these results help us to understand the nature of regulation within medical emergency teams.

Discussion

The goal of this study was to examine the nature of self- and co-regulatory processes within the context of medical emergency simulation training. To conduct these analyses we coded video and audio data for cognitive, metacognitive, and affective processes as they occurred within simulations. Debriefing and interviews were coded for self-reported evaluations. Analytic techniques were conducted using both quantitative and qualitative methods. The results from the quantitative analyses provide insight into the type of CAM events that occurred within this simulation case. Qualitative analyses from interviews, debriefing, and event coding provide further information about the nature of these processes (e.g., effective/ineffective), factors related to the onset of negative emotions, and how these processes may relate to performance (e.g., medical decision-making and crisis resource management skills). In the following section we summarize the key findings in terms of the role of regulatory processes for medical emergency cases. We then describe implications for theory and training design, particularly with regards to teams experiencing difficulty managing a challenging case. We close with a discussion of limitations and future directions of this work.

Team regulation

In terms of metacognition, the results demonstrate that the leader most commonly engaged in planning (e.g., task/role allocation) whereas remaining team members engaged in monitoring (e.g., checking understanding) more commonly than other metacognitive processes. This is not unexpected given that during a medical emergency the leader is expected to provide direction for the action plan and assign roles and tasks for team members. However, further analyses of leader dialogue indicated that task allocation was not consistently assigned to specific team members; instead it was stated as a general group responsibility or plan (e.g., "we need to know"; "we are going to need") without assigning a specific group member to complete the task. This presents a challenge for *closed-loop communication*, as it is not clear who is responsible for following up on the task/action plan and confirming completion. Furthermore, in terms of roles, the experienced staff physicians noted during the debriefing session that it was not clear who the leader was during the case, which suggests clearer role identification was needed. It was interesting that in this case, no instances of *evaluation* (e.g., assessing the outcomes and efficiency of the team's approach) were found in the leader dialogue. It may be the case that this type of evaluation is occurring internally but not directly verbalized during the case, particularly if the approach is deemed ineffective and this is coupled with negative emotions or lack of metacognitive/medical knowledge needed to execute a different approach. Perhaps the team leader was trying to guard expressions of negative emotions; however, it may be necessary in such cases to explicitly verbalize the evaluation process so that other team members can provide input. By consulting with the team, the leader would be engaging in resource utilization—a core tenant of crisis management skills.

Similarly, for cognition, the results reveal that the team leader engaged in summarizing/repetition most commonly whereas the remaining team members favored collecting/providing information of the cognitive processes. Although this is not unexpected given the role of the leader (to stand back and gain perspective of the bigger picture), it is interesting that for both the leader and team, *reasoning* (a higher-order process) is the most infrequent cognitive process. To better understand why a particular strategy or approach is ineffective (based on metacognitive evaluations) it may help to communicate the reasoning or rationale for a particular medical decision or assessment more consistently and explicitly.

With respect to emotions, the results revealed that the case was dominated by negative emotions and there appeared to be consistency among the team members in the types of emotions experienced, particularly in terms of anxiety, frustration, and hopelessness. Thus, we found evidence of achievement emotions (e.g., frustration, anxiety), as well as basic emotions (e.g., anger); however, several emotions typically presented within these frameworks were not exhibited (e.g., sadness, pride, boredom, enjoyment). The lack of occurrence of certain emotions may be related to a number of factors including: the context (e.g., highly engaging and highly valued training is likely to curb boredom), performance (e.g., low performance or low self-efficacy is likely to reduce pride and enjoyment) or the method of emotion detection (e.g., some emotions may have been experienced but not overtly expressed).

In terms of implications for regulation of medical emergency cases, although it may not be necessary to have all team members engaging in CAM processes to the same extent throughout the case, it may be important to consider the balance among members and to ensure that higher-order processes, such as evaluation and reasoning, are exhibited with more consistency (e.g., at key points during medical decision-making or medical intervention). This may require more explicit task assignment, role clarification, and modeling from the leader to demonstrate the importance of these processes to other members and to solicit feedback about the effectiveness of medical decisions and strategies. Although, high-performing teams may have less need to communicate (Cannon-Bowers and Salas 2001), it may be necessary for more novice trainees (or teams that are experiencing difficulty) to communicate more explicitly to coordinate decisions and actions given that their shared cognition and mental models may be insufficiently aligned or incompatible due to differences in team members' knowledge, attitudes, situational awareness, and interpretation of environmental cues (Cannon-Bowers and Salas 2001; Salas et al. 2008b).

The consistency of negative emotions across all team members suggests that although negative affective states are not stated directly, other cues such as body language, facial expression and tonal qualities of statements are detected by team members. In this regard, the social impact of more subtle emotional cues seems to be important (Butler and Gross 2009). Notably, the most common state was *neutral*, yet during the follow-up interview the team leader spoke more directly about negative emotional states, which suggests that to some extent residents express emotions in more covert ways that may remain detectable by team members. Analysis of micro-expressions in future work may help to provide more sensitive detection of emotional states, including those that an individual is attempting to conceal (Ekman 2003; Matsumoto and Hwang 2011).

Although there are likely multiple factors contributing to the onset and continuation of negative emotions, feedback from the leader during the follow-up interview suggests that related factors may include lack of medical knowledge coupled with the emotion-laden nature of the patient's condition. Another possible reason for the persistence of negative emotions is that as the case unfolded, the team developed a shared awareness that the patient's condition—and their control over it—was steadily deteriorating. The results revealed that the negative emotional states were preceded primarily with lower-order cognitive and metacognitive processes. As previously noted, the nature of communication delivery may not have been direct enough to provide an effective strategy, which may be related to the persistence of negative affect. To successfully break this cycle, other metacognitive strategies may have proven fruitful, such as soliciting feedback from team members to evaluate the effectiveness of a particular medical intervention approach or problem-solving strategy. In the section that follows, we discuss how these findings bear on theoretical frameworks.

Theoretical implications

This research represents an important step toward developing and testing theoretically grounded coding schemes within medical emergency training environments. In particular, we found evidence of several negatively valenced emotions from Pekrun and colleagues' (Pekrun 2006; Pekrun et al. 2007) achievement emotions taxonomy, such as *anxiety*, *anger*, *frustration*, *shame*, *and hopelessness*, which represented both activating (e.g., anxiety) and deactivating (e.g., hopelessness) emotions. According to Pekrun's (2006, 2007) control-value theory, anxiety is expected when there is only partial control, coupled with uncertainty about the outcome and a focus on failure (i.e., focus on an uncertain unsuccessful outcome), whereas hopelessness is expected when failure is subjectively considered to be certain (i.e., focus on a certain unsuccessful outcome). The theory also posits that if the activity is valued but subjectively lacks control, frustration is expected to occur (Pekrun et al. 2007); this occurrence is not surprising given that in this case, medical residents appeared to highly value the task (based on high engagement during training and self-report feedback on simulation training) but perceived low control in terms of managing the team and stabilizing the patient (based on feedback from the leader during follow-up interview). Collectively, the emotions detected within the simulation represent both activity and outcome emotions, which suggests that the emotions experienced during a critical case are not only focused on the task at hand (e.g., frustration) but also include team members' concerns about prospective outcomes of success and failure (e.g., anxiety).

The findings from this research also have important implications for the advancement of theoretical models of emotions and self- and co-regulation. In particular, they suggest that these frameworks should incorporate processes using multiple data channels as we found evidence that emotions are not consistently exhibited across all data channels in synchrony (see Azevedo 2014; Azevedo et al. 2013). These models should also articulate the role of self- and co-regulation processes at multiple units of analysis (e.g., individual vs. team) to better understand the social dynamics and interactions involved in regulation (Azevedo et al. in press a, b; Molenaar and Järvelä 2014; Volet and Summers 2013). Furthermore, models of self- and co-regulation would benefit from a more thorough integration of emotions (Ben-Eliyahu and Linnenbrink-Garcia 2013) as this would help to promote investigations of emotions at the metalevel (e.g., monitoring, control), rather than an exclusive focus on the generation of emotion; emotion regulation models have much to contribute to these developments (Gross 2014; Gross and Barrett 2011; Koole 2009).

Finally, we suggest that researchers include both qualitative and quantitative indices of regulatory processes to examine the frequency and duration of these processes as they unfold, as well as the nature of their deployment (e.g., effective/ineffective, positive/negative).

Training implications

Based on our findings and the reciprocal nature of control-value theory (Pekrun 2006), it is plausible that when teams feel a lack of efficacy or control over their ability to effectively manage the case, they may experience negative emotions, which may distract them from effectively implementing management strategies and regulatory processes, leading to further reduction in their sense of control and persistence of a negative state. To interrupt this negative feedback loop, it may help if leaders and team members are better equipped to implement effective cognitive and metacognitive processes to reduce strain on cognitive resources. In particular, it may be useful to encourage trainees to use explicit communication regarding the effectiveness of a strategy (i.e., *evaluation)* and *task allocation* (i.e., role clarity) when engaging in metacognitive monitoring and planning processes as these activities appeared to be underutilized in the current case. It may also be helpful during training to discuss examples of highly effective versus less effective versions of implementation. As we have seen from our analyses, these processes can vary not only in quantity but also quality. It may also help to incorporate prompts during training orientation and debriefing sessions to encourage medical residents to reflect on their emotions and regulatory processes. For example, during orientation sessions, medical experts could discuss the role of emotions for medical decision-making and crisis management. During debriefing, they could also encourage medical residents to consider which affective states should be closely monitored (e.g., negative emotions) and prompt team members to consider how they might recognize and interrupt a cycle of dysregulation. These types of emotion regulation interventions may help to reposition emotions as an enhancement rather than hindrance to performance by promoting more positive states and managing negative states (Pekrun 2006). However, in line with Pekrun et al. (2002), we would caution against suggesting that negative emotions are uniformly maladaptive, as the role of negative emotions is contingent upon context-specific factors and requires further empirical scrutiny.

Limitations and future directions

There are several limitations to this study. First, we focused on only one medical scenario and team, which limits the generalizability of our findings. The advantage of conducting a case study approach is that it affords in-depth analysis of process data, which is not always feasible with larger samples, especially considering the need to develop a reliable coding scheme. However, further work is needed to examine whether these results can be replicated across additional teams with varying levels of expertise (e.g., low versus high team performance) and across multiple scenarios with varying levels of complexity (e.g., low versus high case challenge). It may be the case, for instance, that positive emotions are found among residents who are able to successfully manage the medical emergency. Comparison groups and experimental designs would also help to improve generalizability and provide information about cause-and-effect relations. In a similar vein, although this study was carried out within a high-fidelity simulation (and therefore can be viewed as a surrogate for clinical practice), further empirical work is needed to test whether this context is likely to produce similar cognitive, metacognitive, and affective processes as would be present within a clinical environment. Another limitation of this study is that the construct of co-regulation is relatively new; advancements in conceptual clarity may help to improve sensitivity and coherence when coding team members at multiple units of analysis and across multiple regulatory processes. Finally, transition and time-series analyses will play a key role in analyzing the sequencing and cyclical nature of regulatory events. Despite these limitations, we feel this work provides important insights into the nature of team regulation for medical emergencies and provides fruitful avenues for further work to enhance medical training and ultimately to improve patient care.

Acknowledgments This research was supported by funding from a McGill University Collaborative Research Grant and the Canada Research Chairs program awarded to the second author. We would like to acknowledge the Arnold and Blema Steinberg Medical Simulation Centre for supporting this research. We would also like to thank Inderpal Dhillon for his assistance with data entry and coding.

Appendix

See Table 4

Table 4 Coding schemes

Category	Definition	Examples from simulation
Metacognition coding scheme		
Planning	Involves the selection of appropriate strategies and goals, as well as the allocation of resources that affect performance (e.g., setting subgoals, forming an action plan, allocating tasks/roles)	*At beginning of simulation, leader addresses the entire team and sets a task for them to complete:* "…and we need to know what else has gone on during her pregnancy"
Monitoring	Monitoring of one's online awareness of comprehension and task performance (e.g., checking understanding of self or others, soliciting or providing feedback, help seeking)	*Leader solicits feedback from the team regarding whether a previously assigned task had been completed:* "Is the oxygen actually on?"
Evaluating	Appraising the products, effectiveness and efficiency of one's approach, technique, or strategy	*Team members discussing which size tube to use for intubation. T2 suggests 7.5 tube, and T3 assesses this suggestion:* "7.5 should be good"
Cognition Coding Scheme		
Collecting/providing information	Selecting, attending to, eliciting, and sharing new information	*In response to a question about how much saline to administer, the leader provides the dosage amount:* "Four. Under pressure"
Summarization and repetition	Communication of previously covered information or knowledge by saying it again verbatim (repetition) or by reorganizing it in one's own words (summarization)	*Leader keeps team up to date by informing them when tasks have been completed by other team members:* "So the sentinel is in…"
Reasoning	Manipulating and/or combining knowledge to arrive at conclusions based on that information (e.g., integration of information, inference, hypothesis generation)	*After having read chart and collected vitals from other team members, the leader gives her diagnosis*: "Given her history, it sounds like a curious case of PE"

Table 4 continued

Category	Definition	Examples from simulation
Emotion coding scheme		
Compassion	A feeling of empathy that occurs when moved to help someone in distress	*Team member enters room at beginning of simulation. She walks immediately to patient's bedside. She touches the patient's hand and says:* "Okay, alright. Hi Ma'am I'm your doctor… What's your name?" *When speaking uses higher pitch and a warm and friendly tone*
Relief	A feeling of ease as a distressing condition ceases or changes for the better	*The nurse tells one of the team members,* "Doctor, it actually looks like your oxygen tubing to your mask is on the floor and not connected." *The team member quickly grabs the tubing with a concerned look on her face. She holds it up for the nurse to see, and says with a smile:* "Yeah, well there was no connector on it!" *The issue was with the set-up in the simulation room and was not her fault*
Pride	A feeling of elation and esteem of one's achievement where success is attributed to one's abilities or effort	*Not present in the simulation*
Hope	A feeling of optimism or desire for a positive outcome or success when the outcome is uncertain	*The team is fixated on not being able to figure out how much heparin to bolus and they must make a decision quickly to ensure the safety of the patient. One team member suggests:* "I bet I could look it up!"
Enjoyment	A feeling of pleasure from an activity	*Not present in the simulation*
Gratitude	A feeling of appreciation for an outcome, opportunity, or event caused by another person	*Not present in the simulation*
Relaxation	A feeling of being free of tension and ridgidity	*Not present in the simulation*
Contentment	A feeling of being satisfied or pleased with a situation or outcome	*Not present in the simulation*
Anxiety	A feeling of worry or nervousness about a possible negative outcome or failure when the outcome is uncertain	*As the team members suggest ideas to stabilize the patient, the leader interrupts and states in a concerned tone:* "It's going to drop her pressure more!"
Frustration	A feeling of irritation or annoyance	*A team member asks the leader if she gave the patient a bolus after having asked many times before, to which the leader quickly replies in an exasperated tone:* "Nope, we don't know what the bolus dose is!"

Table 4 continued

Category	Definition	Examples from simulation
Disappointment	A feeling of dissatisfaction or deflation due to discordance between an alternate outcome and the actual outcome	*The nurse has repeatedly asked the leader how much heparin she wants given to the patient and she has not been able to give him a dose. She sighs and gestures with her hand as if she is unsure and trying to think of a solution and then responds in a shaky voice:* "I know…" *Voice trails off and she once again does not provide a dosage amount*
Hopelessness	A feeling of despair that a negative outcome or failure is certain/unavoidable and success seems unattainable	*The team has not being able to determine how to stabilize the patient and patient and fetus are getting worse. The leader announces, while shaking her head and shrugging her shoulders:* "We're going to have to bolus; we're going to have to bolus"
Shame	A feeling of disgrace or humiliation related to an awareness of a personal failure or shortcoming that does not meet perceived standards	*A team member is looking through the crash cart for an item but is not able to find it. The nurse asks if he can help. When she doesn't reply he asks again in a more demanding manner:* "I'm here; can I help you with something, doctor?" *The team member awkwardly smiles and tells the nurse what she is looking for, and he takes over her task*
Anger	A feeling of strong displeasure instigated by a perceived failure or offense of another	*The team has been struggling to figure how much heparin to give the patient. After a fair amount of time has been spent on this, a team member turns to the nurse and says in a tense and accusing tone:* "Yeah, where's the protocol for the heparin in this hospital?"
Sadness	A feeling of grief, sorrow, or unhappiness	*Not present in the simulation*
Boredom	A feeling of dullness and reduced arousal due to lack of stimulation	*Not present in the simulation*
Disgust	A feeling of revulsion or intense dislike accompanied by a desire to be distanced from a situation or object	*Not present in the simulation*
Neutral	A lack of positive or negative valenced emotion; a state of balance lacking distinctive characteristics	*The leader gives her team an order. Facial expression is blank. Tone is even and flat.* "Let's start an I.V. heparin infusion, please"
Surprise	A feeling of astonishment or unexpectedness	*After the nurse announces the fetal heart rate to the team, a team member has a shocked facial expression (mouth open, brows slightly knit). She says to the nurse, as if in disbelief:* "The fetal *what* is 30?" *with an emphasis on the word what*

Definitions adopted from theory and dictionary sources (Lazarus 1991; Pekrun 2006; Pekrun et al. 2007; *Webster's*, 2005; Zeelenberg 1998; Zeidner 1998)

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