Towards Supporting Technical and Non-Technical Skills Development by Using Multimodal Debriefing System After Multi-User VR-Based Simulation Training

Vitaliy Popov, Yaxuan Li, James Cooke, Alanson Sample, Michael Cole
vipopov@umich.edu, yaxuanli@umich.edu, cookej@med.umich.edu, apsample@umich.edu, mcolemd@med.umich.edu
University of Michigan

Abstract: This NSF-funded study aims to develop and evaluate a novel debriefing system that aims to capture and visualize multimodal data streams from multi-user VR environment that evaluate learners' cognitive (clinical decision-making) and behavioral (situational awareness, communication) processes to provide data-informed feedback focused on improving team-based care of patients who suffer sudden medical emergencies. Through this new multimodal debriefing system, instructors will be able to provide personalized feedback to clinicians during post-simulation debriefing sessions.

Overview and motivation

Caring for critically ill patients is a difficult and complex task that requires healthcare professionals to make cognitively demanding decisions under information- and time-constrained circumstances. To be able to act precisely and quickly, they need frequent, high-fidelity training opportunities that offer meaningful feedback on the skills that are essential for quality team-based clinical care. Simulation-based training (as depicted in Figure 1 panel 'A') has been a successful pedagogical strategy to educate clinicians and prepare them to manage low-frequency, high-risk events in a safe setting.

Traditionally, simulation-based training has involved using a mannikin as a patient in a simulated patient care setting. To improve accessibility, resource utilization, and the learner experience, there is a growing movement towards using virtual reality (VR)-based simulation training in healthcare. With these goals in mind, the study team has developed the multi-user Virtual Reality for Cardiac Arrest Resuscitation (VR-CR) platform (NSF IIS- 2202451). This platform leverages state-of-the-art voice recognition and motion capture technologies to allow four participants to be in the same 'virtual room' and work together to care for a virtual cardiac arrest patient - all under realistic time pressure and rapid workload changes (Figure 1, panel 'B'). However, the ongoing challenge for both manikin- and VR-simulation training is the constant and real-time human observation required to provide learners the assessment and feedback needed to drive learning and skill development. This makes this simulation not optimally efficient or scalable (Bracq, Michinov, & Jannin, 2019; Martinez-Maldonado et al., 2020). Importantly, this limitation results in learners receiving feedback that is of variable quality - often generalized, inconsistent, and highly dependent on simulation instructors (Figure 1, panel 'C').

Figure 1
*Panel **A** shows a typical simulation-based training environment where participants practice on a manikin and realistic equipment. Panel **B** shows a screenshot of the multiple person virtual reality training system (VR-CR) that this project will build upon. Panel **C** depicts a typical debriefing scenario where instructors provide immediate feedback to participants on based on their performance. Panel **D** shows our vision for the multimodal debriefing system.*

Study objectives

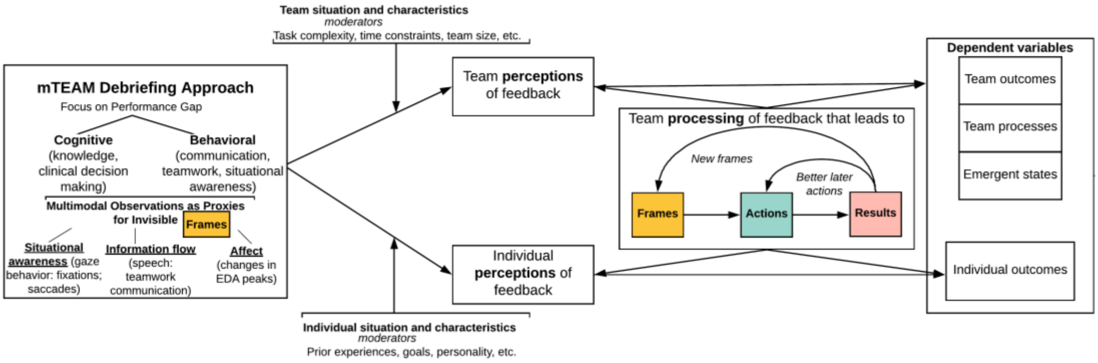
To enhance the current high-stakes learning environment, behavioral data from the video-recorded observation of trainees and event stream log data generated by the VR system will be collated with fine-grained sensor data on visual attention, emotional arousal, and verbal participation to offer new visualizations of the team and individual performance. The following research activities have been developed to fulfill the study objectives:

1) *Conduct a human-centered design study with trainees and instructors to refine the concept of the debriefing system and identify needs and preferences for trainees and instructors.* To inform design and implementation of the multimodal debriefing system, the study team will observe and record a cardiac arrest training scenario using the VR-CR simulation and post-simulation debriefings. Guided by the theoretical underpinnings and the feedback model (Figure 2), we will perform think-aloud, interviews and co-design sessions with trainees and instructors to (a) extract meaningful features from video, event stream log data generated by the VR system, and sensor data on visual attention, emotional arousal, and verbal participation, and (b) conduct exploratory pattern identification using these extracted features and limit the amount of less vital data.

2) *Iteratively engineer and evolve an unobtrusive multi-modal data and sensor collection system*. The meaningful features inferred from the previous step will be leveraged in data processing using machine learning algorithms. The goal is to develop a set of reliable analytical metrics assessing team and individual performance. We will design, implement, and evaluate a series of small-scale usability trials of debriefing system prototype.

3) *Conduct a quasi-experimental study with a pretest-posttest non-equivalent control group to evaluate the potential of the multimodal debriefing system to improve clinical knowledge, skills, and teamwork performance.* This step will help determine the utility, learning gains, and feasibility associated with adding dynamic behavioral tracking to the conventional assessment of clinical skills during VR-based simulation training.

Figure 2
Theoretical underpinnings and the feedback model adapted from Gabelica & Popov, 2020 as a necessary precursor to explain why and how feedback modifies behavior in post-simulation debriefings.



Learning, teaching and technology innovations

For learning, understanding markers that may predispose trainees to errors or delays in therapeutic interventions will provide significant insight into a more holistic assessment of individual and team learning processes and provide unique opportunities for feedback, practice, and/or remediation. For teaching, it remains an open question how instructors can best leverage these rich multi-modal data streams to help trainees reflect on their own performance. The main technological innovation will be the development of multimodal methods of sensing and detecting speech, gaze behavior, cognitive and affective states, and using algorithmic approaches to detect user activity and model behavior in VR simulations. This is the first study using multi-user VR-based simulation to combine multiple data modalities especially for the noncognitive competencies into one innovative comprehensive debriefing system.

References

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