Considering human cognitive architecture in stressful medical prehospital interventions might benefit care providers

Andrew W. Kirkpatrick, MD, MHSc
Jessica L. McKee, BA, MSc
Robert Barrett, PhD, MA
Kyle Couperus, MD
Juan Wachs, PhD

Accepted Sep. 11, 2023

Correspondence to:
A.W. Kirkpatrick
Regional Trauma Services
EG 23 Foothills Medical Centre
1403–29 St NW
Calgary AB T2N 2T9
andrew.kirkpatrick@ahs.ca


SUMMARY

People suffering from critical injuries/illness face marked challenges before transportation to definitive care. Solutions to diagnose and intervene in the prehospital setting are required to improve outcomes. Despite advances in artificial intelligence and robotics, near-term practical interventions for catastrophic injuries/illness will require humans to perform unfamiliar, uncomfortable and risky interventions. Development of posttraumatic stress disorder is already disproportionately high among first responders and correlates with uncertainty and doubts concerning decisions, actions and inactions. Technologies such as remote telementoring (RTM) may enable such interventions and will hopefully decrease potential stress for first responders. How thought processes may be remotely assisted using RTM and other technologies should be studied urgently. We need to understand if the use of cognitively offloading technologies such as RTM will alleviate, or at least not exacerbate, the psychological stresses currently disabling first responders.

Traumatic injury is the greatest cause of potentially salvageable years of life lost. Unfortunately, similar to other catastrophic conditions such as respiratory arrest or cardiovascular collapse, most potentially preventable deaths from traumatic injury occur before a victim can be transported to hospital. Thus, diagnoses and interventions to salvage lives must be delivered by first responders outside of hospital.

The TeleMentored Ultrasound Supported Medical Interventions (TMUSMI) Consortium has long sought to enable advanced diagnoses and interventions in the prehospital setting, performed by less experienced first responders guided remotely by distant experts using communication informatics. A range of diagnoses and interventions have been shown to be feasible and reassuring in controlled studies. Besides helping the patients, this paradigm of care delivery may also benefit the mental health of the care providers. A simulation study in which non-surgeons were remotely mentored to perform damage control packing of exsanguinating intra-abdominal hemorrhage showed significantly increased self-assessed procedural confidence when comparing mentored with unmentored participants. Such a creation of a transactive memory system and cognitive offloading should be better understood as a first step in using informatics and remote decision support to improve, or at least not exacerbate, the stress experienced by those performing care in the field.

Stress disorders among those caring for trauma victims are common at every provider level, from first responders to the most experienced trauma surgeons, resulting in so-called “secondary victims.” This equates with trauma surgeons having the highest rates of burnout among all surgical subspecialties. However, first responders may be the most critical component of the health care system facing great challenges due to mental health stresses. All regular first responders face psychological trauma regularly, with subsequent rates of posttraumatic stress disorder (PTSD) reported to be as much as 10 times higher than that of the general population with at least 1 in 3 suffering.
psychological burden is subsequently correlated with high rates of substance misuse, absenteeism and disability, cutting short the working careers of first responders in their prime. Classic symptoms of PTSD relate to hypervigilance toward potential threats in the environment and involve alterations to cognitive processes such as memory, attention, planning and problem solving. Anecdotally, in addition to the well-understood exposure to terrifying and life-threatening events, catalyzing factors among first responders include self-perceived doubts regarding performance, thoughts of “should have done more,” and ruminating over decisions made that cannot be reversed. As TMUSMI attempts to translate remote telementoring (RTM) support for first responders from the bench to bedside, we consider that human thought processes related to prehospital life-saving interventions (LSIs) deserve a deeper understanding.

Human cognitive architecture in relation to clinical reasoning frameworks can be modelled by dual process reasoning, which postulates 2 distinct systems of reasoning: system 1, representing intuition or automatic thinking, and system 2, representing analytical or deductive thinking. Caregivers need to utilize both intuition and analytical thinking to make critical decisions quickly and accurately, as they are often given uncertain and limited information. Both systems are critical, and one is not considered better than the other, although using only one exclusively would be detrimental. For example, when a care provider with clinical experience and confident pattern recognition is providing LSIs using system 1 thinking, further analysis using system 2 thinking would be redundant and could cause a delay in care; however, when this same care provider is faced with confusing clinical findings or when unforeseen complications occur, then system 2 analytical reasoning is critical to avoid error, even if proper care takes slightly longer. This efficient toggling between both systems relates to the concept of cognitive load. Cognitive load theory refers to the cognitive resources of a care provider that are required by working memory to make critical decisions or to perform complex tasks. If the cognitive load is excessive, it may overwhelm the working memory, leading to increased stress as well as errors. Inexperienced care providers are considered to be at greater risk of cognitive overload, as their cognitive schemata used to organize knowledge and guide cognitive processes are less well developed than those of care providers with previous experience. Further adding to prehospital stress and cognitive load is diagnostic uncertainty or the subjective perception of an inability to provide an accurate explanation of a patient’s health problem. However, when cognitive load is shared with other people, such as an online mentor or physician supervisor, a “memory system that is more complex and potentially more effective than that of any of its individual constituents” is initiated, creating a transactive memory system. Within this system, not only are information integration and decision-making processes improved, but a shared store of knowledge is also used and the time required to find and use appropriate knowledge is made much more efficient, essentially improving working memory. A remote mentor or any type of online medical support can be considered to constitute a transactive memory system.

Other high-reliability industries wrestle with understanding cognitive load within the greater sphere of human factors. The U.S. National Aeronautics and Space Administration’s Task Load Index (NASA-TLX) describes cognitive load as a multidimensional challenge that can exert itself unevenly across 6 fundamental “demands”: mental, physical, temporal, performance, effort and frustration. For example, a first responder may perform a procedure competently and have manageable cognitive demand; however, if the environment adds abnormally high time or physical safety pressures, then cognitive demands — as well as other associated human factor threats — may surge. Adapted for RTM, the NASA-TLX might allow quick categorization of specific RTM conditions and communication strategies adapted to mitigate the cognitive load demands and ideally balance the 2 systems of thinking. Recognizing these factors might thus help RTM to reduce cognitive load in the short term and potentially help mitigate PTSD in the long term.

Thus, using established frameworks of cognitive architecture may allow speculation as to how RTM might address cognitive load for first responders or any care provider, including residents and surgeons, to preserve their working memory, improve patient care and decrease negative long-term effects. Potential targets for stress mitigation with RTM are listed in Table 1. Given the psychological toll that first responders currently face, study is urgently required to understand how providing potentially life-saving care seems to exacerbate and exponentiate the psychological trauma experienced when witnessing traumatic injuries in others. We consider that telementoring will benefit not only patients, who will potentially experience better outcomes, but also the first responders, who will hopefully experience less stress while providing those better outcomes. However, telementoring done poorly can actually decrease performance and increase the stress on first responders, so assumptions are dangerous. Therefore, although the diagnoses and interventions that first responders might offer in the future may be dramatically enhanced through telemedical techniques, we have a professional responsibility to understand how this potential paradigm might either greatly benefit or alternatively exacerbate cognitive overload and psychological distress in first responders. We suggest that, as telementoring is introduced, studies should, in addition to assessing effectiveness, efficacy and cost-effectiveness, include measures of the psychological well-being of those using these techniques.

Affiliations: From the Tele-Mentored Ultrasound Supported Medical Interaction (TMUSMI) Research Group, Calgary, Alta. (Kirkpatrick, McKee); Departments of Critical Care Medicine, Surgery, and the Trauma Program, Calgary, Alta. (Kirkpatrick); the University of Alberta School of Public Health, Edmonton, Alta. (Barrett); the Ready Medic
DISCUSSIONS IN SURGERY

Potential mitigating technique

If an inexperienced first responder is unable to intuitively recognize a critical intervention owing to lack of experience, remote mentors may provide second opinions and interpretations of information as well as confirmation. Remote mentors may have a wealth of experience and electronic databases available to them to apply complex decision-making processes or to incorporate the new interventional skills as the only goal is a one-time life-saving intervention.

Remote mentors serve as a sensory/long-term memory capability being immediately able to interpret pertinent details into the working consciousness of the first responder if appropriate.

A remote mentor can increase the confidence the care provider when performing unfamiliar tasks.

Remote mentors may be reassuring.

Less experienced first responders do not need to know all the indications and theory behind any decision or intervention, as the cognitive load can safely reside with the remote mentor.

Remote mentors can manage extrinsic details of the scene response, such as critical data management or routing backup resources, leaving the first responder to focus working memory on the immediate task.

The first responder does not need to learn and is freed of the responsibility to focus on the actual steps of the decision-making process or to incorporate the new interventional skills as the only goal is a one-time life-saving intervention.

Toggling between cognitive systems

System 1 to system 2

The remote mentor may serve as a checklist or cognitive “pause” to recognize when there are diagnostic inconsistencies that require switching from intuitive to deductive thought processes and so inform the first responder.

System 2 to system 1

If an inexperienced first responder is unable to intuitively recognize a critical intervention owing to lack of experience, an experienced remote mentor may save time by recommending an immediate life-saving intervention.

Expanding working memory

Remote mentors serve as a sensory/long-term memory capability being immediately able to interpret pertinent details into the working consciousness of the first responder if appropriate.

Uncertainty

Technical uncertainty

Remote mentors may provide second opinions and interpretations of information as well as confirmation.

Personal uncertainty

Remote mentors may have access to increased patient information from cloud-type resources that can be cross-indexed without taxing the working memory of the first responder.

Conceptual uncertainty

Remote mentors may have a wealth of experience and electronic databases available to them to apply complex concepts to individual patients without taxing the first responder.

Table 1. Neural processes associated with cognitive overload and potential mitigation through remote telementoring

<table>
<thead>
<tr>
<th>Cognitive stress factor</th>
<th>Potential mitigating technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeling alone</td>
<td>A remote mentor may be reassuring.</td>
</tr>
<tr>
<td>Feeling responsible</td>
<td>A remote mentor in a hierarchical system may assist or take responsibility for potentially psychologically overwhelming decisions.</td>
</tr>
<tr>
<td>Feeling inadequate to the task</td>
<td>A remote mentor can increase the confidence the care provider when performing unfamiliar tasks.</td>
</tr>
<tr>
<td>Cognitive overload</td>
<td>Intrinsic load: Less experienced first responders do not need to know all the indications and theory behind any decision or intervention, as the cognitive load can safely reside with the remote mentor. Extrinsic load: Remote mentors manage extrinsic details of the scene response. Germane load: The first responder does not need to learn and is freed of the responsibility to focus on the actual steps of the decision-making process or to incorporate the new interventional skills as the only goal is a one-time life-saving intervention.</td>
</tr>
</tbody>
</table>

Toggling between cognitive systems

System 1 to system 2

The remote mentor may serve as a checklist or cognitive “pause” to recognize when there are diagnostic inconsistencies that require switching from intuitive to deductive thought processes and so inform the first responder.

System 2 to system 1

If an inexperienced first responder is unable to intuitively recognize a critical intervention owing to lack of experience, an experienced remote mentor may save time by recommending an immediate life-saving intervention.

Expanding working memory

Remote mentors serve as a sensory/long-term memory capability being immediately able to interpret pertinent details into the working consciousness of the first responder if appropriate.

Uncertainty

Technical uncertainty

Remote mentors may provide second opinions and interpretations of information as well as confirmation.

Personal uncertainty

Remote mentors may have access to increased patient information from cloud-type resources that can be cross-indexed without taxing the working memory of the first responder.

Conceptual uncertainty

Remote mentors may have a wealth of experience and electronic databases available to them to apply complex concepts to individual patients without taxing the first responder.

One (RMO) Research Group, Tacoma, Wash. (Couperus); and the National Science Foundation, School of Industrial Engineering, Purdue University, West Lafayette, Ind. (Wachs).

Competing interests: A.W. Kirkpatrick has consulted for Zoll, Acclity (3M/KCI), CSL Behring, Innovative Trauma Care and SAM Medical Corporations, and the Statesman Group of Companies, and is the principal investigator of a randomized trial partially supported by Acclity Corporation. He has previously disclosed a personal relationship with J.L. McKee. J.L. McKee has consulted for Innovative Trauma Care, SAM Medical, Aceso, Acclity (3M/KCI), Zoll Medical and the Andrew W. Kirkpatrick Professional Corp. She has previously disclosed a personal relationship with A.W. Kirkpatrick. K. Couperus is the chief medical officer of Exonicus Inc., a virtual medical simulation training company focused on training individuals on the management of patients with traumatic injuries. No other competing interests were declared.

Contributors: All of the authors contributed to the conception and design of the work, drafted the manuscript, revised it critically for important intellectual content, gave final approval of the version to be published and agreed to be accountable for all aspects of the work.

Content licence: This is an Open Access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY-NC-ND 4.0) licence, which permits use, distribution and reproduction in any medium, provided that the original publication is properly cited, the use is noncommercial (i.e., research or educational use), and no modifications or adaptations are made. See: https://creativecommons.org/licenses/by-nc-nd/4.0/

References