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PERSPECTIVES

Beyond the Individual: A Multidisciplinary Model for Critical Thinking in the Intensive Care Unit

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Abstract: Health profession educators readily identify with the goal of fostering healthcare providers who are critical thinkers focused on quality patient care. In the following paper, we aim to delve into critical thinking at the team level and help educators begin the process of creating a shared mental model focusing on cognition to identify gaps and opportunities for growth in their trainees. We will distinguish between microcognition (an individual's own critical thinking process in a controlled environment), macrocognition (critical thinking process in a real-world environment), and team cognition (the interaction and relationship among team members to augment macrocognition). A common case example will be used to guide the discussion as well as provide a model framework to be used for clinician educators in the future.

Keywords: medical education, cognition, shared mental models, clinician educators

Introduction

Expert practice in the intensive care unit (ICU) requires much more than an individual approach to critical thinking and problem-solving techniques as it is rare for a critical care clinician to find themselves alone at the bedside of a decompensating patient without the assistance of other interdisciplinary team members. The collaborative and dynamic process required—team cognition—is a skill that both faculty and trainees can intentionally develop to optimize teamwork, enhance diagnostic accuracy, and improve patient outcomes over time. Diagnostic errors at an individual level are often attributed to flawed clinical reasoning and cognitive biases. Furthermore, it is difficult to isolate the team aspects that can contribute to these errors.[1] It is essential for critical care providers to develop collaborative critical thinking processes in their healthcare teams, as this is a theoretical opportunity to improve patient safety. In the following perspective paper aimed at the health professions educator audience, we hope to better define theoretical constructs that are helpful to understand at the bedside.

The constructs of macrocognition and team cognition focus on working together to formulate and develop knowledge, represent a problem, and evaluate potential solutions.[2] This is distinctly different than helping one learner develop their own micro-cognitive processes, which requires an understanding and reflection of critical thinking at the individual level. Health professional educators (HPE) who work in critical care settings such as physicians, registered nurses, respiratory therapists, pharmacists, and others are often ad hoc teaching a shared mental model approach to maximize team and individual learning for their team.

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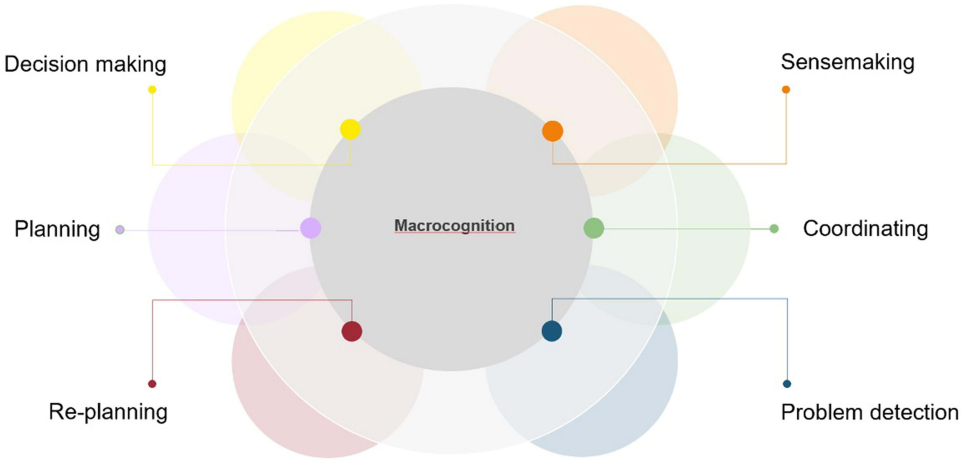

Figure 1 Primary Functions of Macrocognition.

The purpose of this work is to A) define and differentiate between microcognition, macrocognition, and team cognition, B) discuss the impact of macrocognition and team cognition on collaborative decision making in critical care units using a case scenario, and C) discuss next steps for real life application and research of these concepts. We provide a case example intended to allow educators to immediately incorporate these concepts into their curriculum and also serve as a launching point for further work in this space.

Introduction of Micro, Macro, and Team Cognition Theories

Microcognition is an analytical framework in which the individual uses knowledge from an experimental context (ie non-real-life experiment in an artificial setting) to make decisions.[3] This decision-making process is closely linked to the Classical Decision Theory (CDT). In this framework, it assumes that an individual has a clearly defined problem with access to all the necessary information to identify all alternative options. Furthermore, CDT excludes non-analytic factors such as intuition.[3] It is founded on the assumption that experience from this hypothetical scenario can be directly applied to real life.[3] As CDT focuses on maximizing the expected outcome from any information in the most ideal and optimal way,[4] this premise is questionable in a real-world setting, especially in healthcare.

Macrocognition on the other hand, a term created in 1995 by Cacciabue & Hollnagel, is an approach that focuses on an individual's decision making in the real-world setting.[5] It highlights use of real-life scenarios, adjusts with changes in variables, and is based on the Naturalistic Decision Making (NDM) theory.[3,4] Another definition of macrocognition, as reported by Zsambok and Klein, is the way individuals make decisions in the field based on their own prior real-world experience.[6,7] Using current data as well as input from prior experiences can be helpful to navigate a complex healthcare situation and influence both learning and decision making[8–11] Figure 1.

Given the multi-disciplinary aspect of medical care today, individual microcognitive and macrocognitive processes are usually not sufficient for holistic care of the patient. An understanding and reflection of the critical thinking processes at the team level is also crucial. The focus has often shifted to team cognition, an approach that leverages individuals' cognition in a collaborative manner[2] (Table 1). This allows each individual team member to obtain, process, and analyze critical knowledge, ie utilize their micro- and macro-cognitive skills, with the goal of sharing this crucial information with others.[12,13]

Table 1 Terminology

Terminology	Definition
Microcognition	Cognition in artificial settings
Macrocognition*	Cognition in natural decision-making settings
Team Cognition†	Cognition that focuses on coordination and collaboration among individuals.

Notes: Definitions of microcognition, macrocognition, and team cognitions based on *Kline et al[14] and †Fiore et al.[2]

Team cognition requires integration of information and perceptions from multiple members for optimal decision-making, as different expertise can lead to different observations and conclusions.[15] This is referred to as a "shared mind", which is defined as situations in which "new ideas and perspectives emerge through the sharing of thoughts, feelings, perceptions, meanings, and intentions among two or more people."[16] As such, it requires effective communication to allow a "shared mental model" to develop and optimize teamwork, diagnostic accuracy and improve patient outcomes. In the absence of good communication, this may result in the opposite effect with lower shared knowledge among the team members.[17]

A successful team requires optimizing team knowledge, skills, attitudes, team dynamics, and team environment.[18] In healthcare, an effective team should focus on both the diagnostic and behavioral processes, such as awareness of various expertise and communication with these individuals.[19] The success of the shared cognitive model relies on increased team awareness of each other's cognitive abilities.

This is exemplified in critical care as team leaders are trained to utilize distributed cognition to pull upon each team member's expertise.[20,21] Health profession educators in critical care (including physicians, registered nurses (RN), respiratory therapists (RT), pharmacists, and others) can help teach team members to develop a shared mental model of macrocognition and team cognition in order to model best practices and develop teaching strategies for learners.

Case Example

In this example, we will model the various theories using a case-based example focused on multi-disciplinary morning ICU rounds in an academic hospital. In this example, the team consists of an intensivist, medical student, respiratory therapist (RT), registered nurse (RN), and pharmacist.

Medical Student: This patient is clinically improving from his pneumonia. He has not had a fever, and his white blood cell count is decreased. Furthermore, his ventilator requirements are minimal. I think he is ready for possible extubation today.

Intensivist: Based on these clinical parameters, it appears that his pneumonia is better controlled. It is day #3 of mechanical ventilation. We should plan for a spontaneous breathing trial and possible extubation today.

RN: Family is planning to come in at 2 PM, so we can coordinate this spontaneous breathing trial with their arrival.

RT: I can assess a few parameters before then and get back to you.

Pharmacist: Patient is on a few nasogastric medications that will need to be changed to oral route of administration, if extubated.

Intensivist: Okay, please let us know what medications need to be changed.

Case Discussion

In this case, the medical student's and the intensivist's microcognitive processes are built on their knowledge of the typical clinical course of severe pneumonia with ventilator dependence. While didactic classes and case-based training in medical schools occur in a more linear model[4,22] the environment of an ICU places them in a less structured and less predictable environment than their previous training. This could result in a few possible outcomes: 1) the intensivist solely makes decisions based on previous experience and training and 2) the intensivist understands the training and experience of others and works together to develop a collaborative plan.

The microcognitive process from the nurse's perspective focuses on the logistics of the extubation and include incorporating the patient's family into the plan; the RT considers physiology of positive pressure ventilation, and the pharmacist contemplates the practical aspect of medication administration. In this example, each of these healthcare professionals, like the physician, have not progressed their thinking processes to a macrocognitive and team cognitive outlook. Below, we will explore how macrocognition and team cognition can affect this case and encourage clinical educators to think about how they themselves can give feedback on each of these different domains.

We will now show an example of macrocognition. In the earlier example, during morning rounds, the intensivist felt that the patient with community acquired pneumonia who had been intubated for 3 days might be ready for a trial of extubation given minimal ventilator needs and reportedly improving infection. The other team members had some concerns regarding patient factors that would affect their readiness for liberation but agree to move forward with the process. On afternoon rounds, there appear to be challenges in pursuing ventilator liberation of the patient, requiring adjustment of the plan. The intensivist wonders if they had the same shared mental model during morning rounds.

Medical Student: The patient was not extubated.
Intensivist: What happened?
RN: The patient was having episodes of significant agitation, prompting us to increase sedative medications. I was hoping that the patient would be calmer when family arrived, but that was not the case.
RT: He has had a significant amount of coughing due to increased secretion burden requiring frequent suctioning and increases in sedation. The patient became apneic during his spontaneous breathing trial.
Pharmacist: I see that he is on scheduled acetaminophen for back pain, which may be masking fever.
Intensivist: The increase in secretion burden is concerning for the development of possible ventilator-associated pneumonia. Let me review their clinical course again.

Alternate scenario we propose would be: Let us look at an example of rounds where macrocognition was used during rounds to help choose patient's care.
Medical Student: This patient is clinically improving from his pneumonia. He has not had a fever, and his white blood cell count is decreased. Furthermore, his ventilator requirements are minimal. I think he is ready for possible extubation today.
Intensivist: Based on these clinical parameters, it appears that his pneumonia is better controlled. It is day #3 of mechanical ventilation. We should plan for a spontaneous breathing trial and possible extubation today.
RN: I am concerned that the patient was having episodes of frequent coughing bouts and significant agitation, prompting us to increase sedative medications overnight. I was hoping that the patient would be calmer when family arrived, but that was not the case. Family is planning to come in at 2 PM, so if we are planning to trial extubation, we should try to coordinate this spontaneous breathing trial with their arrival and see their response.
RT: Based on my discussion with the RT overnight, and my assessment today, I am concerned about their secretion burden. He has been requiring frequent suctioning and increase in sedation due to coughing bouts. I did try a spontaneous breathing trial on my morning assessment, and he became apneic.
Pharmacist: Patient is on a few nasogastric medications that will need to be changed to oral route of administration, if extubated. However, I also would like to point out that he is on scheduled acetaminophen for back pain, which may be masking any possible fever, if we are worried about ongoing/worsening infection in the setting of increased secretions. He is on Ceftriaxone for Serratia pneumonia, based on prior susceptibilities. Is there concern for inducible AmpC resistance?
Intensivist: The increase in secretion burden is concerning for the development of possible ventilator-associated pneumonia vs inadequate antibiotic coverage. Let me review his clinical course again, and let us hold off on attempting extubation at this time.

This is an effective example of macrocognition, where each individual team member's micro-cognitive and analytic skills are combined to contribute to an overall effect on patient care. This leads to real-time analysis and decision making and helps with effective collaborative decision making. Each member of the team had individual information that affected the decision-making process regarding liberation from the ventilator. The team leader's ability to improve cohesiveness between multiple team members would depend on their comfort level with individual cognitive tasks and shared expertise areas with other disciplines. However, the key to an effective communication in this setting is a collegial atmosphere where members of the team are encouraged to share their opinions to improve overall patient outcomes. The "cohesion" – or overlap in the shared mental model with that of the team members permit effective collaborative decision making.[17,19]

Based on the discussion and clinical course over the day, patient's antibiotics were adjusted, and their sedating medications were able to be weaned gradually over the course of the night. We will now share an example of rounds where team cognition is utilized to highlight the differences between macrocognition and team cognition, which can sometimes appear inter-changeable.

Medical Student: Patient was not able to be extubated yesterday, but the secretions are improved after the antibiotics were changed.
Intensivist: That is good to hear. Does anyone else on the team have any additional thoughts, or any concerns about attempting extubation?
RN: Yes, things do appear better. I was able to decrease some of the sedating medications. Maybe we can try a spontaneous breathing trial this afternoon? If we do not extubate, I can pass along the goal to prepare for SBT tomorrow to the overnight nurse as well.
RT: I agree and will inform you of the RSBI this afternoon. I will also pass along the goals to the overnight respiratory therapist as well.
Pharmacist: I will change the parameters on their sedating medications, so that we are targeting RASS of 0.
Intensivist: Let us make those changes and see how the patient is this afternoon. If his secretions and ventilator settings continue to remain minimal, and he can breathe spontaneously and require minimal sedation, we can try to extubate today afternoon.

In this case, the intensivist explains their individual thought process out loud and solicits input from the other team members as well. This team cognitive process allows each team member to explain how they reached their own conclusions about the plan to liberate. The combination of macrocognition (considering the variables associated with this patient) and team cognition (incorporating different perspectives) allows for all the members to participate in one shared mental model. This results in a more informed decision about the plan for the patient.

Upon reflection of the case, the intensivist realized that macrocognition without team cognition was insufficient for this patient's care. The nurse, pharmacist, and respiratory therapist all had information that would have affected the decision-making process regarding liberation from the ventilator. The intensivist should be aware of the expertise around them and be skilled at extracting this information. By encouraging bidirectional flow of information, the intensivist can elevate their decision-making to a collaborative process. The team leader's ability to improve cohesiveness between multiple team members will depend on their comfort level with individual cognitive tasks and shared expertise areas with other disciplines.

Relationship Between Macrocognition and Team Cognition

Macrocognition can seem overtly very similar to team cognition. However, the distinction is that macrocognition emphasizes the development of new knowledge and performative processes in complex real-world situations. Team cognition emphasizes how team members utilize the individual knowledge gained from microcognition and macrocognition to execute a specific action as a team. The process of team cognition should result in a more informed decision than what would result from macrocognition alone.[2] To incorporate both concepts, the individual may require externalization of internalized individual cognitive processes and reconciliation of differing viewpoints during this collaboration (Figure 2). Effective team performance requires tacit and explicit coordination and communication strategies from its members.

It is important to mention that if only the team cognition concept was applied, the team would focus on working together from an interaction perspective to manage the underlying issue. However, the team may not focus on leveraging their individual expertise to affect the next steps. On the other hand, when macrocognition is added to team cognition, the process of developing new knowledge and information from members is evolved due to the collaborative approach of a shared mental model. Therefore, the team can utilize the collective knowledge of the team in a maximum capacity. This highlights how combining macrocognition and team cognition can optimize patient care.

Current State of Research in Macrocognition and Team Cognition in Critical Care

Outside of medicine, the concept of macrocognition and improving critical thinking in high-stakes teams has been discussed in various fields such as engineering[23] and air traffic control.[14] However, a few studies on the use of macrocognition in critical care have been reported, which are summarized below.

Lin et al studied cognitive decision method (CDM) to describe the macrocognitive processes in three different groups in the ICU (intensivists, nurses, and respiratory therapists).[24] All three groups used sensemaking, anticipation, and

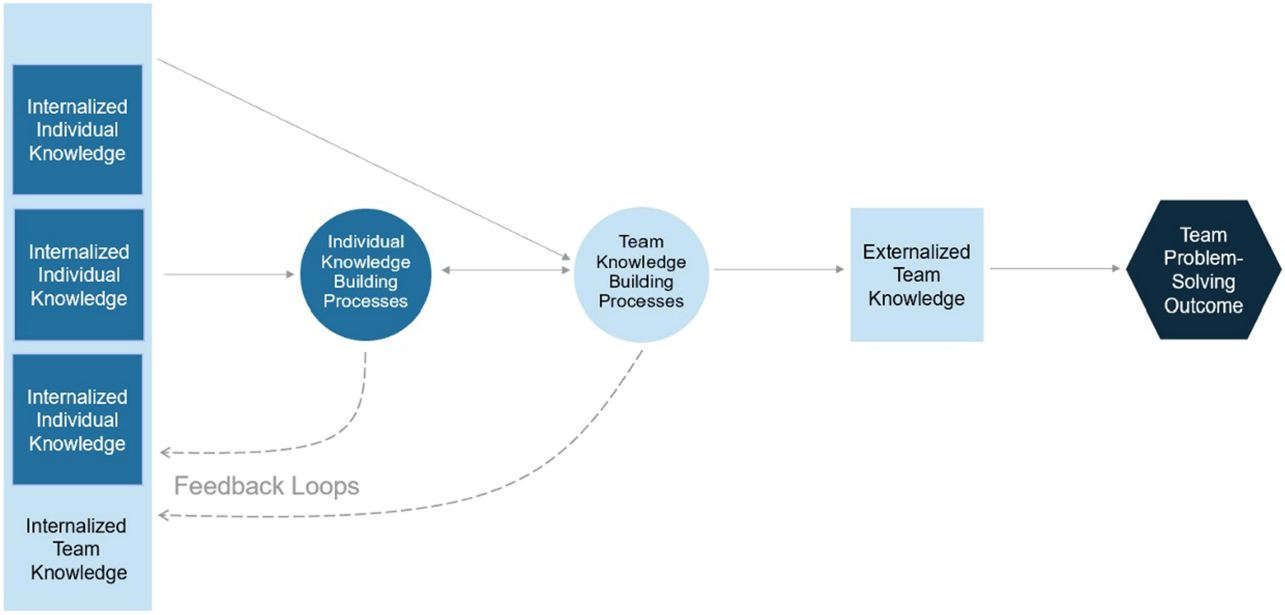

Figure 2 Team Cognition. Illustration of the process of transforming internalized knowledge into externalized team knowledge. Individual (dark blue) and team (light blue) knowledge are denoted by squares. Knowledge building processes are denoted by circles and rely on socialization (tacit-tacit), externalization (tacit-explicit), combination (explicit-explicit) and internalization (explicit-tacit) modes of knowledge conversion.
Notes: Adapted from Fiore SM, Rosen MA, Smith-Jentsch KA, Salas E, Letsky M, Warner N. Toward an understanding of macrocognition in teams: predicting processes in complex collaborative contexts. *Hum Factors*. 2010;52(2):203–224. Copyright © 2010 by Sage Publications. Adapted by Permission of SAGE Publications.[2]

communication, but each group had a differing central process. Physicians utilized multiple processes that were interrelated with problem detection as their central macrocognitive process. Physicians reported that they shifted processes during critical decision-making whereas nurses were consistent and listed managing complexity as a central process. Nurses viewed their central process relating to the management of uncertainty and risk, management of attention, and time management. Respiratory therapists, on the other hand, listed uncertainty, and risk management as their central processes.[24]

Furthermore, Holtrop et al used this framework to elaborate how macrocognitive processes facilitate successful patient outcomes. They found that macrocognition was effective in care management in various practices.[25] Specifically, Nemeth et al worked to understand cognitive processes in burn ICU-related cognitive work. They described a cognitive model that is divided into three main categories: function unit, activities unit, and task unit.[25] Despite this work, there are still significant gaps in this body of literature and bringing this topic to the forefront allows for further research to be performed.

Real Life Application in Health Professions Education

Based on the available literature, we feel there is a need to highlight the difference in types of cognition, specifically macrocognition and team cognition, as well as the importance of open communication and a collaborative environment to provide the best outcomes. Learners need guidance on how to prioritize thinking about the learning process and applying these cognitive strategies to assess their own individual and team knowledge as well as their team interactions. Currently, these skills are often taught in an informal manner during our daily clinical activity, and there is a need for more comprehensive teaching that focuses on synthesizing team members' knowledge and expertise to build a differential and create a management plan.

There are a number of ways that would be appropriate to formally teach and assess these skills. Local, regional, and national conferences would be ideal places to provide education on these principles and disseminate this knowledge on a global level. This venue offers an opportunity to reach a diverse audience of multidisciplinary healthcare educators who play crucial roles in the ICU. This interprofessional education of these clinician educators could serve as a trainer model for individual institutions.As this requires training in a specialized manner, we believe that small group sessions, hands

Box 1 Questions to Stimulate Macrocognitive Process in Debrief Scenarios

Questions to Stimulate Critical Thinking
What are the differences in my background versus my colleagues' background?
How did I come to this decision? How do my colleagues come to their decisions?
What remains unknown in this patient case?
What factors may alter my decision?
How do we integrate my views and my colleagues' views?
How do we reconcile any differences?

on workshops, and simulation scenarios led by experts would be most effective. Different types of modalities for imparting this knowledge can be trialed and adapted for tutelage on an institutional level.

Of these options, we believe simulation training would be most effective in addressing critical thinking and appraisal and development of a "shared mental model" (strategic knowledge in a real-world setting). There are a number of ways we foresee simulation scenarios being helpful in this endeavor. Cross-training in simulation is one strategy that has been used in certain situations, as rotating team roles may provide an opportunity for team members to understand the responsibility of each role and force explicit coordination.[26] The debrief process in and of itself, whether in simulation training or the real-world setting, has traditionally been focused on the chronology of a particular situation; however, if structured around a model of teamwork and performance as recommended by Fernandes et al, it can be an opportunity to "think out loud" and bring forth these macrocognitive and team cognitive processes.[15] The goal of the debrief would be to help individuals vocalize their decision making and explain specifically why they communicated certain statements and how the information sharing impacted their performance.[27] This can then allow the other team members to process information and to ask clarifying questions to provoke new levels of thinking (Box 1). Clinical educators should know that the learner needs to be empowered as they may have an increase cognitive load, positive or negative emotion which might have a negative effect on learning.[28] Empowerment and the use of debrief is a key concepts to overcome these challenges and hopefully promote a better learning environment to essentially reach shared mental model. The work of Hayes et al, which focuses on the five strategies in critical thinking and using additional cognitive interviewing techniques as needed, may provide a framework that can be adapted during this debriefing process.[29] Using audio or video playback can help better evaluate the effectiveness of each individual's communication and start a dialogue with constructive self-reflection.[15]

Discussions on assessment is beyond the scope of this manuscript. However, the Miller's pyramid of clinical competence may be a good framework to evaluate both cognitive and behavioral components of competence. Assessment itself may be more challenging, as often these internal cognitive processes are not directly observable and current assessment methods often focus on the outcome of the process, rather than the decision-making process itself.[30–32] There are some limitations of the current assessment methods that may need to be modified in order to better ensure competency in these particular areas.

Conclusion

In summary, macrocognition and team cognition are skills essential in improving transparent decision making and patient safety and are an important part of multidisciplinary patient care settings. Critical care situations often include multidisciplinary team members with varying levels of expertise (including physicians, nurses, respiratory therapists, pharmacists, and others). This can lead to a complex team structure, and good communication and a collaborative inclusive environment is essential to form a "shared mental model". As of now, there is not much formal training on developing the skills needed to harness a team's metacognitive skills, but there is clearly a growing need for more formal education in this area.

To this end, health profession educators need to teach team members about the concept of shared cognition based on macrocognition and team cognition. They also need to ensure these different disciplines hold compatible knowledge structures, including but not exclusive to their teammates' roles and responsibilities.[27,33] We envision this being done

using a variety of modalities, but the most effective would likely be a multi-disciplinary simulation setting with a focus on debrief.[34] Future work is needed to incorporate these concepts into the education of each interdisciplinary department.

Disclosure

All authors report no conflicts of interest in this work.

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