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Force of Habit: Developing Situation Awareness in Critical Care Transport

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A B S T R A C T

Situation awareness (SA) is a vital cognitive skill for high-stakes, high-hazard occupations, including military, aviation, and health care. The ability to maintain SA can deteriorate in stressful situations, exposing patients to dangerous errors. The literature regarding how to best teach SA techniques is sparse. This article explores specific techniques to promote and maintain SA in dynamic clinical environments using principles derived from cognitive psychology, neuroscience, and human behavioral and organizational research. The authors propose strategies to help individuals and teams to develop ingrained, subconscious behaviors that can help to maintain effective SA in high-stress environments.

Situation awareness (SA) is critical in high-stakes circumstances, such as the resuscitation of critically ill or injured patients. Exploratory research in psychology, neuroscience, human factors engineering, and to a lesser extent health care has led to a deeper understanding of what SA is and how it can be measured. Unfortunately, little is known about how we can adapt training in order to more consistently create behaviors that heighten SA during dynamic, high-stakes clinical events. In this article, the prevailing theory of SA is reviewed, and the evidence for evaluating it in medicine is presented. In addition, the authors draw from the fields of neuroscience and cognitive psychology to suggest some strategies that can develop effective behaviors that promote SA in resuscitation.

What Is SA?

SA is a dynamic process by which cognitive skills are used in perception, comprehension, and anticipation of information from the surrounding environment.[1] In her landmark article "Toward a Theory of Situation Awareness in Dynamic Systems," Dr. Mica Endsley defined SA as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."[1] In the case of resuscitation, it is one's ability to recognize important clinical information, correctly interpret the information and generate an idea of what's going on with a patient, and finally project the clinical trajectory based on this idea in conjunction with one's knowledge and previous experience.

Endsley's model of SA (Fig. 1) involves a cyclic and dynamic system in which individuals are constantly reevaluating their surroundings in order to make effective decisions and adjustments in real time. The widely accepted model of SA presented by Endsley suggests that there are 3 phases or 3 "levels" to SA.

1 Level 1: perception of the elements in the current situation—monitoring the surrounding environment and collecting data
2 Level 2: interpretation of the accumulated information—a deliberate blend of analysis, pattern matching, and recognition[2] and the application of mental models
3 Level 3: projection of future status—using a functional understanding of the situation; the third level applies the mental model to forecast and anticipate what will happen next. Based on this process, a decision can be made, and the appropriate action can be taken.[1]

It is important to recognize that central to the model of SA is the development of level 2 in Endsley's model, which entails interpretation and comprehension. This aspect of SA deals with the creation of mental models or mental representations.[1,3]These are rich

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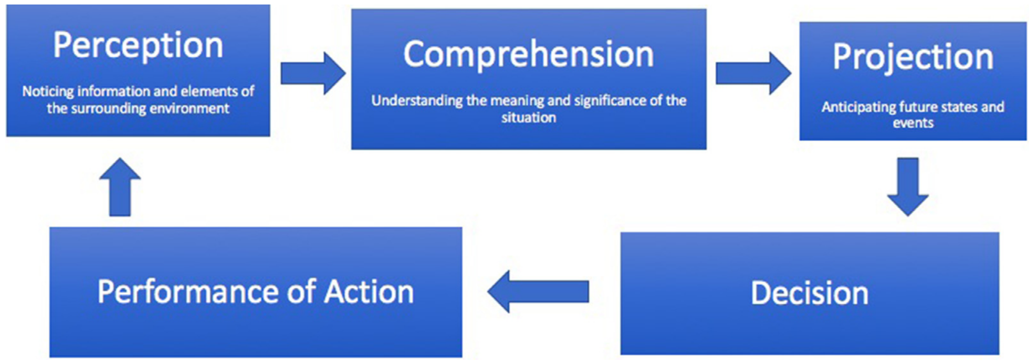

Figure 1. Model of SA concept based on theory presented by Endsley.

knowledge structures stored in memory that illustrate particular combinations of information based on environmental cues and their meaning. This could be the cognitive framework for a clinical condition (eg, tension pneumothorax), the functioning of a particular device (eg, chest drainage device), or a procedure (eg, placement of a thoracostomy tube). Building accurate mental models based on the perception of environmental cues is essential in order to ultimately predict future events.

SA can be categorized as global or local.[4] Humans have a finite working memory and can only process a fixed amount of information at a given time. Therefore, the scope of one's SA can be very broad (global SA), or it can be narrowed to focus in on a particular task (local SA).[5-7] However, it is not possible to simultaneously focus on both. These authors use the term far field SA to refer to global SA and near field SA to refer to local SA.

In resuscitation, it is often important to pay close attention to individual lifesaving interventions while maintaining awareness of the situation overall. Because any individual would be unable to achieve this, team dynamics can be leveraged to use far field and near field SA simultaneously. For example, when conducting rapid sequence intubation, the person managing the airway is entirely focused on manipulating the laryngoscope, observing the airway structures, and successfully delivering the endotracheal tube into the trachea. This team member is maintaining local SA. Contrastingly, another individual (team leader) may bear the broader responsibility of continually scanning the patient, observing hemodynamic parameters, monitoring peripheral capillary oxygen saturation, and surveilling the environment for potentially hazardous factors, thus displaying global SA.

Maintaining effective SA is predicated on a host of factors, and a problem with any component can result in failure. Endsley has identified some of these problems at each level (Table 1).

Poor SA has been implicated as the leading cause of accidents and errors across various industries including in the military, NASA, commercial aviation, and medicine. These events have been most thoroughly documented in the aviation world.[1,8] Similar findings are observed in reviewing medical mishaps in acute care; errors regularly stem from misperception and poor SA.[8,9] This is particularly true in aspects of medicine with dynamic, stressful environments in which the stakes are high.[10] The ability to perform effectively (ie, making timely, accurate decisions and completing technical skills) is contingent on our ability to observe and process important clues from the surrounding environment. Failure to do this as an individual or team results in mistakes.[11]

Measuring SA

The ability to quantify and measure SA is requisite in order to understand and manipulate its component parts and develop focused and effective strategies to improve training.[12-14] The output from experimental measurement of SA can also inform advances in equipment, technology, and design across a number of high-stakes domains.[15]

Behavior rating scales for SA are designed to objectively assess an individual's internal cognitive processes by quantifying actions and events that occur in response to the simulated or real-world environmental cues. The SA global assessment technique has been used across various disciplines including in aviation, air traffic control, nuclear power plant operation, and medical stimulation.[16] The SA rating scale was another tool used by observers to rate a team or individual's level of SA.[17]

SA is also a component of several anchored behavior rating scales designed to evaluate more global team performance. In 2003, Fletcher et al[18] introduced the Anaesthetists' Non-Technical Skills (ANTS) rating scale used to assess the preparedness and functioning capacity of operating room teams during medical and surgical crises, including SA. Other health care disciplines have developed similar models for assessing SA and teamwork during complex, high-acuity, and time-sensitive events. These include the Non-Technical Skills for Surgeons behavioral rating scale[19] and the Ottawa Crisis Resource Management Global Rating Scale for emergency medicine and critical care.[20] (see Table 2)

Although the ANTS rating scale, the Non-Technical Skills for Surgeons behavioral rating scale, and the Ottawa Crisis Resource Management Global Rating Scale focus on individual skills, efforts have been made to develop systems of measurement for the global performance of medical and surgical teams. Several of the more commonly used tools include sections on evaluating SA. Language embedded in the prevalent protocols

Table 1
Errors Related to the Different Levels of Situation Awareness[3]

Level 1: Perception	Level 2: Interpretation	Level 3: Projection
Distraction	Lack of a mental model	Overreliance on a mental model
Diagnostic ambiguity	Inadequate/poor mental model	Not realizing a mental model must change
Failure to scan or observe information	Overreliance on default model	
Misinterpretation of clinical data	Memory failure	

Table 2
A Comparison and Contrast of the Rating Systems for Situation Awareness

	Field	Description	Categories Assessed	Strengths	Weaknesses
The Situation Awareness Global Assessment Technique (SAGAT)	Applied generally	System developed to measure one's SA achieved by pausing a scenario and querying the operator to determine his or her perception of a situation in that time and space.	Perception of data, comprehension of meaning, and projection of near future given integration of information	Measures the 3 levels of SA as outlined by Endsley High degree of validity, sensitivity, and reliability for measuring SA	Intrusive nature of the system Protocol relies on operator recall and memory
Situation Awareness Rating Scale	Applied generally	Self-assessment that measures one's situation awareness in the completion of various tasks	Perception of instability in situation, complexity of situation, variability of situation, arousal concentration, division of attention, spare mental capacity, information quantity, and familiarity with a situation	Easily administered at low cost Can be used generally across many fields. Quantitative measure of SA	Subjective evaluation with recall bias Limited evidence regarding validity, reliability, and sensitivity as compared with SAGAT
Anaesthetists' Non-Technical Skills	Anesthesia	System created to evaluate behavior markers when performing nontechnical skills conferring superior or suboptimal outcomes	4 major categories: task management, teamwork, SA, and decision making	Acceptable validity, reliability, internal consistency, accuracy, and usability in experimental settings	Lacks behavioral markers that evaluate personal factors such as stress management and self-presentation Some behavior markers were complex, subtle, and difficult to recognize Limited data in real-world scenarios
Non-Technical Skills for Surgeons	Surgery	Tool used to develop and assess a surgeon's nontechnical skills in the intraoperative setting	SA, decision making, communication and teamwork, and leadership	Widespread acceptance and use in North America, East Africa, Japan, and Australia Acceptable validity, reliability, sensitivity, and usability	Usability in limited scope of practice Dependent on subjective analysis
Team Emergency Assessment Measure	Emergency resuscitation	Model that assesses team performance in setting of emergency resuscitation	Leadership, communication, cooperation, adaptability, SA, prioritization, and clinical standards	High level of reliability and validity	Limited data on psychometric properties
Mayo High Performance Teamwork Scale	Medicine	Tool used in medical simulation training settings to identify and evaluate a team's crisis resource management skills	SA, communication skills, anticipation of errors, and error containment and management strategies	Acceptable internal consistency, validity, and sensitivity	Limited data on validity and sensitivity in widespread medical settings
Ottawa Global Rating Scale	Acute medical care	Tool used to measure crisis management resource performance in medical simulation settings	Problem solving, SA, anticipation and planning, leadership, resource use, communication output and input, and clinical management	Acceptable validity	Suboptimal interrater reliability in widespread acute care settings

SA = situation awareness.

like the Team Emergency Assessment Measure score include whether the team "monitored and reassessed the situation," "anticipated potential situations," and if the team leader "maintained a global perspective."[21,22] The Mayo High Performance Teamwork Scale includes items that evaluate how team members "call attention to actions that they feel could cause errors or complications" as well as acknowledging statements "directed at avoiding or containing errors or seeking clarification," concepts relevant to maintaining SA.[23]

Building Active Systems of SA

Although our ability to describe and measure SA has improved, there are still limited data regarding how to teach and apply this complex skill. Despite the absence of conclusive evidence on the topic, there are aspects of cognitive and behavioral science that are well studied and might hold clues to developing effective and resilient strategies for maintaining SA for both novice and expert providers. These authors submit that there are 2 fundamental elements that can contribute to this end state:

1. Build active cognitive and behavioral systems of awareness
2. Turn an active system of awareness into an unconscious habit

Active SA systems are cognitive processes or behaviors that deliberately focus attention on critical and/or dynamic environmental cues before potential problems occur, such as changing oxygen saturation or clinical responses to a medication. In contrast, passive systems, which are usually equipment based such as monitor alarms, alert personnel when problems occur. Although passive systems provide reasonable safety nets, active systems are critical to improving SA because they are proactive. They attempt to detect problems and dangers before they manifest.

Maintaining active SA in resuscitation is a skill that can be taught and developed. Members of the team can be instructed on interpreting when a scenario is safe and at its baseline and drilled on the proper responses to potentially dangerous variations from this (periods of high task load, ambiguity, or other nonstandard operations). Rather than passively awaiting for a signal, such as an alarm or flashing light, in an active system, one is constantly surveilling the clinical environment for perturbations that may foreshadow upcoming hazards.

Many occupations outside of medicine have developed active systems to maintain SA in dangerous or high-stakes environments. One example is in the world of aircraft-based search and rescue. Pilots and other aircrew use a systematic approach to scanning in order to optimize their chances of finding people or objects. Using this technique involves locating and fixating on a point about 10° to 20°, approximately 1 finger width, below the horizon. From this point, the rescuer's gaze travels vertically along a line segment to the aircraft. The rescuer will continue this process while adjusting his or her starting point by 3 to 4 finger widths, which ensures for overlapping fields of central vision.[24] Techniques such as this one have been designed through data ascertained from the current literature on visual processing and the neurocognitive patterns associated with perception and comprehension of information, all of which are key concepts to SA.

Another example of active systems that maintain SA can be found in the safety behavior of military aircrews. When taking off and landing, the crews communicate using specific, cued statements that keep everyone apprised of the aircraft's surroundings. For example, a helicopter pilot might call "50 and 50" as he or she approaches the landing zone, signaling descent to 50 feet and 50 knots. In response, crewmembers will clear their designated zones of responsibility with phrases like "clear left," clear right," and "clear back." By doing this, the entire team's SA is maintained, even though no one individual can visualize all areas around the helicopter. Also, having a delegated task allows each member of the team to maintain the locus of his or her attention on a particular area.[25]

These authors submit that developing an active system of SA is also important for high-risk medical procedures, such as rapid sequence intubation. Medical resuscitation teams generally operate in teams of 2 or more. The team member tasked with placing the endotracheal tube demonstrates near field SA, whereas the other member displays far field SA because his or her task involves administering medications and then cyclically scanning the area for potential issues (ie, the monitor, patient, surroundings, their partner, and then back again to the monitor). However, each team member should be using active systems of SA to watch critical features of their field of SA for change. In the near field, the team member placing the airway may be watching carefully for the accumulation of secretions or stomach contents in the oropharynx. In the far field, a team member (or multiple team members) are scanning the surroundings, the patient, and the monitoring equipment looking for cues as simple as identifying that the positive end-expiratory pressure valve fell off the bag valve mask to something as concerning as a precipitous drop in blood pressure or oxygen saturation.

Transforming Active Systems of SA Into Habits

The process of converting a learned behavior to a habit is challenging. It is this process that enables an experienced practitioner to perform a successful resuscitation in the face of a crashing patient or a provider to intubate a patient in imminent respiratory failure with the same precision and organization as previous times. Habits, both good and bad, have the ability to override one's own willpower or cognitive reasoning.[25] This is the basis by which addictions surmount interventions yet has also been the focus upon which clinical errors have been improved (eg, confirming medications before administration or running patient checklists in the operating room before a procedure starts).

Charles Duhigg discusses a general model of habit formation from a neurologic and behavioral standpoint in his book *The Power of Habit: Why We Do What We Do in Life and Business*.[26] Duhigg theorizes that humans operate on "habit loops." Habit loops begin with a cue that triggers the brain to access and express a deeply imprinted thought, feeling, or pattern of behavior. This provoked routine, the habit, is then executed. Finally, performing this habit generates a reward in the form of a chemically stimulated sensation of pleasure, resulting in positive feedback to ensure this process is self-propagating.

Habits, once established, reflect 1 of the most efficient cognitive processes performed by humans. A study performed at the Massachusetts Institute of Technology, Cambridge, MA, showed that the locus for habitual behaviors is in the basal ganglia, an area vital for integration and execution of motor activity.[27-29] Controlled movements are performed by a complex interplay of excitatory and inhibitory neuronal pathways in the basal ganglia. When a habit is formed, there is decreased neuronal activity in this area of the brain. This suggests that learned habit or routine relies less heavily on neurochemical processes and, as a result, is more efficient.

Developing habit loops that enhance one's SA would be advantageous in medicine. This is particularly true in medical emergencies. In chaotic and stressful resuscitation situations, the fidelity of conscious cognitive processes often deteriorates.[5,6] There are specific detrimental effects on the ability to focus and pay attention to important environmental cues.[2,7] However, training attention skills can ensure their precision under stress.[30] By automating behaviors (active systems of SA), emergency medical personnel can minimize the cognitive load of these tasks and facilitate their performance, even in very stressful situations.[31-33] Therefore, developing habitual behaviors might promote SA, improve clinical care, and decrease medical errors in resuscitation.

Research from behavioral and social science provides the following guidance on how to develop effective habit loops:

1. Tie SA-promoting behavior to a trigger that is virtually inescapable: habits are developed more effectively when they are tied to events that one cannot bypass.[34] For example, a common practice in many operating rooms is to run a safety checklist before the surgery begins. The first incision is the mandatory first step in a series of sequential events that as a whole comprise a complex procedure. In prehospital medicine, the patient must be loaded into a vehicle in order to be transported to the hospital. These "force functions" serve as overt triggers or consistent prompts that can be leveraged to initiate a routine behavior. The linking of specific, discrete tasks together under the guise of 1 larger event is referred to as "chunking,"[35] which, in turn, can promote the coexecution of standard and safety behaviors, such as loading a patient for transport and executing a predeparture safety checklist.
2. Make the routine that follows the trigger very specific: there is strong evidence to suggest that by making an objective or goal specific, measurable, attainable, results based, and time bound that the likelihood of attaining a goal is markedly increased. The same is believed to be true of a habit.[36] The desired pattern of behavior to be triggered must be distinct, precise, and specific. Psychologists describe this as the "implementation intention," the purposeful connection between a trigger and routine. In contrast, goal ambiguity negatively impacts the ability to form meaningful habits. In a meta-analysis of 94 studies that included 8,166 participants, Gollwitzer and Sheeran[37] found that the ability to successfully translate goals into behaviors significantly improved when people used very specific intention statements. For example, appropriate intention statements to achieve the goal of being more physically fit would be "When I enter my office building, I will only take the stairs to get to my office," "If I decide to go out to lunch, then I will walk to the restaurant," or "If I go for a run, then I will run no slower than a 7 minute mile pace." Concordantly, the executed behaviors that facilitate active SA must be specific. For example, the sound of the "low pressure" alarm on the ventilator should prompt the provider to assess the vent-tubing connection, trace the tubing to the endotracheal tube, ensure all connections are intact, check the pilot balloon on the endotracheal tube, and so forth. Another example includes checking the monitor for oxygen saturations, heart rate, and blood pressure after administering rapid sequence intubation drugs followed by checking the patient, then the individual placing the airway, and then quickly scanning the surroundings. These are both examples of certain stimuli or actions that trigger a very specific sequence of actions.
3. Repetition and deliberate practice: 1 of the key aspects of developing an effective SA behavior is repetition. Repeated actions prompt even the most sophisticated neural pathways to become stronger and more efficient. The number of repetitions required to strengthen this neural interaction is still ill-defined. In his book *Psycho-Cybernetics, A New Technology for Using Your Subconscious Power*,[38] Dr. Maxwell Maltz noted that amputees required and average of 21 days to become accommodated (physically and psychologically) to the loss of their limb. From these data, Dr. Maltz hypothesized that it takes approximately 21 days to adapt to major life changes. In a more recent investigation at University College London, London, UK, researchers followed 96 subjects in a prospective cohort study to evaluate how long it took people to make a variety of different health-related behaviors. On average, it took people 66 days to make these behaviors automatic. However, the range was quite broad (ie, 18 up to 254 days).[39] It is challenging to extrapolate much from these studies because they pertain to developing habits that generate SA in environments with greater stressors. Furthermore, it is more reliable to measure data on a per event basis as opposed to per day because of the tremendous variability in daily occurrences. These data do indicate that most of the progress in generating a habit automaticity happens in earlier repetitions and that the behaviors must be repeated.
4. Evaluate the routine, and, if it isn't working, change it: dissatisfaction is among the greatest deterrents in successfully converting a behavior to a habit. As the SA routine is established, it is important to try to obtain qualitative and quantitative data that show benefit.[40,41] If the habit is not producing the intended outcome, use the data and the suggestions from other members of the team to adjust and manipulate the routine until the desired outcome is achieved.
5. Always remember the purpose of developing routines: altering a pattern of behavior successfully is heavily dependent on intrinsic motivation.[42] Extrinsic motivation proves only marginally helpful. There must be an underlying belief among the team that this change is necessary and valuable for enhanced performance and safety in resuscitation. The mentality toward such change should be one that recognizes that the SA habit is being adapted to offer better, more efficacious service.

Conclusion

Building active systems and transforming these active systems into SA habits is important to optimize resuscitation. Extensive efforts have been made to define SA. Protocols that include the measurement of an individual or a team's SA exist across many fields like SA global assessment technique, SA rating scale, Anesthesia Crisis Resource Management (ACRM), ANTS, and Non-Technical Skills for Surgeons systems. However, the literature remains sparse on techniques that demonstrate the ability to construct active systems and convert them to subconscious behaviors. The authors propose a system to achieve this through application of accepted psychology principles, current cognitive science, and human behavioral research on habit formation. The proposed system involves teaching respondents and trained personnel to develop active SA behaviors that, when triggered, confer an intuitive and reflexive process. Success in creating this subconscious process is predicated on a number of factors. The desired behavior must be provoked by an unavoidable event, exquisitely specific, repeated interminably, reevaluated if not producing desired outcome, and intrinsically viewed as necessary and important. The authors propose that this training modality will optimize one's SA by converting processes that typically requires active thinking into behaviors that are automatically engaged when prompted.

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