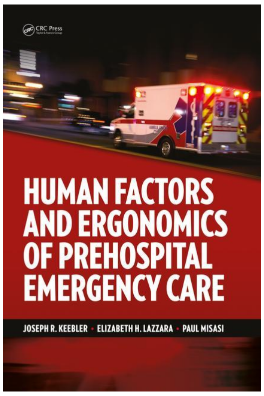


**Human Factors and Ergonomics of Prehospital Emergency Care**
**Critical Essays in Human Geography**

Joseph R. Keebler, Elizabeth H. Lazzara, Paul Misasi

# Cognitive Aids in Emergency Medical Services

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# 9 Cognitive Aids in Emergency Medical Services

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If there were just one defining characteristic of EMS, it would unequivocally be flawless service as quickly as possible. As Kobusingye et al. (2006, p. 1261) suggest, EMS requires "*rapid* assessment, *timely* provision of appropriate interventions, and *prompt* transportation to the nearest appropriate health facility by the best possible means to *enhance* survival, *control* morbidity, and *prevent* disability" (emphasis added). Within this statement lies an obvious paradox: perform optimally *and* rapidly. Yet science and practice both suggest a clear speed–accuracy trade-off (Fitts, 1954). So consistent is this finding that it has been named Fitts's law (MacKenzie, 1992) and, thus, placed on equal footing with other indisputable phenomenon such as gravity and thermodynamics. But the presence of gravity did not stop humans from reaching the moon, nor have the laws of thermodynamics prevented discovery/creation of a variety of superconductors. In short, every law is made to be broken—or at least bent. The question is, how can we bend Fitts's law to make EMS both exceptionally fast *and* highly accurate? We argue that the answer lies, at least in part, with cognitive aids.

Cognitive aids are tools designed to lessen the cognitive burden associated with completing tasks from collecting information to storing and retrieving it, ultimately making the individual more efficient (Rosenthal & Downs, 1985). For example, the *World Health Organization* created a *safety checklist* to increase efficiency and accuracy in surgeries, ensuring that all safety protocols are followed (Weiser et al., 2010). This checklist, and almost all cognitive aids, works by reducing the amount of information that an individual has to process or structure, by off-loading some of it to an external tool (Rosenthal & Downs, 1985). In doing so, cognitive aids reduce task demands and provide additional resources to the user, allowing for a level of efficiency that was previously unattainable. Furthermore, cognitive aids not only improve the demand–resource ratio but also change the way that a task is completed to enable greater precision (Rosenthal & Downs, 1985). The result is an increase in speed *and* accuracy.

To further elucidate how cognitive aids can benefit EMS, we first need to thoroughly define what we mean by cognitive aid. Thus, we discuss the scope and purpose of cognitive aids and then organize them into a general taxonomy. This will lead to the main focus of our effort, an integration of these two into a graphical heuristic, from which we will describe how each type should be trained and used to maximize both the efficiency and effectiveness of EMS.

## SCOPE AND PURPOSE OF COGNITIVE AIDS

The purpose of any cognitive aid is to improve outcomes (e.g., response time, survival rate, employee strain), but the manner in which this is accomplished can differ. We suggest that cognitive aids vary along two dimensions: scope and purpose. First, focusing on scope, we argue that cognitive aids can directly target either cognition or behaviors. Although completely isolating behaviors and cognition is neither reasonable nor practical, we contend that cognitive aids can be designed to primarily target one over the other. Cognitive aids can affect outcomes by directly altering, simplifying, or eliminating behaviors (Rosenthal & Downs, 1985) *or* cognition (Block & Morwitz, 1999; Makany et al., 2009). This distinction is critical when considering the implementation of cognitive aids in EMS. Cognitive aids that primarily target behaviors (e.g., preloaded syringes, behavioral checklists) necessarily are limited in scope as they are designed to target one unique behavior or set of behaviors (Hales et al., 2008). This limited scope allows for increased efficacy within the specified context but decreased generalizability (e.g., a lumbar puncture checklist or EpiPens). However, behaviorally targeted aids tend to be relatively easy to implement and can result in rapid improvements in outcomes (e.g., Dunlap & Dunlap, 1989) as users need only to enact the specified behavior(s) to achieve the desired result(s). Aids that directly target cognition (e.g., mnemonics), however, can be more generalized in scope, allowing for increased utility across situations (Rosenthal & Downs, 1985). This, however, necessitates a sacrifice of detail (e.g., Situation, Background, Assessment, and Recommendation [SBAR]). Generally, these cognitive aids take longer to implement than behavioral aids but can have lasting effects due to relatively stable cognitive changes (Rosenthal & Downs, 1985).

Cognitive aids also vary in their purpose. They can be designed primarily to create structure or simplify processes. Cognitive aids that primarily target structure are designed to refine or create a scaffold, or prescriptive guide, upon which cognitive and behavioral processes are built, organized, and executed (Rosenthal & Downs, 1985). These aids can create lasting effects that generalize across providers but tend to be resource intensive at the outset, requiring significant effort to design and train (Scaife & Rogers, 1996; Hales et al., 2008). Alternatively, cognitive aids can be designed to simplify cognitive or behavioral processes. These aids are designed to eliminate certain task-based demands (Zhang, 1997); however, they tend to be much less generalizable by functioning in only one manner or targeting a specific set of behaviors or cognition (e.g., an abacus or flow chart; Szolovits & Pauker, 1978). This limits both the situations and/or the users that benefit from aid implementation (e.g., Szolovits & Pauker, 1978). Although they can be resource intensive in design, they are not necessarily in implementation, requiring less training than aids that aim to create structure (e.g., Szolovits & Pauker, 1978).

Combining these two dimensions (scope and purpose) provides four broad domains of cognitive aids (see Table 9.1), each of which has unique strengths and weaknesses. First, aids that structure cognition are designed to efficiently organize information for easy recall. For example, a mnemonic device (e.g., SBAR) provides a framework with which patient information can be analyzed, organized, and shared. Cognitive aids designed to simplify cognition, however, can target the initiation or execution of already organized information. Leaving a patient's chart open to a specific page enables quick retrieval of required information. Such aids mitigate the cognitive burden of tasks by off-loading it to an external aid. Cognitive aids that structure behavior, such as those that target cognition, are designed to create a framework that can guide efficient execution of behavior. Decision trees or ordered checklists, for example, provide users with the ideal order of steps to follow when executing a task. Lastly, cognitive aids designed to simplify behaviors remove a time-consuming or problematic aspect of the task in favor of off-loading it to an external tool. Preloaded

**TABLE 9.1**
**Key Aspects of Scope and Purpose of Cognitive Aids**

| | | Scope | |
|---|---|---|---|
| | | **Behaviors** | **Cognition** |
| Purpose | Create structure | • Moderate scope<br>• Rapid changes<br>• Resource intensive to implement | • Wide scope<br>• Permanent changes<br>• Resource intensive to implement |
| | Simplify processes | • Limited scope<br>• Rapid changes<br>• Resource intensive to create | • Limited scope<br>• Resource intensive to create |

syringes, for example, simplify task execution by removing the time-consuming and error-prone step of dosing medication, allowing for quicker administration. Each of these four domains can be targeted by a variety of cognitive aids. In the following section, we outline six major types of cognitive aids, how they simplify or structure behaviors and cognition, and how they can be used in EMS.

## TYPES OF COGNITIVE AIDS

### Checklists

One of the most widely used cognitive aids is organized tools that outline criteria or steps, simplify concepts, and aid information recall (Hales et al., 2008). A checklist is a physical or digital list of steps, ideas, categories, or key points. They should be clear (e.g., simple language and easy-to-read font), in-depth (e.g., all necessary information is included), and, when describing a process of steps, must be in the proper order (Luten et al., 2002; Harrison et al., 2006; Hales et al., 2008). When combined with appropriate intervention techniques, checklists can help EMS avoid missing steps or failing to capture all necessary information (Catchpole et al., 2007). Checklists are primarily designed to structure behavior, ensuring that all aspects of a task are completed. In general, checklists are designed to give information regarding how to complete a task (i.e., behaviors) not what thoughts to have about a problem (i.e., cognition). Yet when checklists are expected to target cognition or to simplify behavior, rather than structure it, users can be left feeling frustrated. This frustration can lead to checklist fatigue—a loss of desire to use the aid (Hales et al., 2008). Despite flexibility and ubiquity, checklists are not *always* the answer in EMS. For example, when a patient is crashing, using a checklist to look at all vitals could waste valuable time in resuscitating the patient. In such case, an alarm on the device monitoring a particular system would be more appropriate.

### Alarms

Alarms are defined as auditory warnings that increase situational awareness and vigilance and can advise required actions (Catchpole et al., 2004). Alarms should signal severity (e.g., louder alarms for more serious problems) and location (e.g., tonal sweeps that allow for auditory localization) and be unique to each event type (Celi et al., 2001; Catchpole et al., 2004). They have the capability to alert individuals to the most important or pressing issues in an environment and are considered “hard defenses” against error (Reason, 2000). An alarm for cardiac arrest, for example, eliminates the need to repeatedly check heart rate and compare it to safe levels. Although alarms, like checklists, are designed to ultimately influence behavior, their primary purpose is structuring cognition. In other words, alarms do not provide much information about how to solve a problem (i.e., behaviors) but primarily inform individuals that there is an issue, and what that issue is (i.e., cognition). As previously mentioned, the pitch or pattern of alarm can trigger a cascade of thoughts that ultimately leads to actions designed to eliminate the cause of the alarm. This motivated behavior can occur faster and more accurately because individuals have been trained on the meaning of the alarms and have created an accurate and effective cognitive structure. The users then have little need to search their environments for the source, instead relying on their knowledge of the alarm to inform their thoughts and, ultimately, actions. However, like checklists, alarms have been subject to overuse and improper application, which leads to a desensitization to *all* alarms, a phenomenon named alarm fatigue (Cvach, 2012). Despite published standardization of medical device alarms (IEC, 2006), they are often difficult to discriminate and do a poor job of signaling the severity of the issue (Sanderson et al., 2006). Coupled with a lack of training on the nuances of the various alarms, this has increased rates of alarm fatigue and physiological strain (Morrison et al., 2003).

## Physical Tools

Physical tools are unlike alarms and checklists in that they are designed to simplify behaviors and cognition, not structure them. Physical tools are tangible objects that are designed with the specific purpose of reducing human error or necessary effort through the simplification, restriction, or enhancement of behavior. This category of cognitive aid encompasses a vast array of objects, such as differently sized and colored tubing, preloaded syringes, or calculators, designed to reduce human error and simplify tasks. To be useful, physical tools should be cost-effective (e.g., no more expensive than the cost of the alternative and any lawsuits that result in errors associated with use of the alternative), easy to use (e.g., intuitive and ergonomically designed), and pilot tested by the intended users (Celi et al., 2001; Luten et al., 2002; Catchpole et al., 2007). For example, bar code technology, specifically designed packaging, and premixed medications are useful tools to prevent medication errors (Cohen et al., 2007)—a costly error in EMS. Use of these aids can reduce error by allowing for cognitive off-loading (Luten et al., 2002; Dror & Harnad, 2008). However, heavy reliance on the physical tool's shape or size can be problematic as there are few regulations governing standardization. Further, over-reliance on physical tools can cause complacency, creating new opportunities for errors, as was seen in the airline industry with the introduction of automatic pilot options (Parasuraman & Riley, 1997).

## Mnemonic Devices

Mnemonic devices are "cognitive cuing structures that typically are made up either of visual images or of words in the form of sentences or rhymes" (Bellezza, 1984, p. 252). These patterns are used to structure, represent, and aid in the recall of connected ideas. A commonly used mnemonic in healthcare, for example, is SBAR. This mnemonic device is used as a reminder of a clear and consistent manner in which information should be given from one practitioner to another during a patient handover (Philibert & Leach, 2005). Mnemonic devices are designed to primarily structure cognition. They organize information in a logical way, but mnemonic devices are entirely cognitive in nature and must be memorized and recalled when appropriate. This places more of a cognitive burden on the healthcare provider than some other forms of cognitive aids but has been shown to reduce cognitive burden when compared to unstructured information (Verhaeghen et al., 1992). Mnemonic devices should be easy to remember (e.g., short and/or evocative of vivid imagery) and, if describing a sequence of steps, be in order (Hales et al., 2008). Given that their power comes from structuring cognition, which may ultimately lead to structured behavior (e.g., check airway, breathing, circulation [ABC]), mnemonic devices designed to simplify thoughts or behaviors may be less effective. Furthermore, mnemonic devices are not standardized across contexts or even care providers. Thus, when EMS interact with workers at various institutions, the staff may not be familiar with the same mnemonic devices, leading to confusion and miscommunication. Returning to our handover example, although SBAR is the most common mnemonic, in a recent study, 24 different patient handoff mnemonics were identified by trained reviewers (Riesenberg et al., 2009). This could lead to the perpetuation of nonfunctional mnemonic devices, the disuse of those that are effective, or confusion over what information to convey in which manner. Ultimately, this reduces both the speed and the accuracy of care delivery, resulting in patient harm and provider stress.

## Cues

Cues are digital or physical stimuli (e.g., posters, signs, or warnings) designed to elicit specific behavioral patterns. In other words, cues primarily structure behaviors. Cues have been shown to reinforce organizational culture (Pettigrew, 1979) and prevent or promote certain behaviors (e.g., Pittet et al., 2000; Ford & Torok, 2008). Ultimately, however, the purpose of any cue, whether it is a stop sign or a pop-up reminder that Windows has critical updates, is to initiate behavior that might not otherwise occur. In general, however, cues can be easily ignored. They may be effective at altering behavior upon initial implementation, but unless the perceived consequences of disobeying the cue are too high, the effects can rapidly diminish. Even though this pattern is seen with both physical and digital cues, digital cues (e.g., pop-up reminders on a computer or mobile device) can serve to initiate or prevent behaviors in a more real-time, situation-specific manner than their physical counterparts. This can help alleviate the problem of rapidly diminishing effects by creating novel stimuli or by limiting presentation of the cue to only relevant situations. In doing so, digital cues can structure behavior more effectively based on the situation at hand, perhaps without falling subject to inattentional blindness (Anderson et al., 2010). In EMS where time is of the essence, both physical and digital cues hold promise due to their ability to rapidly structure behavior, reducing the time required to act, and increasing accuracy, all without placing a greater burden on the worker.

## Decision Support Systems

Decision support systems (DSSs) are defined in this chapter as algorithm-based tools that take information regarding a situation or patient and provide suggestions regarding courses of action (Miller et al., 2015). These can be as simple as paper-based flow charts or as complex as programs integrated into the electronic medical/health records. DSSs rely upon empirically derived algorithms to lead the user to the most likely diagnosis or the best course of action. In essence, this is the same process that a human goes through when mentally making decisions, but we are subject to a range of biases and errors. DSSs are designed to simplify this process, reducing the possibility for human error. Certainly, DSSs are only as effective as the algorithms from whence they are derived and the inputs with which they create output, but certainly, they simplify cognition. In fact, a well-designed cognitive aid should not only increase accuracy but should also increase the speed with which the user can come to a conclusion regarding the situation and react. As such, DSSs can be incredibly useful for EMS. Digital DSSs, in particular, hold great promise. Many DSSs are able to eliminate the need for human input, instead sampling the environment or patient and providing recommendations. Blood pressure monitors, for example, which automatically provide the user with a suggested diagnosis of hypertension, prehypertension, or arrhythmia, can save the user time and can be more accurate, in trying to determine if the blood pressure or heart rate is abnormal. Furthermore, modern technology has increased the amount of accessible information, the speed with which it can be used, and the vast number of DSSs that can tap into this information (DesRoches et al., 2008). Mobile applications, for example, have allowed a tablet or cell phone to rapidly provide EMS with suggested diagnoses and/or course of action, all without sacrificing time. However, similar to the aforementioned cognitive aid types, overreliance on these aids has resulted in dissatisfaction from both the care provider and the patient.

## A VISUAL HEURISTIC OF COGNITIVE AIDS

Combining the six types of cognitive aids (Table 9.2) with the two design dimensions (scope and purpose), we have created a visual heuristic (Figure 9.1) to help determine which cognitive aids should be used to target specific goals in EMS, how EMS should be trained to use them, and how the aids can be paired to address unique problems in EMS.

Cognitive aids in quadrant I are designed to structure behaviors and include checklists and cues. The cognitive aids in quadrant I are not meant to provide novel information but rather are used to create structure for behaviors that have already been learned. *SPEEDBOMB* (Mommers & Keogh, 2015), for example, is a checklist designed to confirm that the user has properly executed preintubation steps (e.g., *suction*, *positioning*, *equipment*). This checklist is not designed to teach these tasks but can help to ensure that the executed behaviors follow the proper sequence and are completed properly. Similarly, *SleepTrackTXT* (Patterson et al., 2014), which is a digital cue system that helps EMS to track their fatigue levels, is not designed to inform providers that fatigue is dangerous. It is not even designed to teach providers how to avoid fatigue but rather to elicit a specific structure of behaviors that have already been trained.

Cognitive aids located in quadrant II, designed to structure cognition, include mnemonics and alarms. For example, *RASTAFARI* (Legrand et al., 2015) is a mnemonic designed to help providers learn and properly sequence the steps of prehospital and early in-hospital management (e.g., *rule of 9*, *associated trauma and intoxication*, *secure airway*). This mnemonic is helpful not only when learning this sequence by simplifying and structuring the information into easily remembered chunks, but

**TABLE 9.2**
**Taxonomy of Cognitive Aids and Examples in EMS**

| Aid | Definition | Examples in EMS |
|---|---|---|
| Checklists | Organized tools that outline criteria or steps, simplify concepts, and aid information recall (Hales et al., 2008) | • SPEEDBOMB (Mommers & Keogh, 2015)<br>• General, Acute Coronary Syndrome, Asthma and chronic obstructive pulmonary disease checklists (Kerner et al., 2015) |
| Alarms | Warnings that increase situational awareness and vigilance, and can advise required actions (Catchpole et al., 2004) | • MWVSM (Van Haren et al., 2014)<br>• Ventricular-assist devices alarms (Mechem, 2013) |
| Physical tools | Tangible objects designed to reduce human error or necessary effort through the simplification, restriction, or enhancement of behavior | • Preloaded bougie (Baker et al., 2015)<br>• LUCAS-2 (Perkins et al., 2015) |
| Mnemonic devices | "Cognitive cuing structures that typically are made up either of visual images or of words in the form of sentences or rhymes" (Bellezza, 1984, p. 252) | • RASTAFARI (Legrand et al., 2015)<br>• I-PASS (Starmer et al., 2012) |
| Cues | Digital or physical stimuli (e.g., posters, signs, reminders, or warnings) designed to elicit specific behavioral patterns | • SleepTrackTXT (Patterson et al., 2014)<br>• Universal Barrier Precautions posters (Kelen et al., 1990) |
| DSSs | Algorithm-based tools that use situation or patient information to provide potential courses of action (Miller et al., 2015) | • DSS for prehospital care (Vicente et al., 2013)<br>• Acute cardiac ischemia TIPI (Selker et al., 1991) |

also during task execution, by continuing to structure the cognitive processes of EMS by providing a framework upon which the situation-specific information can be interpreted. Another example of a cognitive aid in quadrant II is the alarm system associated with the *miniature wireless vital signs monitor* (*MWVSM*; Van Haren et al., 2014). The alarm sounds when the patient's vital signs fall within one of five predetermined status regions. These alarms elicit a set of associated cognition that has been learned (through either formal training or informal learning). The alarm can be helpful when first learning the sets of risky vital sign combinations by providing a set structure upon which the new information can be built but continues to be helpful by eliciting these learned categories.

DSSs are located primarily in quadrant III, as they are designed to simplify cognition. The *acute cardiac ischemia time-insensitive predictive instrument* (*TIPI*; Selker et al., 1991) is a simple algorithm that combines seven variables that can be collected upon initial contact with the patient and provides a probability of acute cardiac ischemia. This decision aid can be incorporated into a digital program or hand calculated; either way, it simplifies the decision process of whether a patient should

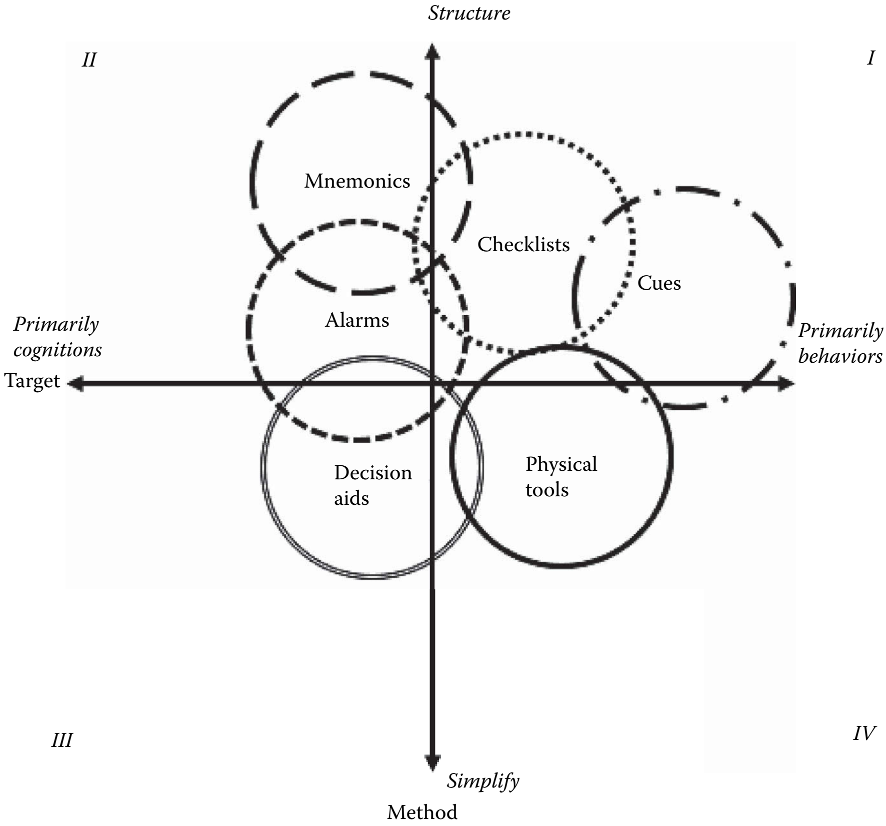


**FIGURE 9.1** A visual heuristic of cognitive aids and their methods and targets. Overlapping circles represent potentially useful pairings of cognitive aids.

be admitted or triaged. EMS using this DSS need not know or be trained on the math or research that led to the development of the TIPI, nor could they be more effective without this cognitive aid. As such, the TIPI should and many other decision aids simplify cognition and allow EMS to rest upon the work and research of many others in order to rapidly deliver the best and most appropriate care.

Physical tools are primarily located in quadrant IV because they focus primarily on simplifying behaviors. The preloaded bougie (Baker et al., 2015), for example, is designed to optimize the process of endotracheal tube (ETT) placement and is one of many similar ETT introducers. Bougies are a general tool designed to supplement visualization or to overcome patient factors that make ETT introduction difficult by providing a guided path upon which the ETT can be sent into place. For EMS, this multistep process has been simplified through the design of preloaded bougies, upon which the ETT is already placed. This not only reduces the number of steps required to complete the task, which could save critically important seconds in an emergency situation, but can also reduce the chance of human error and provider stress under the pressures of said emergency situation. Despite the utility of physical tools, EMS should know how to complete the task without the benefits of simplification so that in situations where the aid is unavailable or malfunctioning, the task can still be completed.

## TRAINING USE OF COGNITIVE AIDS

Maximizing effectiveness of any implemented cognitive aids requires proper training (Marshall, 2013), as it familiarizes users with the aids' purpose, method of use, and utility. Salas et al. (2012) note that the design of the training can improve (or hinder) knowledge, skills, and/or attitudes. Trainees must be provided with instruction, demonstration, varied opportunities to practice, and feedback regarding their practice and performance (Salas & Cannon-Bowers, 2001; Aguinis & Kraiger, 2009; Salas et al., 2012). Effective training requires information that is provided in an engaging manner, relevant demonstrations that include examples of good and bad behaviors (Baldwin, 1992), and job-relevant practice opportunities (Salas & Cannon-Bowers, 2001). Specific to cognitive aids, presentation of information should include the problem that the aid addresses (typically the speed–accuracy trade-off), appropriate uses, and limitations. Demonstration requires proper use of the aid and the targeted behavior in a job-relevant context. Practicing aid use and learned behaviors can occur in simulation or on the job and requires varied opportunities to explore various methods of interaction. Regardless of practice context, timely and relevant feedback must be provided by an expert (Salas et al., 2008). Trainers should explain the utility of the cognitive aid as it relates to EMS to enhance transfer of skills (Alliger et al., 1997). This information can be garnered from an appropriate training need analysis that takes into consideration the purpose and ultimate goals of the training session (Salas et al., 2012). With regard to cognitive aids in EMS, consideration of which quadrant houses the targeted cognitive aid can facilitate this process (see Table 9.3).

### TRAINING QUADRANT I

Focusing on quadrant I, aids primarily designed to structure behavior have specific needs with regard to practice. Information provision should focus on detailing the utility of the aid, when it is and is not appropriate, and how it fits into current cognitive structures (e.g., other aspects of a larger training program). Demonstration should include both proper and improper uses (Baldwin, 1992), given that these aids tend to be fairly flexible but have only one best method of use. Unlike many other cognitive aids, however, those that lie primarily in quadrant I are designed for specific circumstances, and thus, practice should occur within these situations or should target these specific situations alone. It has been shown that varied practice yields better results than simply overlearning a skill in one situation (Machin & Fogarty, 2003), but given that there is only one (or perhaps a handful) of situations in which this cognitive aid will be used, dramatically varying unnecessary uses is rather fruitless. Instead, varied practice should focus more on adaptability and how to proceed to use the aid properly if certain aspects of the task or environment proceed unexpectedly.

**TABLE 9.3**
**Training Cognitive Aid Use by Quadrant**

| | Information | Demonstration | Practice | Feedback |
|---|---|---|---|---|
| Quad I | • Necessity of the aid<br>• How it fits into cognitive structure | • Proper and improper uses | • Varied conditions<br>• Only target relevant situations | • Focus on promoting use of these aids<br>• What went well and what did not |
| Quad II | • Distributed overlearning | • Walk-through cognition<br>• Less necessary | • Distributed opportunities to recall learned structure | • Focus on promoting use of these aids<br>• What went well and what did not |
| Quad III | • Necessity of the aid<br>• Do not overcomplicate | • Proper and improper uses<br>• Task without use of the aid | • Varied situations and conditions | • Focus on promoting use of these aids<br>• What went well and what did not |
| Quad IV | • What behaviors it is simplifying<br>• Why and how it is should be used | • Proper and improper uses<br>• Task without use of the aid | • Varied situations and conditions | • Focus on promoting use of these aids<br>• What went well and what did not |

For checklists, the practice aspect of training should focus on adhering to each step or acknowledging each item on the checklist regardless of the situation. For example, the *Necessary*, *Enough*, *Working*, *and Secure* (Schoettker et al., 2003) checklist was designed for advanced trauma life support, providing workers with a reminder to check and record problems with the airway, breathing, circulation, etc. This checklist is typically used for patients who experience road trauma, falls, or violence. Each patient should receive the same overall checks, but the differences between each type of patient and their situation necessitate adaptation in some capacity. Adaptability, in this sense, can certainly be trained and prepared through practicing in varied contexts. This ensures that the procedure (i.e., structure of the behaviors) remains consistent regardless of dynamic, unique, or challenging situations.

Cues similarly require varied practice to be maximally effective. The efficacy of a cue is dictated not only by the degree to which the appropriate behavior is learned through training but also by the ability for the reminder to activate behaviors in the moment. Take the *level 1 MI protocol* (Henry et al., 2005), for example, that provides guidance regarding how to appropriately stabilize and transfer patients with potential myocardial infarction to the *Minneapolis Heart Institute*. This protocol is printed on posters in emergency departments of all local hospitals, as well as on index cards that are distributed to area EMS. Individuals need to be trained not only to respond to the rare occurrence of myocardial infarction through the effective and accurate use of this cue but also to recognize situations in which this cue is relevant. Only through varied practice (situations and patients) can EMS learn the latter, while the former should proceed according to the cue and trained behavior regardless of the situation.

## Training Quadrant II

Shifting focus to quadrant II, which houses all cognitive aids that seek to structure cognition, we find that training these aids requires overlearning of information. Given that the purpose of this type of cognitive aid is to change the manner in which the user thinks, it makes sense that training the use of these aids should primarily focus on long-term cognitive changes. The best way in which a training program can permanently affect cognitive structure is through distributed overlearning (Rohrer & Pashler, 2007). Further, given that behavioral changes are not the primary, but rather secondary, target for these aids, a heavy focus on demonstration and practice is not necessarily warranted, nor practical. Demonstrations that do occur should include walk-throughs of elicited cognition, so as to help create cognitive structures that can be refined at a later date. Alarms, for example, are only as effective as the cognition that they elicit, and unidentified alarms are problematic. Training should focus on alarm exposure to ensure that EMS can identify each type. Alarms that have been undertrained can be a distraction, forcing the provider to determine the cause of the alarm instead of focusing on the task. Alarms that have been overtrained can elicit a cognitive structure immediately, without significantly distracting the care provider, instead automatically initiating a response. Take the different alarm patterns of a pager-based alarm system such as that proposed by Russek (1994) and that of the user's mobile phone. Both are silent and rely upon vibrations, but through repeated exposure, the user has overlearned which vibration patterns indicate that a patient needs emergency medical attention and the other indicates the arrival of a text message.

Mnemonics, too, must be overlearned through distributed rehearsal. The extent to which a mnemonic is effective depends on the ease with which it is used. Many mnemonics exist to target a variety of cognitions (e.g., SBAR, *Introduction*, *Situation*, *Background*, *Assessment*, *and Recommendation* [*ISBAR*], *GRIEVING*), but each mnemonic is designed to simply provide the user with a structure upon which cognition can be organized. These mnemonics need to be overlearned; otherwise, the user will exert effort trying to remember the mnemonic, which is only a mechanism, not the outcome. For example, when transitioning a patient to new care, the EMS provider should automatically be prepared to follow SBAR or ISBAR rather than trying to remember what mnemonic to use and what each letter represents. Instead, the mnemonic should structure how cognitions are activated, organized, and communicated. This can be achieved only through overlearning, repeated exposure to the mnemonic, and extensive rehearsal. There are many mnemonics that an EMS provider must memorize, but each is useful in its own settings, but even the rarely used mnemonics need to be readily activated.

## Training Quadrant III

Cognitive aids in quadrant III are designed to simplify cognition. In order to do so, it is imperative that users are given ample opportunities to practice using the aid.

Unlike cognitive aids in quadrant I, those in quadrant III should be trained in a much more varied manner, allowing the user to explore the aid and how it can benefit him/her. It is difficult to dictate how a cognitive aid should simplify the user's cognition, given the variability between individuals in cognitive structures. However, if the user is given ample opportunities to explore how the cognitive aid can most effectively supplement the current cognitive structure, perhaps by bypassing certain steps, or entire processes, then the aid becomes exponentially more useful to the individual user. Further, information regarding the aid should include simply how the aid can be helpful and reduce the burden of the task, as well as how to properly use the aid. There is no need to explain how the aid works given the purpose of simplifying cognition, not making them more complex. Demonstration should include proper and improper uses of the aid and potentially what task execution would look like without the aid to impart perceptions of utility.

The primary cognitive aid type in quadrant III is DSSs. This type of cognitive aid typically converts a large amount of input into a single output, but the number of potential outputs is often vast. Flow charts, for example, rarely lead to one conclusion but rather help guide the user through a series of hurdles to one of many potential outcomes. Only through varied exploratory practice can individuals truly grasp the potential uses of the flow chart and how it can supplement or replace certain aspects of their cognitive processes. Digital DSSs are even more reliant upon varied exploratory practice given their seemingly limitless outputs. If users are not comfortable with the interface, something that can be trained through varied experiential learning and practice (De Freitas & Oliver, 2006), then they will be less likely to use the DSS, and thus, it loses its efficacy. Furthermore, through varied experiential practice and feedback, with the DSSs, the user may develop a generalized sense of efficacy with the aid, thus increasing the likelihood of use in a variety of situations.

## Training Quadrant IV

Cognitive aids located in quadrant IV are targeted at simplifying behaviors. Information provided about the aid should include which behaviors it is simplifying, why, and how. This should help increase buy-in as well as help to create a mental model regarding how the aid can be used on the job. It is also imperative that information and feedback clarify proper and improper uses. However, it has been shown that for behaviors in which there is only one correct method of execution (e.g., using an EpiPen), it is more effective to show only the proper technique and to not demonstrate improper use. Practice should be accompanied with timely feedback that again clarifies what practiced behaviors were correct and in-line with the proper use of the cognitive aid and which behaviors need to be altered in order to better use the aid.

Physical tools are the primary type of cognitive aid in quadrant IV and as such should receive specialized training focusing on proper use. Whether the physical tool is a breathing bag, a preloaded syringe, or a calculator, it is imperative that the user knows exactly how to use it. Almost always, there is only one proper way to use a physical tool. Certainly, context may dictate variations in this behavior (e.g., varying placement of the electrodes of an automated external defibrillator on an infant, versus a child, versus an adult), but there is still only one correct way to use the aid.

By demonstrating proper use and providing feedback on the EMS provider's usage of the aid, training can help ensure accurate and speedy usage and, ultimately, delivery of care.

## FINAL CONSIDERATIONS FOR COGNITIVE AIDS IN EMS

Practice and theory alike have suggested that various cognitive aids should be helpful in providing EMS with a way in which to increase both speed and accuracy. Yet consistent findings regarding the efficacy of cognitive aids in EMS remain elusive. Unlike many other high-performance fields such as aviation and nuclear safety, EMS includes a diverse population of practitioners, environments, and tasks. It is, therefore, necessary to abandon the notion of "one size fits all" when it comes to cognitive aids for EMS and to understand how to address unique problems in the field. This chapter provides a brief overview of the plethora of cognitive aid types as well as a visual heuristic with which EMS and managers can begin to discuss cognitive aids in a systematic way. Future research needs to look at the incremental effects of pairing cognitive aids (e.g., combined alarms and physical tools), as well as any potential trade-offs that may occur when using multiple cognitive aids at once.

Using the previous information, EMS and managers should be better able to implement cognitive aids or pairs of cognitive aids to address certain work tasks, depending on the unique demands. Further, by better understanding the scope and purpose of each cognitive aid, EMS managers can better provide training to ensure that cognitive aid-based interventions are maximally effective. Ultimately, we suggest that cognitive aids provide a unique and underutilized solution for EMS, facing overwhelming demands on their time and abilities.

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