# Mental Practice: Applying Successful Strategies in Sports to the Practice of Emergency Medicine

John E. Schneider, MD*; Maxwell Blodgett, MD; Spenser Lang, MD; Chris Merritt, MD, MPH; Sally A. Santen, MD, PhD

*Corresponding Author. E-mail: schneider@wustl.edu.

Emergency physicians are expected to learn and maintain a large and varied set of competencies for clinical practice. These include high acuity, low occurrence procedures that may not be encountered frequently in the clinical environment and are difficult to practice with high fidelity and frequency in a simulated environment. Mental practice is a form of a cognitive walk-through that has been shown to be an effective method for improving motor and cognitive skills, with literature in sports science and emerging evidence supporting its use in medicine. In this article, we review the literature on mental practice in sports and medicine as well as the underlying neuroscientific theories that support its use. We review best-known practices and provide a framework to design and use mental imagery scripts to augment learning and maintaining the competencies necessary for physicians at all levels of training and clinical environments in the practice of emergency medicine. [Ann Emerg Med. 2024;84:159-166.]

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## INTRODUCTION

Emergency physicians and professional athletes work in high pressure situations. Although the stakes differ drastically, there are training, psychological, and performance aspects of our professions that are similar. In sports psychology, there is growing research on the effect of a strategy called "mental practice" that is beginning to spill over into medical education research that can inform the practice of emergency medicine (EM).

Core to the practice of any specialty are those competencies, including diagnoses, problems, and skills, that all physicians should be prepared to manage or perform. Especially important in EM, the mandate of which remains being prepared for "anything, anytime, anywhere," is the achievement and maintenance of competency in those potentially lifesaving skills that are high acuity, low occurrence. Examples of these high acuity, low occurrence skills abound, particularly with respect to procedural competencies. Take, for example, transvenous cardiac pacing as a skill within the EM repertoire. This skill requires preparation, anticipation of needs, teamwork, and specialized equipment and abilities. No emergency physician should be tasked with considering this procedure for the first time in a critically ill patient, yet it happens infrequently enough that this may well be the case. To learn safely may initially depend on highly resource-intensive instruction in a safe, simulated setting that brings learners to sufficient competency.[1] Not all emergency physicians have readily available access to task trainers, simulation centers, team-based instruction, or adequate time to achieve this level of learning. However, even if EM learners are brought to competence through such costly means, to rely on these high acuity, low occurrence events occurring often enough in practice even to maintain these core competencies is insufficient and irresponsible. It is here, in the learning, anticipation, achievement, and maintenance of competencies, that mental practice may hold promise. Reading or passive learning modalities, such as videos or podcasts, are convenient and inexpensive, but relatively lower yield compared to active learning modalities.[2-4] Dedicated simulation to achieve mastery may be effective, but the cost, time, and relative inaccessibility restraints may limit its use for emergency physicians. Virtual reality is an emerging modality for medical education, but its current role also might be limited given the cost and ability to access the appropriate equipment and software.[5] A middle ground that is engaging in preparation, but less resource-intensive, is necessary to fill this competency maintenance gap as well as learning newly emerging procedures and skills.

Mental practice is defined as the cognitive rehearsal of a task without physical movement.[6,7] There are concepts that overlap with mental practice and have been described in the medical literature, such as reflection, reflective learning, stress inoculation, cognitive offloading, relaxation, breathing, focusing exercises, self-talk, and others.[8,9] For our purposes, we will consider mental practice to be a deliberate process of imagined performance of an event or procedure with a focus on mental imagery, imagined kinesthetics, and emotions of a situation or event. If learners and practitioners can train to use mental practice techniques, and such techniques are honed and perfected, then competency may be preserved through high-value educational practices available "anywhere, anytime." Here, we review some of the evidence in support of mental practice in sports, highlight the transition to its use in medicine, discuss the neuroscientific foundation of these theories, and finally propose a framework for developing mental practice schema for emergency physicians.

## EVIDENCE IN SPORTS

Unsurprisingly, sports literature on mental practice indicates that physical practice of a skill is the ideal form of practice as it results in faster mastery of physical skills.[10,11] However, like many situations in medicine, physical practice may not always be possible due to weather restrictions, fatigue, injury, or the prohibitive cost of training equipment, to name a few. Successful research in the domain of mental practice has been conducted in sports for decades and has led to important lessons that can be applied to training in emergency medicine.[7,11,12]

The results indicate that mental practice can improve outcomes in "closed-skills" sports scenarios, such as a gymnastics routine or canoe slalom racing, or a specific closed skill within a sport, such as a golf, basketball, or hockey shot, as well as "open-skills" sports that have a constantly changing environment, such as football or wrestling.[10,13-18] The research suggests that mental practice is more useful in sports or skills that have a larger cognitive component compared to tasks that are purely physical.[7,11,19] For example, consider the factors that go into taking a chip shot in golf from a sand bunker onto a sloping green and the skills needed to place a working intravenous cardiac pacemaker for a symptomatic bradycardic patient. Each requires a larger cognitive load due to the visuospatial and anatomical haptic variables compared to other examples, such as a shot in a darts game or placing a peripheral intravenous catheter.

A recent meta-analysis of the evidence for mental practice in sports summarizes the data that can be applied to EM.[11] Mental practice has been shown to be used more often by experienced and expert athletes compared to novices.[10,11,20] This is particularly true for novices who have not yet learned a specific skill.[11] The duration of an effective mental practice session is likely somewhere between 20 to 30 minutes, which fits with known literature in memory, retention, and cognitive fatigue.[11,21] Reflecting themes in spaced repetition and deliberate practice, the literature suggests greater benefit from repeated and deliberate use of mental practice techniques that are repeated in a time interval more than one week compared to a single episode.[11]

## NEUROSCIENCE LITERATURE

Recent research in the neuroscience field is establishing a framework and foundation for why and how mental practice can improve both cognitive and physical performance, with important implications for clinicians and educators alike. Prevailing theories that support the use of mental practice fall in the category of "motor cognition" research in the neuroscience community.[22] Motor imagery is a necessary step in the process of motor execution. In fact, imagery is the necessary first step in the motor execution process by which an individual evaluates the feasibility and potential actions as anticipatory predictions (Figure 1). The next step includes the physical execution where motor imagery is compared with sensory feedback and motor neuron activation that follows.[22-26]

One example of a simple motor action, typing speed, has shown that experts visualize and prepare for future keystrokes they have yet to perform.[27] A similar explanation helps demonstrate why the rapid reactions of expert athletes are not solely due to the greater speed of their nerve signals and actions, but also their ability to better anticipate future situations and events from surrounding cues.[28] For example, a study showed that tennis experts were better able to predict where another

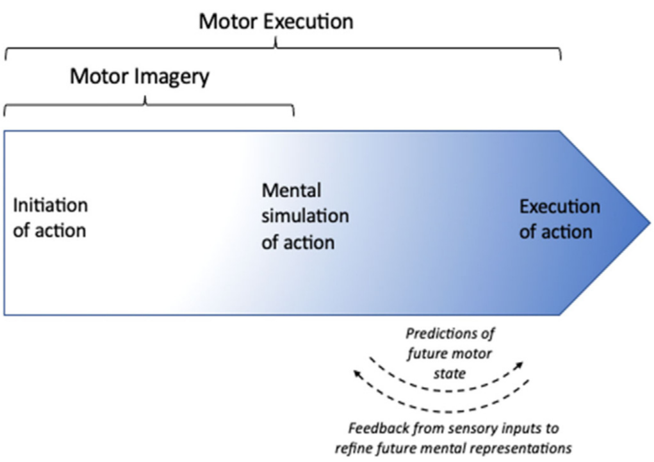


**Figure 1.** A model of motor execution. Mental practice makes use of the innate intermediate step of visualization that occurs when we perform actions. Motor imagery refers to the use of mental practice as applied to motor actions and shares an overlapping neural framework with motor execution. Motor imagery is a necessary intermediate step in the execution of actions. The mind predicts the body's future physical state after an action is executed. Feedback from the actual final physical state is then compared with the predicted final physical state to refine future mental simulations. When one undertakes mental practice, they are making use of this pre-existing framework.

tennis player's serves and shots will land even before the opposition's racquet has hit the ball, thus informing future motor actions.[29] Mental practice can improve future motor performance by fine tuning this process, resulting in more effective predictions and motor execution in the future.[24] Similar processes occur in medical procedures.

The neural underpinnings of mental practice have been robustly studied as well.[30-32] Functional neuroimaging studies have identified overlapping areas of activation during both mental practice and motor execution, implying shared neural correlates.[31] Frontal and parietal cortical regions, subcortical regions, and the cerebellum are consistently activated in both motor imagery and motor execution. Lesions in these regions—whether that be from stroke, movement disorders, or induced in transcranial magnetic stimulation studies—can result in the impairment of both processes.[30-33]

A meta-analysis in this field shows similar themes as the sports literature research, providing additional validity evidence for mental practice. In aggregate, mental practice interventions tend to have positive moderate effects on performance, although mental practice does not surpass the effects of physical practice.[7] Other similarities include novices with at least some experience benefiting more than those with more experience, an optimal mental practice length of approximately 20 minutes, greater improvement in tasks that contain relatively more cognitive components, and spaced repetition of mental practice techniques improving outcomes.[7]

## HEALTH CARE LITERATURE

Although perhaps not as extensively studied as in the sports world, the health care literature provides some insight into the use of mental practice in medicine. Areas of study most often divide assessments of outcomes of mental practice between technical skills (ie, laparoscopy, suturing) and nontechnical skills (ie, resilience, teamwork, confidence in ability).

The use of mental practice to acquire or improve technical skills has been evaluated most thoroughly in the surgical literature. Multiple studies have shown improvements in skill acquisition in various areas, such as performing cricothyrotomies, laparoscopic suturing, bronchoscopies, and hysterectomies.[34-37] A 2015 meta-analysis evaluated 9 different randomized controlled trials, with 5 studies showing favorable results for mental practice and 4 having neutral results.[38] The conclusion suggested that mental practice provides the most benefit when run parallel to physical practice and when used with physicians who have some baseline knowledge of the skill being taught. Two additional studies also show similarly that novices tend to benefit more than experienced clinicians when using mental practice.[6,37] Further studies demonstrated improved retention of surgical skills when residents transitioned from simulators to the operating room after formal mental practice training.[39] Another study employed mental practice for cataract surgery during COVID-19, when most operating rooms were shut down. They found that using this mental practice script improved surgeon confidence and decreased anxiety about performing this surgery after a lengthy time off.[40]

Outside of technical skills, mental practice shows promise, although with some mixed results in the literature. Mental practice has been shown to improve stress response, theoretically leading to improved outcomes.[41] Another studied aspect of mental practice in nontechnical skills is within teamwork and team performance. A systematic review in 2020 found that out of 8 studies evaluating mental practice in mostly simulated scenarios, only 3 demonstrated benefits within nontechnical areas, whereas most studies demonstrated improved technical performance.[42] However, there was high variance in the type of mental practice used. Only 2 studies included team performance-specific mental practice, and both showed efficacy.[43,44] Further reviews again show promise of mental practice on immediate nontechnical skills but fail to look at longevity or future behavioral change.[45] In summary, mental practice plays a role in improving nontechnical skills, inducing team performance and stress inoculation; however, results are highly dependent on the method and timing of mental practice training and use.

## BEST PRACTICES FOR MENTAL PRACTICE FOR EMERGENCY PHYSICIANS

Given the evidence presented above, mental practice is likely an understudied and potentially underused education strategy for emergency physicians. The evidence does not suggest that it is superior or even equivalent to clinical experience and active learning strategies, such as simulation or using task trainers for physical practice of a skill. However, these active learning strategies are not always feasible and can be cost prohibitive, inaccessible, and inefficient for large groups of learners to practice spaced repetition in short intervals. Mental practice could be very useful in augmenting both passive and active learning strategies. This is particularly true for the retention of knowledge and skills necessary for high acuity, low occurrence procedures; events where reproducing the physical skills in a realistic manner is difficult to achieve;

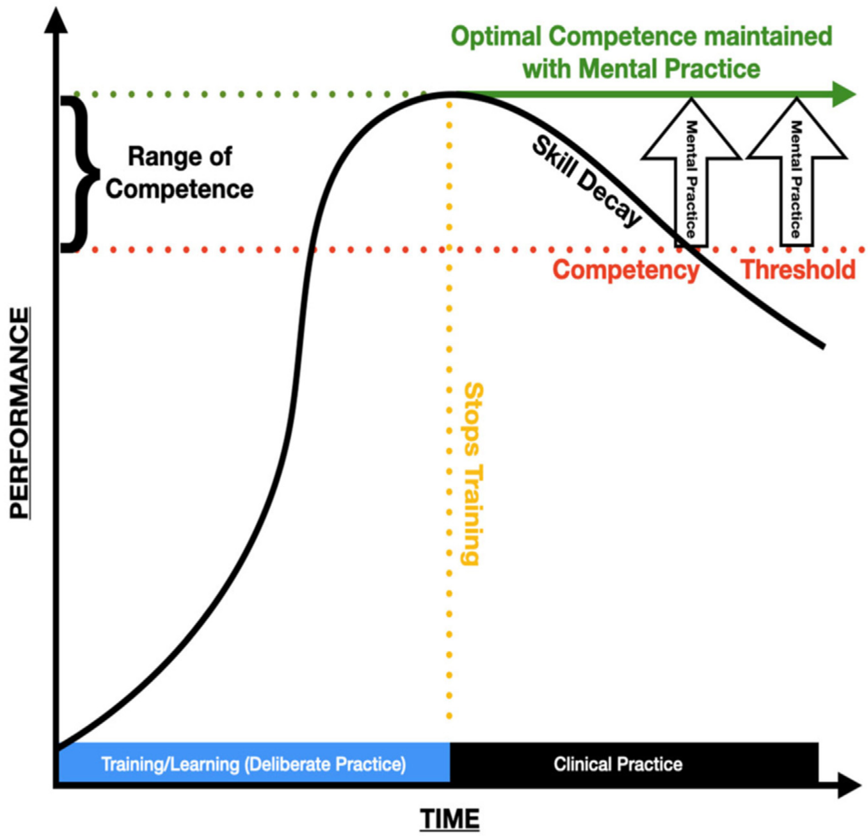


**Figure 2.** The role of mental practice and spaced repetition in ameliorating skill decay. Skill decay occurs after training is complete such that one's skills might fall below the competency threshold. Mental practice can be used with spaced repetition to maintain skills at an optimal competency.

skills with a high cognitive component; emotionally charged events; or events when new skills and procedures are required for clinical practice. Consider, for example, the utility of mental practice for learning and maintaining skills to be a competent provider capable of performing a fiberoptic, nasal-tracheal intubation; providing a new regional anesthesia plane block; running a neonatal resuscitation; or performing a transesophageal echocardiogram. The utility and range of applications has exciting potential for trainees in residency and the seasoned community or academic physician alike.

Pulling from the motivation change field, there are 4 stages in the process for physicians as they address their potential subpar competency: contemplation, planning, action, and maintenance. First is *contemplation;* physicians need to step back and acknowledge that they are no longer competent or need to refresh their knowledge and skills and determine that it is important for them to address the deficit. Once the physicians have determined it is important to refresh the skill, they will begin the *preparation* phase by refreshing competency in the skill, which is where mental practice is useful. The next stage of change is *action* where the emergency physician takes on the plans for increasing or sustaining competency and then developing a habit or routine for *maintenance.* Pusic et al[46] described the role of deliberate practice on maintaining

I advance the needle, watching the needle tip as it advances towards the hyperechoic transverse process, and I feel a firm resistance of the needle hitting the bone. I then pull back slightly so that the needle tip is seen adjacent to the transverse process, I ask my assistant to aspirate to ensure my needle is not in a blood vessel. There is no blood return through needle into the extension tubing, so I ask my assistant to administer 1-2ml of anesthetic for a "test hydro-dissection." I watch as the dark, hypoechoic fluid coming out of the tip of the needle begins to lift the more hyperechoic erector spinae muscle off the surface of the hyperechoic transverse process. This confirms my needle tip is in the correct location.

**Figure 3.** A sample of a portion of a mental imagery script for an erector spinae plane block. The colors represent visual (red), kinesthetic (green), and cognitive (yellow) cues meant to enhance mental imagery when reviewing the script.

**Table.** Application of the PETTLEP model to rehearsal of cricothyrotomy.

| Element | Description | Example |
|---|---|---|
| Physical | Mental practice can occur entirely within one's mind. However, active physical involvement by performing physical movement or holding instruments should be used whenever possible to supplement mental imagery with motor imagery. | As you rehearse, physically use your nondominant hand to grasp an imaginary cricothyroid membrane and feel yourself holding the scalpel between your thumb and index finger of your dominant hand. If you have a scalpel nearby, you may hold it during this step of the procedure. |
| Environment | Environmental cues should be specific to the physical environment in which the skill should be practiced. | Envision yourself at the head of the bed in the resuscitation bay of your emergency department as you perform the steps of the procedure. You may even undertake mental practice in the resuscitation bay itself for added fidelity. |
| Task | Different task characteristics require points of emphasis. Some tasks are inherently more visual, kinesthetic, or cognitive. Imagery should be aligned with these task characteristics. | As you approach the patient, visualize your target of the cricothyroid membrane, the soft indentation between the prominent thyroid cartilage superiorly, and the cricoid cartilage inferiorly. In your mind's eye, feel for the discontinuity in the cartilaginous structures with your dominant forefinger. |
| Timing | Timing of the task should be the same in rehearsal as in real life. Realistic tempo and relative timing during mental practice can result in more consistent performance. | Perform all of the mental steps of the cricothyrotomy from gathering of materials to passage of the endotracheal tube in sequence and in a timed manner. Do not speed up or slow down procedural steps to allow for a realistic mental depiction of the procedure. |
| Learning | Imagery should dynamically adapt to reflect changes in individual performance. As one becomes more fluent in a procedure, mental representations of steps of the procedure may evolve. | The balance of imagery may skew toward kinesthetic elements in a novice and on more cognitive elements in a more mature learner. Regularly review of the mental practice script to ensure it is correctly targeted to one's stage of learning and actual practice. |
| Emotion | Heightened emotions result in autonomic responses that have both psychological and physiologic impacts on procedural performance. Efforts should be made to simulate these emotions so that one may optimize performance in light of them. | You are called urgently into the room by your usually even-keeled charge nurse, an unsettling change in demeanor. As you walk into the patient's room, you can immediately feel the worry of the patient, emergency medical services, and nursing as you see the patient's facial swelling. You feel your heart racing through your chest as you are hit by the gravity of the patient's critical illness and the urgency that you must rapidly act to save their life. |
| Perspective | Imagery may occur through both first person (imagining oneself) or third-person (looking as an observer in the room) frames. The first person frame should be used to elicit physiologic responses, such as a heightened stress response, to maximize verisimilitude of simulation. | Imagine yourself, rather than someone else, performing the procedure. As you work through the procedure, think about how you would perform and react to each step along the way. |

competency; mental practice may prevent or slow the loss of competency (Figure 2).

One form of mental practice that has been shown to be effective in medicine is the use of mental imagery scripts. Mental imagery scripts were developed from research on expertise that uses a technique called "verbal protocol analysis."[47] This process involves combining and coding interviews of "content experts" into a unified script that can be reviewed at any time.[6] The medical literature includes examples of mental imagery scripts with validation evidence that are color coded to cue readers into the visual, cognitive, and kinesthetic aspects of a procedure.[6,37] Figure 3 shows an example of this for an erector spinae plane block. One issue is that there are not preexisting scripts for most EM procedures or scenarios, so emergency physicians would need to create and provide validation evidence for them.

One model of developing mental imagery scripts has shown promise in a variety of fields of research.[10,48-54] This strategy is called Physical, Task, Timing, Learning, Emotion, and Perspective (PETTLEP), which was developed based on the neuroscientific models with the intention of addressing a lack of methodological rigor in mental imagery script development.[55,56] The acronym relates the components that should be included when developing mental practice techniques: *P*hysical, *E*nvironmental, *T*ask, *T*iming, *L*earning, *E*motion, and *P*erspective components.[49] The Table shows these components and how they might be implemented for a cricothyrotomy.[48,49]

We encourage emergency physicians to use content experts and best-known practices to develop and maintain a bank of mental imagery scripts for emergency physicians to access, just as we do for articles and podcasts, as an important resource of learning and maintaining various competencies that are vital in the practice of EM. We could review a mental imagery script before every shift or create individualized schedules for spaced repetition of high acuity, low occurrence procedures (and others) based on one's needs. Mental imagery scripts for new or unfamiliar procedures, such as performing a transesophageal echocardiogram or a regional plane block, could be reviewed frequently, adjusted for practice setting and equipment variations, and tapered off as the user felt more comfortable performing these in the clinical environment. Much like how athletes use cognitive walkthroughs before events, mental practice could become routine in our practice.

Mental practice has been shown to improve performance; however, mental imagery scripts need to be developed further in EM. Emergency physicians should acknowledge that their skills and knowledge decay, especially when there is not sufficient opportunity for spaced repetition and deliberate practice. This is often the case for high acuity, low occurrence or novel procedures. An approach for addressing these deficits is necessary, and mental practice could play an important role. As mental practice is implemented it will be important to include deliberate research methodology using proven imagery techniques that incorporate best practices, such as PETTLEP and spaced repetition in 20 to 30 minutes segments, to specifically address technical and nontechnical skills. Additional study is necessary including but not limited to the use of qualitative and iterative research approaches for richer data, considering the details and barriers for implementation in clinical practice, evaluating patient-centered outcomes, identifying what procedures and events mental practice is most effective for, considering what scripts are best for each "level" of learner, and determining how best to harmonize mental practice with other proven teaching and learning modalities.

The existing evidence in sports and the medical field that is supported by the neuroscience literature points to a potentially untapped opportunity for mental practice to augment how emergency physicians of all experience levels and practice environments learn, prepare, and prevent knowledge and skills decay. Anders Ericsson said it well when he wrote, "the key challenge for aspiring expert performers is to avoid the arrested development associated with automaticity and to acquire cognitive skills to support their continued learning and improvement."[57] The early data suggest that mental practice could be an efficient and successful strategy for the challenge of acquiring and maintaining the everexpanding list of competencies that make the practice of emergency medicine both so challenging and so rewarding.

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*Author affiliations*: From the Department of Emergency Medicine (Schneider), Washington University in St. Louis, St. Louis, MO; the Department of Emergency Medicine (Blodgett), Christiana Care Health System, Newark, DE; the Department of Emergency Medicine (Lang, Santen), University of Cincinnati, Cincinnati, OH; and Pediatric Emergency Medicine, The Warren Alpert Medical School of Brown University (Merritt), Providence, RI.

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