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Mental Rehearsal and Scripting: Understanding the Mechanism, Deliberate Practice and Learning Styles Association to Meet the Mental Demands of Emergency Medicine

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Abstract

*In the practice of Emergency Medicine **(**EM**)**, there is a need for quick thinking, fast decision-making as well as rapid, decisive interventions and procedures for patients presenting with a wide spectrum of emergent problems. Emergency physicians **(**EP**)** must acquire, maintain and sustain their competencies in numerous high stakes, time dependent procedural skills and techniques. Simulation-based training has become commonly employed for up-keeping and updating skills, both technical and non-technical. This is short of having the opportunities to perform these procedures and skills on actual, real patients. Some of these procedures are common, 'bread and butter' ones, whilst others are rare and hard to come by.*

*Mental rehearsal **(**MR**)** and scripting is an intellectual, cognitive process of 'simulating' tasks and procedures in our minds without actually performing them physically. It is a technique widely used in surgical disciplines, elite sports training, aviation industry, military and many others. MR is suited for EPs, given the spectrum of skills they have to master as well as their job description, which can be stressful, fast-paced and very hectic. MR has been shown to improve focus, keep practitioners calmer, enhance ability to maintain self-confidence, composure, attention and precision. It helps practitioners maintain a certain level of preparedness, very similar to what is needed in highly competitive, elite sports. This paper shares some relevant facts on MR, how it is applicable for deliberate practice, the underlying neural mechanisms as well as the clinical steps involved.*

In the future practice of EM, the use of technology will continue to increase and be integrated into EPs work processes. The demand for training will follow the same trajectory and MR can become a valuable training tool or supplementary training tool, as relevant. With more artificial intelligence guided procedures and their incorporation into digital EDs of the future, delivering visual and auditory cues, coupled with the use of MR can be an impactful, value-added 'investment' for EPs to maintain competence and mastery in the armamentarium of skills and procedures they need to know and perform.

***Key words**: mental rehearsal, visualization, visual cues, technical and non-technical skills, emergency physicians.*

Introduction

The Practice of Emergency Medicine

The practice of Emergency Medicine is extremely fast-paced, dynamic and requires a unique thought process as well as mental model of practice. There are very rapid developments and changes happening all the time. It is also the practice of frontline Medicine, with a lot of quick thinking and decision-making as well as the need for rapid interventions and procedures. There are many complex, clinical events happening all the time, 24 hours a day, which require systematic prioritization, proper resource utilization and management. **(**1-3**)** As a result of this, Emergency Physicians **(**EP**)** must be extremely familiar and comfortable with the performance of many multi-faceted procedures, which requires skills, talent, familiarity, precision and confidence. They would need to have deep understanding of the procedures and skills involved as well as be able to negotiate the current climate of inter-professional collaborative practice which takes place in many state-of-the-art Emergency Departments. As they deal with 'life and death' situations daily, they must be able to establish priorities, be decisive with limited information available and have a large breadth of knowledge with significant depth. In short, EPs must achieve, maintain and sustain their competence in numerous procedural skills, many of these are high stakes and time-dependent. **(**1,4**)**

To flourish in such a dynamic environment, it is a must for the EP to be nimble, to upkeep their skills and knowledge as well as know that even the rare procedures require their expert inputs very quickly. For maintaining skills and practicing for rarer events and procedures, EPs are often involved in training using simulation. Example of these would include preparing for the Emergency Department Thoracotomy **(**EDT**)** or peri-mortem caesarean section. These cases are rare and only happens, may be once or twice a year in most EDs. However, on the occasion that it does happen and requires an EP to make the decision and perform it, it has to be quick. They need to be very familiar and preferably would have practiced it multiple times before, whether as a real case or in simulation-based learning. With increasing complexities of cases and high levels of stress, both individual and team-based processes can break down in the ED. Fixations can occur. 'Cognitive tunneling', or the exclusion of relevant diagnostic information due to other fixations can happen frequently. **(**4,5**)**

Mental performance of an EP is an important domain of consideration. It is made up of the psychological and cognitive factors involved in the EPs' ability to execute goal-directed behavior. Essentially, how EPs think, process information and manage emotional stresses, influence how they perform. One technique or option that EPs can prescribe to **(**besides the actual performance or

simulation-based training**)**, in order to maintain skills and upkeep competencies, is the use of mental rehearsal or scripting. The term "mental rehearsal" can be understood to mean practice in the absence of gross muscular movement. It is the cognitive rehearsal of a skill or procedure in the absence of any overt physical movement or action. It is thus all about 'thinking about it' and not actually performing it. **(**6,7**)** The term is often synonymously used with other terminologies such as; mental practice, mental imagery, warm-up imagery, mental scripting, visualization techniques **(**representation of an object or phenomenon, in its absence**)** or imagery practice, amongst others. It is a technique used to enhance the acquisition and retention of technical and procedural skills. It is equivalent to 'training technique', where specific steps are 'imagined' and rehearsed before the actual physical performance or action. **(**6-8**)** This is also highly relevant for surgical skills training for surgeons, imagery practice and visualization by elite athletes and mental practice by musicians. The terms describing it may be slightly different but it means the same practice. It is proven to be safe, cost effective and can be used by any persons who is aware, has been trained to use it and finds benefit from it. It can be used by both novices right up to the level of faculty development for upskilling and skills maintenance. It is even appropriate for both low and high stakes examinations preparation and for warm-up before actually performing any procedure or surgery. Mental rehearsal can be used on its own or as a prelude to performing the procedure/ skill, the latter represents a 'hybrid use'. **(**8-12**)**

Mental Rehearsal for Technical Skills and Non-technical Capabilities

Mental rehearsal inculcates the systematic use of mental imagery to "see and feel" an action, task or procedure. The visual representations in our mind can influence both mental and physical performance. This is imagined in the EPs' mind without engaging in actual play or physical movements. This has been shown to be an effective technique which can enhance actual performance, skills, outcomes and even success rates of procedures. This can be done individually, or in a supervised fashion for novice learners. In fact, mental rehearsal can also be applied for team-based activities and training. This is thus suitable for team-based learning and performance whereby visualization of how to act and function in a team is 'rehearsed' or practiced mentally. **(**6, 10-12**)** There are also studies which have shown that the use of mental rehearsal can expedite learning and knowledge acquisition, both technical and non-technical **(**8, 12, 13**)**

In sports, visualization has been shown to improve focus and attention, shape the attitude of athletes in a positive way, increase self-control abilities, helps athletes with goal setting, discipline and organization. It also helps them to attain certain level of preparedness, with their character being calmer

and more adaptable to stressful situation of the competitive sports. This is applicable to EPs as well in the practice of Emergency Medicine **(**14**)**.

Some examples of technical skills that can be trained using mental rehearsal include insertion of central venous line, endotracheal intubation, emergency department thoracotomy, steps in cardiac arrest management as per advanced cardiac life support algorithms, insertion of intra-osseous needle, donning and doffing personal protective equipment **(** PPE**)** and many others. Mental rehearsal can also be utilized in training for non-technical skills such as resuscitation and trauma team performance, inter-professional collaborative practice centred in the ED, communications skills as well as decision making algorithms/ pathways. Mental rehearsal can help establish team goals, set priorities and maintain situational awareness.

Deliberate Practice Mental Rehearsal

Mental rehearsal can be done repetitively, as many times as one wishes. This is deliberate practice and is one of the techniques used by elite athletes, replaying their game over and over again to ace and master every step. Each task can also be sub-divided into smaller steps to deeply analyze each stage. Doing this helps increase familiarity, by training our neural synaptic connections to reach the maximum firing, towards mastery. In the process of repetitive mental rehearsal, some people may come up with mnemonics to be used as 'memory jolt'. Experts, faculty and elite athletes review and mentally rehearse their steps again and again to see where changes and refinements can be incorporated. With this, the procedure, task or performance becomes assimilated into their 'working memory'. **(**8, 15**)**

Deliberate practice is also about consistently improving or getting marginal incremental gains and improvement with each repetition or practice. This is what helps athletes surpass their competitors, as this is where they may be 'pushed' somewhat outside their comfort zones. The same can also be said pertaining to the EPs medical skills and procedural capabilities; both technical and non-technical skills **(**eg. teamwork, communications, decision making**)**. It is also important to be clear that deliberate repetitive practice is not just about numbers but also the quality **(**of each practice session or experience**)**. It will also be more impactful if there is immediate feedback or inputs to highlight faults and wrong steps. This ties in with the repetitions being purposeful and not just aimed at overall, general improvement. It could be specifically targeted to cover the gaps and areas of lapses or weaknesses, which will have a more significant overall impact on procedure success or performance. **(**12-15**)**

For novices and young learners, mental rehearsal does not always guarantee great outcomes on its own. Supervision and guiding questions can be used to assist them to develop their 'mental scripts'. There are also options to blend in cognitive, visual, auditory and kinesthetic cues. These can be customized to the learners' predominant learning type. **(**11**)** When prescribing or recommending mental rehearsal, faculty should take into account the learning styles of their learners. This is to ensure the greater effectiveness of the techniques prescribed. Learners' preferences with their predominant learning styles are important considerations as the way learners structure content, form, use concepts, solve problems as well as integrate information are dependent on these. Their means of representation ie. whether predominantly visual, auditory or kinesthetic becomes a crucial bearing. If the learner thinks in images, their mental maps will hold a lot of information. The photographs, display or schematics help them to establish the relationships between ideas and concepts. This will affect the way they perform their mental rehearsal. For the dominantly auditory learners, they may need to hear narratives and recordings in a step by step fashion. Those using kinesthetic reporting systems tend to involve feelings and bodily movements. **(**11-13**)**

The usual steps involved in mental rehearsal are as follows:

1. Review and revision of cognitive aids
2. Reflection on prior experience, if any
3. Guidance by scripts **(**if needed, especially for novice**)**
4. Addition of 'fidelity' eg. standing up as it is often the way procedures are done in the ED. Some procedures are better done in a sitting position.
5. Performance in real-time **(**or in your mind**)**, with as many repetitions as needed

These steps can be repeated in cycles for learning and re-learning, especially for complex tasks.

The Mechanisms Postulated

Application of brain-medicine interface can assist our understanding of how new task acquisition and performance happens. The use of mental rehearsal techniques has been said to saturate the neuronal firing at the synapses and this is comparable to as if the person is actually performing the tasks or motor movements. There are also postulations that the brain activity during mental rehearsal, shifts from the left to the right hemisphere, in particular to the right upper quadrant of the brain. This is the area which is known to guide intuitive and more imaginative tasks. This idea is developed further with

the fact that mental rehearsal is grounded in the dual coding theory, which states that cognition has inputs from: **(**Fig 1**) (**10, 12, 13, 16-18**)**

a) Verbal and non-verbal activities and
b) Imagery and linguistic activities

Memory and recall is developed from a range of complex integration of stimuli and pathways. This is enhanced and strengthened when encoded by both a. and b. synergistically. **(**Fig1**)**

Mentally doing a task activates the same area of the brain as physically doing it. When looking at neural correlates, Nyberg et al reported changes in neural activity in the same area when doing a task mentally as well as physically.**(**13**) (**Table 1**)** However, they did note that different association areas were also activated during the two processes ie the mental imagery/ visualization activated areas in the visual cortex whilst the actual physical motor, warm-up activity activated areas in the motor cortex. This suggest that slightly different neural pathways are laid down during the two techniques. When mentally rehearsing techniques, there is firing of neurons that are responsible for skills acquisition. Researchers refer to this as "functional equivalence", whereby there is a strong overlap of neuro-sensory and neuro-motor pathways. **(**13**)** Mental rehearsal also speeds up the process of learning, in general. **(**16, 17**)** The details of the neural activities and conduction in the Initial Phase, Learning Phase and Automatic Phase of learning and acquisition with mental rehearsal, are summarized in Table 2. These phases learners have to go through are relatively similar in motor performance, observation of motor performance as well as mental rehearsal. In the Initial Phases, preparation, reading, watching videos and watching a demonstration are important. In the learning phases, moving on to the Automatic and Retention Phases, the learning gets further consolidated and strengthened. This means movement towards competency and mastery of skills. **(**Table 2**)** Mental rehearsal affects mental performance and can impact reaction times as well as decision making times. The visual memory created helps EPs recall information viewed and practiced, prior or in the past. **(**19-24**)**

What makes mental rehearsal powerful is the fact that it has been shown to make persons who practice it calmer and more adaptable to stressful situations. This is also very relevant for EPs and the practice of Emergency Medicine. It also has links to positive psychology; this is where it reverses the usual medical model of looking to diagnose and treat dysfunction, to one that seeks to understand the strengths and positive attitudes leading to success and positive outcomes. This remains an exciting area needing further research. **(**23, 25-27**) (**Table 1**)**

The Future of Emergency Medicine

Emergency Medicine will continue to evolve rapidly. It will remain dynamic. The patient load, numbers of elderly patients, complexities of cases and demand for emergent care will continue to be high. The use of technology, including AI **(**artificial intelligence**)** in work processes and procedures will continue to increase. Thus, preparing EPs to be integrated into the workforce of the future EDs must align with all these developments. Demand for procedural and task training will increase. This is where the use of mental rehearsal and scripting will become more practical, popular and in demand. Nurturing and implementing new innovation and techniques will also align with the increasing use of mental rehearsal by EPs. There will be more AI-guided procedures and mental rehearsal will add value in preparing EPs to be versatile and competent. This will prepare them better and supplement their basic knowledge as well as integrate with other forms of tools and technology. The use of AI mechanisms incorporated into the digital EDs of the future will be able to deliver the visual and auditory cues to advise EPs on the steps to follow during procedures as well as warn them of potential risks. This can help reduce inter-EP variations and maintain standards. This will also shape EM training, education and career paths to fit the future needs. **(**28-30**)** To maximally benefit from the application of mental rehearsal, prerequisites such as,

a) A good and reasonable level of self-awareness
b) Internal motivation **(**knows what drives and energize themselves as EPs**)** and
c) The attitude in approaching learning, against the background of the magnitude of available tools and methods

are important. These factors affect confidence level and have influence over EPs thoughts management and behavior. Thought management involves concentration, focus and development of composure and confidence. All these factors can be strengthened with the use of mental rehearsal regularly. It also links to meeting the intellectual demands of EM practice.

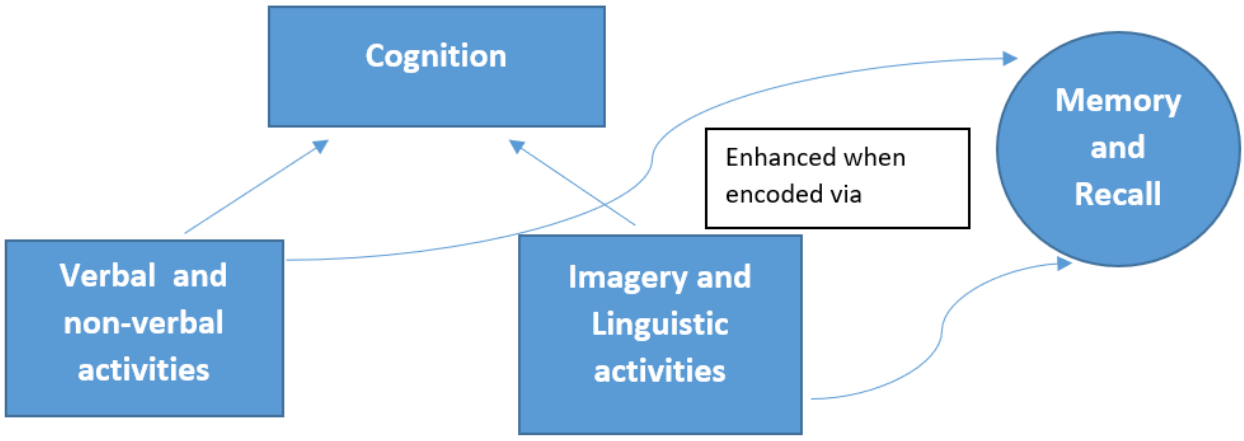

Figure 1: Link between cognition with verbal/ non-verbal activities as well as imagery/ linguistic activities.

Actual Action	Mental Practice/ Imagery
Learning by Observation	Mentally visualized and rehearsed
Effective way to enhance motor skills and procedural skills	Able to achieve enhancement of targeted motor skills
Excitement of brain areas involved in motor skills during period of observation and action. Additional activation of areas in the motor cortex	Reactivation of the same brain areas as in physical performance, with additional activation in the visual cortex.

Table 1: Comparison of Actual Motor Action versus Mental Practice

Learning Phases	The Different Phases	Components/ Elements	Mechanism/ Postulation
Initial Phase	**PreparatoryPhase**	Reading up, watching videos, watching demonstration of procedures, learning via simulation or simulated models, virtual reality training, familiarization through technical support	Initial structural and functional organization/ re-organization takes place in the neural networks of learners.

Initial Phase	**Fast Phase**	Immediate acquisition and improvement	General increase in cortical activities, with cortico-cerebellum and cortico-striatal influence operating in parallel
Learning Phase	**Consolidated Phase**	Improvement in performance and skills at least for 6 hrs post first/ one session	Increased level of pre-synaptic activities and excitability in spinal networks. Continued strengthening of synaptic activities
Learning Phase	**Slow Phase**	Positive gains, improvement across several sessions and preparation	Continued strengthening of synaptic activity, with longer term potentiation. Decrease inhibitory inter-neuron influence
Automatic Phase	**Automatic Phase**	Can perform motor task or skill automatically, readily	General decrease in cortical activity. Greater synaptic conductivity maintained. Continued decreased inhibitory inter-neuron influence. Cortico-striatal looping consolidate motor sequencing learning whilst cortico-cerebellar looping consolidates adoption learning.
Retention Phase	**Retention Phase**	Familiar, comfortable, knowledge has been assimilated into neural networks. Able to perform with longer period of absence of practice in between	Synaptic conductivity maintained and strengthened. Decreased inhibitory inter-neuron influence is maintained.

Table 2: The different Phases of Learning with Mental Rehearsal **(**13, 14, 24**)**

Conclusion

The bottomline of good Emergency Medicine practice is attaining and maintaining competence with procedure skills and tasks to improve the quality of care, patient safety and outcomes of care delivered to patients with emergent problems. All these must be sustained and evolve within the lifespan of practice of an EP. Competency and mastery of skills becomes crucial. This is where against the background of actual performance, observation and simulation, mental practice and scripting offers a unique and effective tool which can be utilized as "anytime, anywhere" training.

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