# 1 Evidence Behind Mental Training

Mayank Roy, Jihui Li, Fernando Safdie, Armando Rosales, and Raul J. Rosenthal

## Introduction

Surgical training has changed at a rapid rate over the last few decades. Introduction of minimally invasive surgery has bought new dimensions but simultaneously has introduced new challenges, including tactile feedback, haptics, and two-dimensional vision [1]. Surgical training has moved toward competency-based assessment both outside and inside the operating room. These competencies have been defined by training governing bodies such as the Accreditation Council for Graduate Medical Education and the American College of Surgeons [2]. Several standard-setting, competency-based curricula focusing on cognitive knowledge, surgical skills, and nontechnical skills have been launched. Future direction of the American College of Surgeons Division of Education includes expansion of mastery-based training and validation of knowledge and skills using specific standards and benchmarks [2]. A number of relatively new assessment methods and tools have been developed, psychometrically tested, and successfully implemented for formative and summative assessments of surgery residents. These include Objective Structured Assessment of Technical Skills (OSATS) [3], Global Operative Assessment of Laparoscopic Skills (GOALS) [4], Patient Assessment and Management Examinations (PAME) [5], and Objective Structured Clinical Examinations (OSCE) [6]. Major progress has been made with regard to assessment of residents in skills laboratories, remediation of deficiencies, and evaluation of operating room readiness of residents [7].

M. Roy · J. Li · F. Safdie · A. Rosales · R. J. Rosenthal (✉)
Department of General Surgery, Cleveland Clinic Florida, Weston, FL, USA
e-mail: roym@ccf.org; rosentr@ccf.org

## Simulation Training

The implementation of work time directives in most parts of the world has limited the amount of time a trainee can spend in the hospital and acquire skills, which were traditionally learned in the operating room through a classical apprenticeship model [8]. Economic, social, cultural, and legal constraints are some of the other reasons that have limited the opportunities for a trainee to acquire some of the core skills in the operating room. This has led to an ever-increasing demand for use of simulation in laparoscopic surgery as an alternative. Laparoscopic surgery is particularly well suited to technical skills training as it requires a skill set based on instrumentation, depth perception, and fine motor control [9]. The need for preliminary training outside of the operating room is underscored by the fact that many surgeons feel inadequately prepared to perform complex surgeries, including laparoscopic procedures, after completing residency training. Simulation training has become a standard pathway for laparoscopic surgery training. Simulation may be useful in learning and assessing certain skills in a controlled and safe environment as it has shown to decrease the error rates in surgery and improve patient care [10]. It has been suggested that simulation-based training allows for the development of the "pre-trained novice," an individual who has been trained to the point where many psychomotor skills and spatial judgments have been automated, allowing them to focus more on learning operative strategy and how to handle intraoperative complications, rather than wasting valuable operating room time on the initial refinement of psychomotor skills. With adequate pre-training, the trainee can gain maximum advantage from the supervised opportunities for training in the operating room or endoscopy suite [11]. It has the advantage of repeated practice outside the operating room before a surgeon performs surgery on the real patient. However, simulator training is limited because of its predictability and lack of random stimuli


R. J. Rosenthal et al. (eds.), *Mental Conditioning to Perform Common Operations in General Surgery Training*,
https://doi.org/10.1007/978-3-319-91164-9_1

that can challenge the learner to process perceptual cues. A systematic review of skills transfer concluded that surgical simulation-based training seems to be transferrable to the operating room; however, most studies have not used comparable simulation-based training methodologies [12]. Simulators are usually sufficient to teach novice learners simple tasks of low fidelity. The most valuable metric that simulation-based training can provide is the measurement of error [11].

## Concept of Mental Training

Mental training – mental imagery, referred to as "visualizing" or "quasi-perceptual experience" – has been shown in some studies to be an effective tool to enhance performance in surgery. Mental practice has been defined as the "cognitive rehearsal of a task in the absence of overt physical movement" [13]. Wraga defined it as "an internal representation that gives rise to the experience of perception in the absence of the appropriate sensory input" [14]. Most studies have reported that it produces larger changes in learning than no practice, but smaller changes in learning than physical practice [15]. It has been shown in some situations to be more effective than physical practice [16]. This is attributed to the fact that mental imagery activates similar neural processes to those used in actual performance of a given skill [17]. However, for mental practice to be most effective, the subject must be familiar with the task itself before the imagery takes place. Sirigu et al. have tried to quantify mental imagery by asking subjects to mentally rehearse a finger opposition sequence to the increasing pace of metronome. Subjects had to indicate maximal speed at which they could mentally perform these movements and compared it to maximal speed of executed finger opposition sequence [18]. The posterior parietal, premotor, and supplementary motor cortexes have all been implicated in motor imagery. These regions are also engaged in planning and preparation of movements, suggesting a neural overlap between imagery and motor planning and preparation [19]. In addition to a detailed description of the procedure, mental training for surgery requires that the procedure must first be broken down into its so-called nodal points, the necessary structural motor components that must be performed in sequence. The following four kinds of mental training sessions can be distinguished [20]:

**External observation training** The trainee observes a model while it is performing the movement to be learned.

**Subvocal training** The trainee calls up a clear visual image of the movement through external or internal self-talk.

**Internal observation training** The trainee visualizes himself or another person from the outer perspective performing the movement he or she wants to practice.

**Ideomotoric training** The trainee imagines the movement from the inner perspective. He visualizes himself executing the movement and tries to feel it, including as many sensory aspects of the process as possible.

## Factors Affecting Mental Training

Some of the earlier research in mental training demonstrated that the reaction time, which increases with complex tasks, goes down with specific mental training tasks [21]. Stransky et al. showed that skills gained by mental training can be cross-transferred to other tasks and can be generalized to laparoscopic skills [22]. Based on their study, they recommended the use of simple computer- or paper-based mental rotation training instead of more expensive materials to enhance certain aspects of surgical performance of trainees. Various factors such as duration and frequency of the session and the influence of individual differences on psychological characteristics, such as trait and state anxiety, have been shown to moderate the effect of mental practice [23]. Shane et al. investigated the ability for gamers and non-gamers to become proficient on simulated surgical tasks [24]. They found that all participants eventually achieved proficiency but gamers required less time to reach this goal. Gopher et al. compared the flight performance of participants who either did or did not previously undergo 10 hours of video game experience. They found a transfer of skills from the video game to flight performance. Further, individuals that had video game training performed significantly better in test flight. Feltz suggested that short duration mental practice may produce larger effect sizes than long duration mental practice [15]. A recent study from Kremer et al. suggested that above some minimum, the amount of mental practice does not affect the outcome [25]. The study had some limitations, including small power and heterogeneous groups.

## Effect of Mental Training in Elite Performers

A surgeon usually has to use intuitive and analytic skills in making decisions. Both these skills rely on previous experience and actions, which have worked in the past. Malcom Gladwell made the concept of the 10,000-hour rule popular in his book *Outliers*. It hypothesized that there is consistency across fields of a minimum required logged hours of performance before a skill can be mastered. However, mere logging of hours is not enough – it has to be deliberate practice, which will optimize improvement and has been shown to be more effective in optimizing motor performance than unguided practice [26]. Deliberate practice has been used to acquire and maintain skills necessary to be a master in various fields. Sports athletes have traditionally used mental training before the event to enhance performance [27]. Experienced athletes structure individual stimuli into chunks of relevant information based on similar patterns they have seen before [28]. These chunks of information are a way of encoding large volumes of meaningful data, which can be related to previous experiences and outcomes. Elite performers' visual patterns show that they focus on fewer cues, albeit for longer. By contrast, novices tend to have rapidly changing visual attention as they attempt to pick up as much information as possible. Similarly, an expert laparoscopic surgeon locks the target and rarely switches gaze. Essentially, an expert is able to ignore all the useless information around him. There is evidence that mental training plays an important role in many professional and recreational activities, and researchers have used spatial training to directly improve such skills. Visual imagery focuses on external aspects, with special reference to the relation of body and environment, whereas motor imagery focuses on internal states of movement, such as dynamics and force production [29]. Whereas images can probably refer to all senses, dynamic images of the motor act focus typically on kinesthetic or visual information. Participants are able to distinguish both processes, kinesthetic and visual, and also imagine features from other modalities such as acoustic input. However, that does not imply that they occur only in one sensory modality isolated from the others.

In the sports domain, athletes often use more than one modality when reporting their images. For example, a baseball batter might see the ball being released from the pitcher (visual), feel his muscles in his upper arm as he gets ready to swing (kinesthetic), and then hear the "crack of the bat" (auditory) when he makes contact with the ball. What this means is that athletes can practice physical skills without actually performing them in practice or competition. Experienced musicians might report acoustic, tactile, and kinesthetic information from their images. Indeed, many people can switch between modalities either voluntarily or when obliged by task instructions [29].

## Effect of Mental Training in Surgery

Arora et al. under the guidance of Darzi developed a mental practice training script to enhance mental imagery of laparoscopic cholecystectomy [30]. They performed their study in two phases. In the first phase, an image script was developed; in the second phase, the script was validated. For script development, three experienced surgeons (who each performed >100 laparoscopic cholecystectomies) were recruited from a teaching hospital, and each surgeon was interviewed using a cognitive "walkthrough" for the procedure. Specifically, the surgeons were instructed to imagine they were performing a laparoscopic cholecystectomy and to report the visual, cognitive, and kinesthetic cues they experienced throughout. Finally, the findings (steps and cues for laparoscopic cholecystectomy) from all three interviews were merged to create a single mental practice script. The cues were color-coded as an additional mnemonic prompt to elicit imagery. In the second phase of their study, 20 subjects (10 experienced surgeons >100 laparoscopic cholecystectomy, 10 novice surgeons <10 laparoscopic cholecystectomy) were recruited from two teaching hospitals using convenience sampling. Each subject underwent mental practice training. Ability to practice this procedure mentally was assessed before and after mental practice training with a modified version of a validated questionnaire (minimum score, 8; maximum score, 56) adapted from Cumming et al. [31]. The questionnaire assessed various aspects of mental script, including level of confidence in performing the task, knowledge of the procedure, the ease with which visual imagery could be used to see the performance, the ease with which kinesthetic imagery could be used to feel the performance, and the general readiness to perform the procedure. Both experienced (48 before mental practice vs. 53 after MP; $p = 0.007$) and novice (15 before mental practice vs. 42 after mental practice; $p = 0.005$) surgeons demonstrated significant improvement in global imagery score after mental practice in their study. The same group of researchers using a randomized controlled trial demonstrated the effect of improved imagery on actual performance [13]. They randomly assigned two groups of participants with comparable baseline skills to either mental practice or control group. Each participant performed 1 laparoscopic cholecystectomy per day on a full procedural simulator for 5 days (sessions). Before each session, each participant within the intervention group underwent mental practice training using a validated mental practice script developed from the previous study [30]. The primary outcome measure was the quality of performance of each of the 5 laparoscopic cholecystectomies performed by all participants. These were video-recorded and blindly assessed by two experienced laparoscopic surgeons and rated using the generic Objective Structured Assessment of Technical Skills (OSATS)-based global rating scale. This is an extensively validated scale consisting of seven items, each scored on a five-point Likert scale [32]. The imagery for the mental practice group was significantly superior to the control group across all sessions, and improved imagery significantly correlated with better quality of performance.

Immenroth in a randomized controlled trial showed that mental preparation is more effective than additional practical training or no additional training in laparoscopic cholecystectomy in surgeons with limited experience [33]. In addition, mental training was regarded by trainees as a valuable tool in their education.

## Summary

Despite multiple studies conducted on mental training, there are certain limitations to all the research done. It is difficult to evaluate some of the earlier reviews and meta-analyses because they combined traditional mental practice studies, which did not have an imagery component with studies employing imagery. Most studies have used elite athletes who are highly motivated for excellence. The results may not be generalized to a different population.

The new approaches to redesigning training should continue to build on the advances that have been made in surgery training in recent years. Surgical and procedural skills training courses, delivered through dedicated skill laboratories and using various simulation-based approaches, are becoming accepted adjuncts to traditional patient-based training models. The onus of acquiring new skills and applying it in the real situation still depends on the trainee. Some trainees can acquire these skills at a much faster pace than their peers. There is a lot of evidence in the literature supporting the use of mental training to enhance performance. Recently it has been used in surgery. This cognitive rehearsal is cheaper than practical training. Once the trainee has the skills, he or she can carry out the mental training on his or her own. However, mental training cannot and should not replace practical training. Surgical steps must be broken down in nodal points, which the trainee must learn and practice mentally to enhance performance. This book has been based on the concept of nodal points, and every procedure has been divided and subdivided into multiple nodal points. Once the trainee is familiar with the nodal points, then surgical steps can be practiced mentally to enhance performance.

## References


1. van der Meijden OA, Schijven MP. The value of haptic feedback in conventional and robot-assisted minimal invasive surgery and virtual reality training: a current review. Surg Endosc. 2009;23(6):1180–90.
2. Sachdeva AK, Flynn TC, Brigham TP, Dacey RG Jr, Napolitano LM, Bass BL, Philibert I, Blair PG, Lupi LK, American College of Surgeons Division of Education, Accreditation Council for Graduate Medical Education. Interventions to address challenges associated with the transition from residency training to independent surgical practice. Surgery. 2014;155(5):867–82.
3. Reznick RK, MacRae H. Teaching surgical skills--changes in the wind. N Engl J Med. 2006;355(25):2664–9.
4. Vassiliou MC, Feldman LS, Andrew CG, Bergman S, Leffondre K, Stanbridge D, Fried GM. A global assessment tool for evaluation of intraoperative laparoscopic skills. Am J Surg. 2005;190(1):107–13.
5. MacRae HM, Cohen R, Regehr G, Reznick R, Burnstein M. A new assessment tool: the patient assessment and management examination. Surgery. 1997;122(2):335–43; discussion 343-334.
6. Sachdeva AK, Loiacono LA, Amiel GE, Blair PG, Friedman M, Roslyn JJ. Variability in the clinical skills of residents entering training programs in surgery. Surgery. 1995;118(2):300–8; discussion 308-309.
7. Sanfey H, Ketchum J, Bartlett J, Markwell S, Meier AH, Williams R, Dunnington G. Verification of proficiency in basic skills for postgraduate year 1 residents. Surgery. 2010;148(4):759–66; discussion 766-757.
8. Collins JP, 2nd International Conference on Surgical Education and Training. International consensus statement on surgical education and training in an era of reduced working hours. Surgeon. 2011;9(Suppl 1):S3–5.
9. Villegas L, Schneider BE, Callery MP, Jones DB. Laparoscopic skills training. Surg Endosc. 2003;17(12):1879–88.
10. Fried MP, Satava R, Weghorst S, Gallagher AG, Sasaki C, Ross D, Sinanan M, Uribe JI, Zeltsan M, Arora H, Cuellar H. Identifying and reducing errors with surgical simulation. Qual Saf Health Care. 2004;13(Suppl 1):i19–26.
11. Gallagher AG, Ritter EM, Champion H, Higgins G, Fried MP, Moses G, Smith CD, Satava RM. Virtual reality simulation for the operating room: proficiency-based training as a paradigm shift in surgical skills training. Ann Surg. 2005;241(2):364–72.
12. Sturm LP, Windsor JA, Cosman PH, Cregan P, Hewett PJ, Maddern GJ. A systematic review of skills transfer after surgical simulation training. Ann Surg. 2008;248(2):166–79.
13. Arora S, Aggarwal R, Sirimanna P, Moran A, Grantcharov T, Kneebone R, Sevdalis N, Darzi A. Mental practice enhances surgical technical skills: a randomized controlled study. Ann Surg. 2011;253(2):265–70.
14. Wrage M. Imagery. In: Encyclopedia of cognitive science, vol. 2. London: Nature Group; 2002.
15. Feltz DL. The effect of mental practice on motor-skill learning and performance: a meta-analysis. J Sport Psychol. 1983;5(2):25–57.
16. Wohldmann EL, Healy AF, Bourne LE. A mental practice superiority effect: less retroactive interference and more transfer than physical practice. J Exp Psychol. 2008;34(4):823–33.
17. Moran A, Guillot A, Macintyre T, Collet C. Re-imagining motor imagery: building bridges between cognitive neuroscience and sport psychology. Br J Psychol. 2012;103(2):224–47.
18. Sirigu A, Cohen L, Duhamel JR, Pillon B, Dubois B, Agid Y, Pierrot-Deseilligny C. Congruent unilateral impairments for real and imagined hand movements. Neuroreport. 1995;6(7):997–1001.
19. Rushworth MF, Johansen-Berg H, Gobel SM, Devlin JT. The left parietal and premotor cortices: motor attention and selection. NeuroImage. 2003;20(Suppl 1):S89–S100.
20. Eberspacher H, Immenroth M. Mental training--does it also help the modern surgeon? Zentralblatt fur Chirurgie. 1999;124(10):895–901.
21. Shepard S, Metzler D. Mental rotation: effects of dimensionality of objects and type of task. J Exp Psychol Hum Percept Perform. 1988;14(1):3–11.
22. Stransky D, Wilcox LM, Dubrowski A. Mental rotation: cross-task training and generalization. J Exp Psychol Appl. 2010;16(4):349–60.
23. Spittle M, Morris T. Internal and external imagery perspective measurement and use in imagining open and closed sports skills: an exploratory study. Percept Mot Skills. 2007;104(2):387–404.
24. Shane MD, Pettitt BJ, Morgenthal CB, Smith CD. Should surgical novices trade their retractors for joysticks? Videogame experience

decreases the time needed to acquire surgical skills. Surg Endosc. 2008;22(5):1294–7.
25. Kremer P, Spittle M, McNeil D, Shinners C. Amount of mental practice and performance of a simple motor task. Percept Mot Skills. 2009;109(2):347–56.
26. Duvivier RJ, van Dalen J, Muijtjens AM, Moulaert VR, van der Vleuten CP, Scherpbier AJ. The role of deliberate practice in the acquisition of clinical skills. BMC Med Educ. 2011;11:101.
27. Weinberg R. Does imagery work? Effects on performance and mental skills. J Imagery Res Sport Phys Act. 2008;3(1):1.
28. Garland DJ, Barry JR. Sport expertise: the cognitive advantage. Percept Mot Skills. 1990;70(3 Pt 2):1299–314.
29. Munzert J, Lorey B, Zentgraf K. Cognitive motor processes: the role of motor imagery in the study of motor representations. Brain Res Rev. 2009;60(2):306–26.
30. Arora S, Aggarwal R, Sevdalis N, Moran A, Sirimanna P, Kneebone R, Darzi A. Development and validation of mental practice as a training strategy for laparoscopic surgery. Surg Endosc. 2010;24(1):179–87.
31. Cumming J, Olphin T, Law M. Self-reported psychological states and physiological responses to different types of motivational general imagery. J Sport Exerc Psychol. 2007;29(5):629–44.
32. Reznick R, Regehr G, MacRae H, Martin J, McCulloch W. Testing technical skill via an innovative "bench station" examination. Am J Surg. 1997;173(3):226–30.
33. Immenroth M, Burger T, Brenner J, Nagelschmidt M, Eberspacher H, Troidl H. Mental training in surgical education: a randomized controlled trial. Ann Surg. 2007;245(3):385–91.