Indian Journal of Surgical Oncology (September 2023) 14(3):540–544
https://doi.org/10.1007/s13193-023-01798-6

REVIEW ARTICLE

Observational Learning in Surgical Skill Development

Karthik Nagaraja Rao[1] · Ripu Daman Arora[2] · Ambesh Singh[1] · Prajwal Dange[1] · Nitin M. Nagarkar[3]

Received: 9 March 2023 / Accepted: 4 July 2023 / Published online: 10 July 2023

Abstract

Observation plays a key role in the development of surgical skills, as it allows trainees to learn from experts and improve their performance through trial-and-error practice. This process, known as motor learning, involves the creation of new neural pathways that enable precise control of surgical instruments through hand movements. In recent years, there has been a shift towards minimally invasive surgery, which requires surgeons to continually learn new motor skills to control specialized instrumentation. Motor learning can be enhanced through repetition and the observation of expert performances. Observational learning is particularly useful when it is used in combination with physical practice, as it can provide hints and clues about important aspects of the task that may not be immediately apparent through verbal instruction alone. The role of mirror neurons, which are activated both when an action is performed and when it is observed, is also important in the process of observational learning. By understanding the mechanisms behind observational learning and the factors that influence its effectiveness, trainers can optimize the use of this method in surgical training.

Keywords Observational learning · Mirror neurons · Surgical training · Surgical skills

Introduction

Observation can be a key factor in the development of surgical skills, as it allows trainees to learn from experts and improve their performance through trial-and-error practice. This process, known as motor learning, involves the creation of new neural pathways that enable precise control of surgical instruments through hand movements. Surgical training involves developing a range of skills, including the ability to make quick and accurate decisions under pressure, as well as physical dexterity and endurance [1]. In recent years, there has been a shift towards minimally invasive surgery, which requires surgeons to continually learn new motor skills to control specialized instrumentation. Motor learning can be enhanced through repetition and the observation of expert performances [2]. Observation is frequently employed in surgical training through process demonstrations and the opportunity to watch and assist surgeries in operating rooms. This article attempts to give an outline of motor skill learning by observation and the elements which could maximize its usefulness in surgical training.

What is Observational Learning?

Observational learning is a type of learning that involves watching someone else perform a task or action [3, 4]. This can help an individual learn a new skill or behavior more quickly, as they are able to see how it is done and then try to replicate it. *Observing someone else perform a task creates a mental representation or blueprint that helps the observer recreate the movement*. Observational learning is particularly useful when it is used in combination with physical

✉ Karthik Nagaraja Rao
karthik.nag.rao@gmail.com

Ripu Daman Arora
neelripu@gmail.com

Ambesh Singh
ambesh.singh26@gmail.com

Prajwal Dange
prajwal.dange@gmail.com

Nitin M. Nagarkar
directoroffice@aiimsraipur.edu.in

1 Head Neck Surgery and Oncology, Department of Head and Neck Oncology, All India Institute of Medical Sciences, Raipur, India

2 Department of Otolaryngology and Head Neck Surgery, All India Institute of Medical Sciences, Raipur, India

3 Institute of Medical Sciences, Raipur, India

practice, as it can provide hints and clues about important aspects of the task that may not be immediately apparent through verbal instruction alone. Additionally, observational learning can be an efficient way to teach a skill to a large group of people, as it can be done through videos, simulators, and online courses [5].

Observing a skilled surgeon perform can help learners learn important skills that are essential for skilled performance, including creating an efficient information gathering strategy, learning important task features, learning advanced skills like judgement and awareness, and honing motor skills. This type of learning can also lead to the development of motor control mechanisms, though the exact mechanism by which observation affects motor control is still being debated [6]. People often make anticipatory eye movements while observing, focusing on stimuli before engaging with it, which suggests that watching a pattern can aid in the development of efficient information-gathering skills. Studies on observation have shown that witnessing others can aid in learning important aspects of a task, such as the movements that must be taken in a technique [7, 8]. Furthermore, objective techniques for sensorimotor tasks can be directly acquired from a model, resulting in the development of elevated judgement capabilities. Finally, it has been demonstrated that observation aids in the development of motor control systems [9].

In the context of surgical training, the development of motor regulatory systems through observation is especially important because it necessitates learning how to handle a range of novel equipment safely and efficiently. According to studies on the human mirror neuron system, specific regions of the motor cortex are very capable of picking up manual dexterity through observation [10–12]. Overall, *observation is an essential component of learning for competent performance in a variety of tasks and plays a significant role in motor learning.*

Role of Mirror Neurons

Once an action is performed or witnessed, a collection of neurons in the motor and premotor cortex called the mirror neuron system are correspondingly stimulated [12, 13]. Although it was initially found in macaques, this network is now well established in humans as well [10, 14, 15]. The movement is reproduced in the observer's cortex when motor regions are stimulated while they are perceiving. *Mirror neurons enable the development of a representation of the seen activity without the need for physical practice, which can make it easier for the observer to replicate identical movements. The mirror neuron system may facilitate the direct mapping of observed movements to repeated motions or it may facilitate the understanding of movement intentions*. These are the main hypotheses for the acquisition of motor skills through observation [16, 17]. The efficiency of action observation for learning motor skills might vary depending on the structure and frequency of witnessed activities, the traits of the individual conducting the activity, the feedback systems, the observer's focus, and the visual signals used. There is evidence that, similar to physical practice, observational learning may encourage the development of motor abilities through by observing errors [18]. Muller et al. hypothesized that mental visualization informs processes for staying calm under pressure and was found to be essential for building long-term surgical resilience. They recommended it to be incorporated into the surgical residency curricula as it offers progressive education on mental visualization and fosters intraoperative environments that promotes adapting to risk [19].

Learning from Expert and Novice

It is generally accepted that watching an expert perform a task is the greatest approach to pick up a new skill. Even more helpful for learning than watching expert performance, gaffe performance refers to viewing blunders or errors made while performing a task [20]. This is due to the fact that viewing faults activates systems for error detection and correction, which can improve motor control similarly to physical exercise. Performing tasks like lifting strange things and performing endoscopic surgery while seeing someone else make mistakes can help learners master those skills [21]. Even though observing expert performance provides an ideal template for optimal performance, *observing both expert and gaffe performance may be most beneficial for learning, because it enables the evolution of fault recovery systems from the gaffe performance*. In contrast to the conventional method of exclusively learning from an expert, this proposes that learners can learn from the mistakes of others and avoid making the same mistakes themselves. This strategy could be a practical and economical way to improve learning in surgical settings since it enables trainees to learn from their colleagues' mistakes rather than only those of experienced surgeons [22, 23].

Being Attentive Pays

In order to learn via action observation, the role of attention is crucial. Giving verbal and visual clues while being observed might enhance performance in activities. Observing the eye movement patterns of experts can improve the speed of learning new abilities by providing suggestions on information to focus and fostering motor skills via a better efficient sensory-motor route [24]. *It's crucial to choose the best area of focus when performing surgery, such as whether it's better to watch the movements of the surgeon's hands or the instruments. The movement of the operator, or surgical instrument, has been demonstrated by point light displays to often offer important information*. Students learning the best gaze methods can benefit from observing specialist's eye movements during surgical procedures. In order to learn through action observation, feedback is an essential element [25]. It aids in directing the learner's comprehension of their performance and serves as a signal for necessary corrections. Offering biased input on the timing mistake when learning the timing of a straightforward movement can affect both the model and the observer movements [26]. When errors are detected during a simulation task in a medical setting, specific feedback can enhance performance. However, receiving too much input might cause dependence and impede learning [27, 28]. *According to the guiding hypothesis, providing partial feedback can be the most beneficial in fostering learning through the growth of error detecting skills* [29, 30]. In surgical training, some input could be helpful, but it's also crucial to let trainees see and practice their own error spotting techniques.

Virtual and augmented reality are playing an increasingly significant role in surgical education and care. Several studies have shown that VR enhances skill development outside of the operating room, although evaluating the transferability of these skills to the clinical setting remains challenging. Currently, AR is predominantly employed for simulated training and intraoperative navigation [31]. Nevertheless, as the technology progresses to better replicate the surgical environment, these tools are expected to become more widespread in both training and patient care contexts.

Practice, Practice, and Only Practice Makes a Surgeon Sharp as Knife

Learning motor skills, such as those required for surgical procedures, requires both physical and observational practice. While observational practice entails observing someone else complete the activity, physical practice involves actually performing the task. Although it has been established that both kinds of practices are helpful for developing new skills, it is still unclear how best to combine them [32]. *More physical practice is better for skill learning, according to studies, as it enables the development of a more precise approach for the task* [33]. How much observational practice is ideal for learning surgical techniques, nevertheless, is presently unclear. While some studies have found no difference between numerous observations and one, others have suggested that multiple observations may be more useful [34, 35]. Depending on the hardness of the task being learnt, the ideal number of observational practices may differ.

Learning results can also be impacted by the structure of practice sessions in addition to their frequency. *It has been observed that doing a range of tasks during physical practice, as opposed to concentrating on one task at a time, might improve learning retention and applicability* [36, 37]. This type of effect is termed as contextual interference effect [38]. Variable practice schedules, wherein the students are introduced to a variety of models and activities in a random order, can also be beneficial for observational practice.

Although physical practice is essential for the efficient acquisition of motor skills, observational practice has its advantages as well. In fact, *when physical practice is added after observational practice, the advantages are frequently maximized*. This can be observed in the sports literatures that the best method for learning how to serve a shuttle in badminton is a combination of physical practice and observation [39].

Overall, it seems that a combination of physical and observational practice may be the most effective way to learn motor skills for surgery. Physical practice is necessary to implement the motor plan developed through observation, while observational practice can provide a blueprint of the task and help learners develop error detection and correction mechanisms [40].

Conclusion

Observing someone else perform a task creates a mental representation or blueprint that helps the observer recreate the movement. Observational learning is particularly useful when it is used in combination with physical practice, as it can provide hints and clues about important aspects of the task that may not be immediately apparent through verbal instruction alone. Observational learning can be used in the context of surgical training to enhance learning in several crucial areas, including the creation of efficient information-gathering methods, the acquisition of task-specific knowledge, the learning of better skills like judgement, anticipation, and the improvement of motor control. Absolutely relying on observational learning may not suffice for performing complex surgeries, particularly those involving minimal access techniques. While observational learning can be beneficial for some surgical procedures, it may not provide the necessary proficiency for more intricate surgeries. The structure and number of observed procedures, the traits of the expert executing the task, the mechanisms of feedback, attentiveness, and the visual information presented are all elements that can affect the effectiveness of observational learning. There is also evidence that a mixture of expert and novice models may be most beneficial for learning, as it allows for the development of error detection and correction mechanisms. Attention to key information and the use of feedback can also enhance learning through observation. Overall, observational learning is a valuable tool in the training of skilled performance in various tasks, including surgical procedures.

Author Contribution All authors have contributed equally towards this manuscript.

Declarations

Consent to Participate Informed consent taken from all the patients.

Conflict of Interest The authors declare no competing interests.

Provenance and Peer Review Not commissioned, externally peer-reviewed.

References

1. Percy DB, Streith L, Wong H, Ball CG, Widder S, Hameed M (2019) Mental toughness in surgeons: is there room for improvement? Can J Surg 62(6):482–487
2. Muratori LM, Lamberg EM, Quinn L, Duff SV (2013) Applying principles of motor learning and control to upper extremity rehabilitation. J Hand Ther Off J Am Soc Hand Ther 26(2):94–103
3. Van Gog T, Paas F, Marcus N, Ayres P, Sweller J (2009) The mirror neuron system and observational learning: implications for the effectiveness of dynamic visualizations. Educ Psychol Rev 21(1):21–30
4. Ferrari M (1996) Observing the observer: self-regulation in the observational learning of motor skills. Dev Rev 16(2):203–240
5. Harris DJ, Vine SJ, Wilson MR, McGrath JS, LeBel ME, Buckingham G (2018) A randomised trial of observational learning from 2D and 3D models in robotically assisted surgery. Surg Endosc 32(11):4527–4532
6. Mulder Th (2007) Motor imagery and action observation: cognitive tools for rehabilitation. J Neural Transm 114(10):1265–1278
7. Katal A, Singh VK, Choudhury T, Imran F (2022) Enhancing teaching and learning through peer observation: an Indian case study. Educ Res Int 22(2022):e7825178
8. Larssen BC, Ong NT, Hodges NJ (2012) Watch and learn: seeing is better than doing when acquiring consecutive motor tasks. PLoS One 7(6):e38938
9. Andrieux M, Proteau L (2016) Observational learning: tell beginners what they are about to watch and they will learn better. Front Psychol 29(7):51
10 Ariani G, Pruszynski JA, Diedrichsen J (2022) Motor planning brings human primary somatosensory cortex into action-specific preparatory states. Baker CI, Serino A, Kikkert S, editors. eLife 11:e69517
11. Cook R, Bird G, Catmur C, Press C, Heyes C (2014) Mirror neurons: from origin to function. Behav Brain Sci 37(2):177–192
12. Acharya S, Shukla S (2012) Mirror neurons: enigma of the metaphysical modular brain. J Nat Sci Biol Med 3(2):118–124
13. Bonini L, Rotunno C, Arcuri E, Gallese V (2022) Mirror neurons 30 years later: implications and applications. Trends Cogn Sci 26(9):767–781
14. Ehrenfeld T. Reflections on mirror neurons. APS Obs [Internet]. 2011 Feb 27 [cited 2023 Jan 9];24. https://www.psychologicalscience.org/observer/reflections-on-mirror-neurons
15. Kilner JM, Lemon RN (2013) What we know currently about mirror neurons. Curr Biol 23(23):R1057–R1062
16. Hickok G (2009) Eight problems for the mirror neuron theory of action understanding in monkeys and humans. J Cogn Neurosci 21(7):1229–1243
17. Rajmohan V, Mohandas E (2007) Mirror neuron system. Indian J Psychiatry 49(1):66–69
18. Han Y, Syed Ali SKB, Ji L (2022) Use of observational learning to promote motor skill learning in physical education: a systematic review. Int J Environ Res Public Health 19(16):10109
19. Mueller F, Brommelsiek M, Sutkin G (2022) Mental 3D visualization: building surgical resilience for performing high-risk procedures. J Surg Educ 79(3):809–817
20. Learning from mistakes: how does the brain handle errors? [Internet]. Frontiers for Young Minds. [cited 2023 Jan 9]. https://kids.frontiersin.org/articles/10.3389/frym.2020.00080
21. Miall C (2010) Motor control: correcting errors and learning from mistakes. Curr Biol 20(14):R596–R598
22. Joseph T (2017) A step forward in surgical education? Int J Surg Oncol 2(8):e33
23. D'Angelo AL, Kchir H. Error management training in medical simulation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 [cited 2023 Jan 9]. http://www.ncbi.nlm.nih.gov/books/NBK546709/
24. Wulf G, Lewthwaite R (2016) Optimizing performance through intrinsic motivation and attention for learning: the OPTIMAL theory of motor learning. Psychon Bull Rev 23(5):1382–1414
25. Gredebäck G, Falck-Ytter T (2015) Eye movements during action observation. Perspect Psychol Sci 10(5):591–598
26. Lopetegui M, Yen PY, Lai A, Jeffries J, Embi P, Payne P (2014) Time motion studies in healthcare: what are we talking about? J Biomed Inform 1(49):292–299
27. Lodge JM, Kennedy G, Lockyer L, Arguel A, Pachman M. Understanding difficulties and resulting confusion in learning: an integrative review. Front Educ [Internet]. 2018 [cited 2023 Jan 9];3. https://www.frontiersin.org/articles/10.3389/feduc.2018.00049
28. Metcalfe J (2017) Learning from errors. Annu Rev Psychol 68(1):465–489
29. Badets A, Blandin Y (2004) The role of knowledge of results frequency in learning through observation. J Mot Behav 36(1):62–70
30. Seidler RD, Kwak Y, Fling BW, Bernard JA (2013) Neurocognitive mechanisms of error-based motor learning. Adv Exp Med Biol 782. https://doi.org/10.1007/978-1-4614-5465-6_3
31. McKnight RR, Pean CA, Buck JS, Hwang JS, Hsu JR, Pierrie SN (2020) Virtual reality and augmented reality—translating surgical training into surgical technique. Curr Rev Musculoskelet Med 13(6):663–674
32. Muratori LM, Lamberg EM, Quinn L, Duff SV (2013) Applying principles of motor learning and control to upper extremity rehabilitation. J Hand Ther Off J Am Soc Hand Ther 26(2):94–103
33. Bates AW (Tony), Bates AW. 3.6 Experiential learning: learning by doing (2). 2015 Apr 5 [cited 2023 Jan 13]. https://opentextbc.ca/teachinginadigitalage/chapter/4-4-models-for-teaching-by-doing/

34. Wulf G, Schmidt RA (1997) Variability of practice and implicit motor learning. J Exp Psychol Learn Mem Cogn 23:987–1006
35. Shea CH, Wulf G, Whitacre C (1999) Enhancing training efficiency and effectiveness through the use of dyad training. J Mot Behav 31(2):119–125
36. Yamada C, Itaguchi Y, Fukuzawa K (2019) Effects of the amount of practice and time interval between practice sessions on the retention of internal models. PLoS One 14(4):e0215331
37. Darling-Hammond L, Flook L, Cook-Harvey C, Barron B, Osher D (2020) Implications for educational practice of the science of learning and development. Appl Dev Sci 24(2):97–140
38. Pauwels L, Swinnen SP, Beets IAM (2014) Contextual interference in complex bimanual skill learning leads to better skill persistence. PLoS One 9(6):e100906
39. Wong TKK, Ma AWW, Liu KPY, Chung LMY, Bae YH, Fong SSM et al (2019) Balance control, agility, eye–hand coordination, and sport performance of amateur badminton players. Medicine (Baltimore) 98(2):e14134
40. Larssen BC, Ho DK, Kraeutner SN, Hodges NJ. Combining observation and physical practice: benefits of an interleaved schedule for visuomotor adaptation and motor memory consolidation. Front Hum Neurosci [Internet]. 2021 [cited 2023 Jan 9];15. https://www.frontiersin.org/articles/10.3389/fnhum.2021.614452