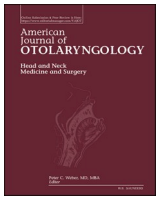
American Journal of Otolaryngology–Head and Neck Medicine and Surgery 43 (2022) 103495

Contents lists available at ScienceDirect

American Journal of Otolaryngology–Head and Neck Medicine and Surgery

journal homepage: www.elsevier.com/locate/amjoto



Harnessing the power of spaced repetition learning and active recall for trainee education in otolaryngology

ARTICLE INFO

Keywords
Spaced repetition
Active recall
Practice testing
Residency
Training
Education

ABSTRACT

Medical education is rapidly evolving. The historical reliance on textbook reading is being increasingly replaced by trainees in favor of using non-traditional platforms such as podcasts, videos, and app-based learning. Neuroscience research on human learning has demonstrated superior long-term retention when the synergistic principles of spaced repetition and active recall are employed. Spaced repetition entails the repeated exposure to learned material over successive iterations, whereas active recall involves the intentional reconstructive process of retrieving previously learned material, often through prompting (e.g., answering open-ended questions without multiple choice answers), rather than passively reviewing previously learned information (e.g., re-reading a textbook chapter). These concepts have revolutionized medical student education, with use of open-source spaced repetition platforms, such as Anki, and question banks becoming ubiquitous. Paralleling educational platforms within otolaryngology are emerging. Headmirror's OtoRecall app provides a free, peer-reviewed, open-access option for otolaryngology trainees to harness the power of these learning principles.

1. Introduction

> Learning is rooted in repetition and convexity, meaning that the reading of a single text twice is more profitable than reading two different things once.
>
> –Dr. Nassim Nicholas Taleb

A revolution away from traditional learning methods, such as didactics and textbook reading, towards newer platforms, such as podcasts, videos, and app-based programs, has transpired within medical education over the past two decades [1,2]. Traditional methods are becoming increasingly abandoned by trainees for options that confer an elevated perceived efficiency of learning. Two principles derived from neuroscience research surrounding human learning have received particular attention in recent years: the synergistic concepts of spaced repetition and active recall [3–5].

Spaced repetition involves the repeated review of previously learned material at various intervals. Oftentimes, these intervals are gradually spaced over time as learners become increasingly comfortable with the content. Simply put, spaced repetition encompasses the adage, "practice makes permanent." Practically speaking, trainees are often faced with numerous resources from which they could learn but insufficient time to study from each resource. Furthermore, there often exists an endless depth of knowledge that is apparent to the trainee but can only be truly learned after years of subspecialty training. Taken together, trainees commonly encounter a "fear of missing out" on critical information – a reality that extends from both the breadth of the resources available and the depth of the content itself. This reality often leads trainees to the unfortunate assumption that reading two things once is better than reading a single thing twice. However, neuroscience research demonstrates that spaced repetition of previously learned material confers significant long-term retention benefits [4,5]. In this way, when living in the reality of residency and its scarcity of time, prioritizing *not forgetting* previously learned material is likely to lead to better long-term learning than prioritizing getting through as much material as possible. Early evidence in the setting of studying for the otolaryngology in-service examination supports this assertion [6].

Perhaps the most powerful evidence surrounding learning neuroscience extends from the data on active recall, or retrieval practice. Active recall requires learners to intentionally reconstruct previously learned material. Remarkably, research has demonstrated that long-term retention of learned material may be as much as 2–3 times greater using active recall compared to traditional means, such as re-reading previously highlighted textbook chapters, creating concept maps, taking and re-reading personal notes, or listening to lectures [3,7,8]. Employing active recall principles during individual studying can be practically challenging and time-consuming, but use of structured prompting – such as answering questions, especially those without multiple choice answers to choose from – can be an easy way to take advantage of the memory retention benefits of active recall. Of course, this sort of prompting without having a "right answer" to choose from most closely parallels the everyday experience of trainees, whether answering questions in the operating room or directly applying the knowledge to patient care in real-time.

In light of this research, Headmirror's OtoRecall was created [9]. OtoRecall is a peer-reviewed, open-access mobile app freely available on Apple's App Store as well as Google Play for Android devices. With approximately 4500 questions and growing that cover every subspecialty of otolaryngology, the app was specifically designed to prompt users with high-yield questions written with an attempt to maximize the potential benefits of active recall. Moreover, the user assigns each question a degree of confidence in the answer, and this informs a spaced repetition algorithm active in the background to gradually space review of learned material based on the user's knowledge of each topic. About

https://doi.org/10.1016/j.amjoto.2022.103495
Received 1 May 2022
Available online 13 May 2022

one hundred topics within the app cover each subspecialty, and the user can tailor what they are studying to each specific topic within each subspecialty. Of particular importance for use by otolaryngology trainees with inconsistent and limited periods of time to study, research has shown that the relative spacing interval bears less importance on long-term retention than simply using the overarching principle of spaced repetition over time [10]. Stated otherwise, consistently answering questions three to four days a week over several months is more important than perfectly adhering to any "ideal" spaced repetition algorithm. With approximately 2500 global users to date, OtoRecall provides a platform whereby the otolaryngology community can harness the power of spaced repetition and active recall for trainee education.

Ultimately, only clinical experience will confer the necessary education to independently practice otolaryngology. However, individual learning develops a literacy in the important concepts by the trainee. Conceptually, studying foundational topics provides the scaffolding on which the 5+ years of residency training will build. Nothing will ever supplant clinical experience for the otolaryngology trainee, but the framework to apply this clinical experience must be largely developed by the trainee. In this vein, spaced repetition and active recall are critical ideas that allow the trainee to develop this framework of knowledge more efficiently, and growing options exist within otolaryngology education that are allowing trainees the opportunity to take advantage of these principles.

Author contributions

John P. Marinelli, Tiffany P. Hwa, Christine M. Lohse, Matthew L. Carlson (all authors): Drafting of the manuscript; approval of the final version of the manuscript; accountable for all aspects of the work.

Funding

Internal departmental funding was utilized without commercial sponsorship or support.

Declaration of competing interest

None.

Acknowledgements

The views expressed herein are those of the authors and do not reflect the official policy or position of Brooke Army Medical Center, the U.S. Army Medical Department, the U.S. Army Office of the Surgeon General, the Department of the Army, the Department of the Air Force, or the Department of Defense or the U.S. Government.

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