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Spaced Effect Learning and Blunting the Forgetfulness Curve

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Abstract

Medical education requires learners to absorb, retain, and apply vast amounts of information at every level of training. This process is constrained by the limitations of human memory, which were described by psychologist Hermann Ebbinghaus as a "forgetfulness curve." As he explained, material encountered during a lecture or study session is typically lost rapidly over the ensuing days. Ebbinghaus' solution to this problem—spaced repetition—involves revisiting studied content at multiple, specifically selected time intervals to reinforce learning and facilitate long-term retention. Using question-based repetition, as opposed to passive reading/listening modalities, can help optimize this process. Spaced learning has been used for training in multiple fields including finance, management and technology development. It has also been utilized by medical students preparing for exams and by select residency training programs. This article examines the range of ways spaced repetition has been employed in medical education, with a focus on applications in Otolaryngology training. It also discusses possible future avenues for use of this system to improve long-term retention in Otolaryngology residency and beyond.

Keywords

spaced repetition, forgetfulness curve, testing effect, undergraduate medical education, resident learning, otolaryngology training

The Forgetfulness Problem in Medical Education

From biochemical pathways to complex surgical techniques, learners at both the undergraduate and graduate levels of medical education are tasked with absorbing, synthesizing, and retaining tremendous amounts of information. As the time allotted to didactics is progressively truncated at most medical education institutions, students are faced with a shrinking window for acquiring the necessary academic knowledge while also practicing and honing their clinical skills. Additionally, with limited time to pass on huge amounts of material, medical instructors are rarely able to implement educational techniques prioritizing retention. Methods such as scaffolding, through which techniques and topics being studied are distilled into smaller components to encourage problem solving and critical thinking, frequently fall by the wayside.[1] As students strive to perform well on standardized examinations and become successful practitioners with no scaffolding and often insufficient opportunity to study, they must not only take in new information but also prevent attrition of their existing knowledge base.

Human memory has finite capacity. Psychologist George A. Miller was the first to find that humans can only keep 7 items (±2) in their short-term memory at a given time, later noting slight variations in that total number for different types of data (letters, numbers, etc.)[2] Miller's findings have filtered into many aspects of contemporary life; for instance, it's no

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coincidence that iPhone passcodes are capped at 6 digits. Retaining and recalling information for a prolonged period of time poses an even greater challenge than short-term acquisition. German psychologist Hermann Ebbinghaus investigated the "forgetfulness curve," a graphical representation of the exponential decline in information retention as a function of elapsed time.[3] Though Ebbinghaus conducted his research over a century ago, it was replicated by a group of researchers as recently as 2015 with similar results.[4] According to Ebbinghaus, the greatest drop in information retention occurs just after the new information is initially introduced. That is to say, data gathered while listening to a lecture or reading a chapter is often lost within a few hours or days of leaving the lecture hall or closing the book. By the end of the week, 90% of that material is gone.[3]

Use of Spaced Learning in Boosting Retention

While describing this grim prognosis for information retention, Ebbinghaus also offered a possible mechanism for combatting the attrition. His research showed that by revisiting the new information being studied at specific time points along the forgetfulness curve, learners can blunt its steep decline. With several well-placed reviews, nearly all of the information being learned can be retained. One review immediately following introduction of new material (ideally within 1 hour), followed by another review within the next 24 hours, then one within the next week and one within the next month are optimal for lasting retention.[3] By implementing Ebbinghaus' findings, trainees across the professional spectrum can engage in more effective and efficient learning with an emphasis on long-term retention and recall.

While reviewing information at predetermined intervals is beneficial on its own, the process of long-term data retention can be further optimized by utilizing the testing effect. This tenet of education theory contends that rereading study materials is far inferior to answering questions or otherwise actively engaging with the studied topic, with several studies demonstrating that learners who test themselves on the same material and in the same timeframes as their passively-reviewing peers perform better.[5] These studies have shown that attempting to retrieve the studied information and subsequently committing to an answer choice helps a learner recall that concept more readily when tested next.[6] Though choosing an incorrect answer may be discouraging, studies have shown that making an incorrect choice can be beneficial to long-term learning, sometimes more so than choosing correctly.[7] To glean greatest benefit from these active learning attempts learners must receive feedback on their choice, usually by reading an explanation contextualizing why the selected choice was correct or incorrect.[8] Engaging with the material in this way challenges the learners' understanding and ultimately leads to improved retention.

Repetition at predetermined time points to beat the forgetfulness curve—a strategy referred to as "spaced learning"—has been increasingly utilized as a training tool. Qstream, an application developed at Harvard Medical School in 2008, implemented this strategy while also drawing on the benefits of the testing effect by presenting users studying a given topic with questions and their accompanying explanations at spaced intervals.[9] By centering the repetition process around questions rather than text or videos, the application makes the learner repeatedly practice making an educated decision on the tested subject. Qstream and various other companies providing similar platforms for spaced learning have been adopted by industry training programs across the country. The application has been used for onboarding, expanding knowledge of company policy and processes, development for employees transitioning to expanded roles, and instruction in skills such as market analysis and sales strategy.[10] It has also been utilized alongside experiential workplace learning to enhance retention, for instance as a supplemental tool for warehouse workers' onsite logistics management training.[11] These services have been employed in the finance, medical technology and pharmaceutical spaces, with Qstream clients including Pfizer, American Express and Stryker. As of 2018, over 350,000 learners had utilized Qstream for professional development in some capacity.[12]

Spaced Learning in Medical Education

Spaced learning has demonstrated promise as a countermeasure to the forgetfulness problem in medical training, becoming a ubiquitous part of individual study efforts and formal training programs alike. A review of 120 papers on spaced learning in medical education showed that 90% had been written in the past decade, highlighting the recent rise in utilization of spaced learning in this setting. The review also showed that spaced learning has been implemented in a range of formats, including online instruction, physical classrooms, and skills training simulations for medical trainees.[13]

Spaced repetition platforms, most notably the flashcard application Anki, have become ubiquitous among medical students preparing for classroom and board examinations. The Anki application for Android phones alone has been downloaded by more than 5 million users.[14] Other programs geared towards medical learners such as BrainScape and SuperMemo are similarly using spaced repetition to promote retention, with some offering additional features including analytics on the individual's study habits and sleep patterns. Use of these programs is largely initiated on an individual basis, and multiple studies have demonstrated that students who elect to implement these programs into their study routines score higher on standardized licensing examinations.[15] However, few institutions have attempted to formalize academic use of these programs through flashcard homework assignments or school-supported decks for students to review.

To assess the possible future utility of spaced repetition instruction at the medical school level, several groups have investigated implementation of this system in clerkship training. In a study of learners on a urology clerkship, educational emails about urology topics were distributed to the group at spaced intervals. Medical students who received the emails scored statistically significantly higher on the associated end-of-year examination. Students who had completed their urology clerkship early in the academic year rather than shortly before the exam were shown to receive the most benefit from this system, further demonstrating that spaced learning is efficacious in fostering longer-term recall.[16] Another study of urology students showed that those who received adaptive spaced repetition materials—where interval length and number of repetitions were assigned based on the learner's performance—achieved similar test scores to students with non-adaptive materials, despite doing less prep work than the non-adaptive cohort. The researchers concluded that spaced repetition with adaptive characteristics was useful in boosting learning efficiency in addition to retention.[17]

In graduate medical education, spaced learning has been shown to be a useful method for improving scores on board examinations. A study of orthopedics residents preparing for their basic science examination showed a positive correlation between time spent using an Anki flashcard deck and exam performance.[18] Infectious disease fellows supplied with a Qstream deck reported high degrees of satisfaction with this learning methodology, especially as it pertained to preparing for their boards.[19] Spaced learning has also been shown to assist graduate medical learners in acquiring knowledge otherwise not emphasized in their clinical training, for instance, improving histopathology slide interpretation among surgical trainees, who rarely practice this skill in their daily activities.[20] Studies have shown that using spaced repetition for exam preparation provides greater benefit to interns compared to other residency classes, perhaps due to their comparatively limited initial knowledge base and implementation of this learning system earlier in the course of their training.[21]

While the utility of spaced learning in studies has been well-supported by past projects, there is also emerging evidence for its use in contexts beyond improved memorization. In one study, spaced repetition via regular email bulletins was used to teach residents how to provide medical students with substantive, useful feedback. The residents who received this training were shown to give significantly more frequent and more helpful feedback as reported by medical student survey responses.[22] This suggests promise for implementation of spaced repetition in areas outside of board study, with the potential to help residents and fellows continue developing their patient communication and teaching skills, as well as other core competencies not formally taught throughout the training process. Furthermore, the spaced repetition approach has also shown utility in the development of technical skills necessary for procedural specialties. A study of pediatric surgery students compared students' abilities to tie square knots on a bowel model and later on a higher degree of difficulty atretic esophagus model between those trained with spaced learning and those without. Though both groups showed overall improvement on their second assessment, those with spaced repetition training produced significantly superior sutures in terms of speed, strength and quality, and also reported less anxiety in completing the task.[23]

Spaced Learning in Otolaryngology Training

Similar to other graduate medical education settings, use of spaced repetition has shown significant benefits in Otolaryngology training. In one study, residents were granted access to an otolaryngology question bank on a spaced repetition review application prior to their in-service exam. The participating residents saw a 3% increase in score, adjusted for post-graduate year.[24] Another project at Tehran University of Medical Sciences gave residents daily multiple-choice questions that were cycled back every 10 days throughout the study period. Residents at this program scored statistically significantly higher than similar learners on their in-service test, despite not showing any significant difference from similar learners in previous years.[25] As in other procedural fields, Otolaryngology learners have also been shown to benefit from spaced repetition in developing their technical skills. One study showed that spaced practice could improve performance in physical tasks, as residents trained in basic mastoidectomy skills over the course of several short sessions showed significantly greater improvement than those who participated in one longer training session.[26] Though such studies show promise, they have primarily been conducted in small populations thus far. Further investigation is needed to better understand the efficacy and possible applications of spaced learning in both the academic and technical aspects of Otolaryngology training.

Existing educational programs within the field of Otolaryngology offer avenues for future implementation of spaced learning on a larger scale. The American Academy of Otolaryngology-Head and Neck Surgery developed an online platform for educational activity entitled OTO Logic offering nearly 1400 educational activities such as recorded lectures, interactive cases, and e-courses. The Academy has expressed its intention to continue to expand its educational programming by incorporating gamification, using competition to motivate learners to engage with their colleagues and challenge themselves.[27] Gamification in combination with spaced learning would optimize learning and retention potential, ensuring that Otolaryngologists at every experience level continue to acquire lasting knowledge.

One current feature of OTO Logic that could benefit from a spaced repetition component is OTO Quest, a question bank introduced in 2021 with over 800 questions that can be assembled into timed practice exams. These exams are tailored to fit the individual, as learner confidence in answering each

question is measured and compared to performance. The learner may later retry questions answered incorrectly or with low confidence.[28] An individual could conceivably use these settings to create a spaced learning program on their own by choosing to redo incorrectly answered questions more frequently than correct questions, but there is not currently a standardized option to do so on the platform. Integrating spaced learning more explicitly into this question bank would help learners better retain continuing medical education content long-term. Several platforms used to study for Otolaryngology examinations such as Board Vitals and DosedDaily similarly offer extensive question banks with customizable features, but no spaced learning options at this time. The time-consuming aspects of creating these banks—question development and collection—have already been done. Including an algorithm for spaced repetition of these questions should be a simple modification and could help learners better prepare for their exams and future practice.

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