Brain scientists offer medical educators tips on the neurobiology of learning

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Everyone would like MDs to have the best education – and to absorb what they are taught. The lead article in the April 4 issue of the journal *Academic Medicine** connects research on how the brain learns to how to incorporate this understanding into real world education, particularly the education of doctors.

"Repetition, reward, and visualization are tried and true teaching strategies. Now, knowing what is happening in the brain will enhance teaching and learning," said Michael J. Friedlander, executive director of the Virginia Tech Carilion Research Institute and professor of biological sciences and of biomedical engineering and science at Virginia Tech. He is the lead author on the article, "What can medical education learn from the neurobiology of learning?"

Friedlander collaborated on the article with Dr. Linda Andrews, senior associate dean for medical education, Baylor College of Medicine; Elizabeth G. Armstrong, director of Harvard Macy Institute, Harvard Medical School; Dr. Carol Aschenbrenner, executive vice president of the Association of American Medical Colleges; Dr. Joseph S. Kass, chief of neurology and director of the Stroke Center at Ben Taub Hospital and assistant professor of neurology, Center for Ethics and Health Policy, Baylor College of Medicine; Dr. Paul Ogden, associate dean for educational program development, Texas A&M Health Sciences Center and College of Medicine; Dr. Richard Schwartzstein, director of the Harvard Medical School Academy; and Dr. Tom Viggiano, the associate dean for faculty affairs, professor of medical education and medicine,

and the Barbara Woodward Lips professor at Mayo Medical School.

The research

In the past 50 years, behavioral approaches combined with functional brain imaging and computational neuroscience have revealed strategies employed by mammals' brains to acquire, store, and retrieve information. In addition to molecular and cellular approaches to describe the workings of the underlying hardware changes that occur in the brain during learning and the formation of memories, there has also been progress in higher-order, human-based studies of cognition, including learning and memory. Scientists have used functional magnetic resonance imaging (fMRI) of the living brain combined with computational modeling to elucidate the strategies employed and the underlying biological processes.

The research has shown how learning leads to functional and structural changes in the cellular networks including the chemical communication points or synapses between neurons at a variety of sites throughout the central nervous system. The functional changes in the effectiveness of communication between individual neurons and within networks of neurons are accompanied by substantial changes in the structural circuitry of the brain, once thought to be hard-wired in adults.

"One of the most exciting advances, as a result of optical imaging of the living brain, is the demonstration that there is growth, retraction, and modifying connectivity between neurons," said Friedlander. "We have also seen that the mature brain can generate new neurons, although, this research is so new that the functional implications of these new neurons and their potential contribution to learning and memory formation remain to be determined," he said.

The recommendations

The most effective delivery of the best possible care requires identifying and assigning levels of importance to the biological components of learning. Here are 10 key aspects of learning based on decades of research by many scientists that the article's authors believe can be incorporated into effective teaching.

Repetition:
Medical curricula often employ compressed coverage over limited time frames of a great amount of material. Learning theory and the neurobiology of learning and memory suggest that going deeper is more likely to result in better retention and depth of understanding. With repetition, many components of the neural processes become more efficient, requiring less energy and leaving higher-order pathways available for additional cognitive processing. However, repetitions must be appropriately spaced.

Reward and reinforcement:
Reward is a key component of learning at all stages of life. "The brain's intrinsic reward system – self-congratulations with the realization of success -- plays a major role in reinforcement of learned behaviors," Friedlander said. "An important factor is the realization that accomplishing an immediate goal and a successful step toward a future goal can be equally rewarding."

In the case of medical students, there are considerable rewards ahead of them in addition to the more immediate rewards of the satisfaction of understanding medicine. The students who derive joy from learning as they proceed through their medical education may have a greater chance of using the brain's capacity to provide reward signals on an ongoing basis, facilitating their learning process.

Visualization:
Visualization and mental rehearsal are real biological processes with associated patterned activation of neural circuitry in sensory, motor, executive, and decision-making pathways in the brain. Internally generated activity in the brain from thoughts, visualization, memories, and emotions should be able to contribute to the learning process.

Active engagement:
There is considerable neurobiological evidence that functional changes in neural circuitry that are associated with learning occur best when the learner is actively engaged.. Learners' having multiple opportunities to assume the role of teacher also invoke neural motivation and reward pathways -- and another major biological component of the learning process: stress.

Stress:
Although the consequences of stress are generally considered undesirable, there is evidence that the molecular signals associated with stress can enhance synaptic activity involved in the formation of memory. However, particularly high levels of stress can have opposite effects. The small, interactive teaching format may be judiciously employed to moderately engage the stress system.

Fatigue:
Patterns of neuronal activity during sleep reinforce the day's events. Research suggests that it is important to have appropriate downtime between intense problem-solving sessions. Downtime permits consolidation away from the formal teaching process.

Multitasking:
Multitasking is a distraction from learning, unless all of the tasks are relevant to the material being taught. The challenge is to integrate information from multiple sources, such as a lecture and a hand-held

device.

Individual learning styles:
Neural responses of different individuals vary, which is the rationale for embracing multiple learning styles to provide opportunities for all learners to be most effectively reached.

Active involvement:
Doing is learning. And success at doing and learning builds confidence.

Revisiting information and concepts using multimedia:
Addressing the same information using different sensory processes, such as seeing and hearing, enhances the learning process, potentially bringing more neural hardware to bear to process and store information.

The researchers recommend that medical students be taught the underlying neurobiological principles that shape their learning experiences. "By appealing not only to students' capacity to derive pleasure from learning about medicine but also to their intellectual capacity for understanding the rationale for the educational process selected … real motivation can be engendered. … They become more effective communicators and enhance their patients' success at learning the information they need for managing their own health and treatments as well."

More information: *"What Can Medical Education Learn From the Neurobiology of Learning?" by Michael J. Friedlander, PhD; Linda Andrews, MD; Elizabeth G. Armstrong, PhD; Carol Aschenbrenner, MD; Joseph S. Kass, MD; Paul Ogden, MD; Richard Schwartzstein, MD; and Thomas R. Viggiano, MD, MEd. *Academic Medicine*, Vol. 86, No. 4 / April 2011

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