The Neuroscience of Learning

Introduction

Higher learning changes us. We broaden our understanding of the human and natural worlds, meet people who leave lasting impressions, get to know others who are different from us, and have experiences that make us more capable, teach us important lessons, and inspire us to keep learning. We now know that higher learning—at any age—changes our brains as well. In fact, that is what learning is—a process of change in the microscopic structure and functioning of our brains.¹ Neuroscience research shows that learning is a physical, biological, energy-dependent activity (hence the use of the term neurobiological in reference to learning) that occurs in response to sensory inputs—the stimuli that come from our environment. Those stimuli, in all their variety, instigate changes in the connections of neurons to one another (synapses) and in the ways neural networks (the interconnections of many neurons through many synapses) work. Acquiring new knowledge or skills, developing cognitive abilities such as critical thinking, adopting a different perspective or point of view, and becoming expert in any endeavor, from fluency in a second or third language to virtuosity in playing a musical instrument, are examples of the outward and visible manifestations of these basic neurobiological processes and events.² We learn when—and because of, and only if—interactions between our brains and the environment (what we call our experiences) cause changes in our brains. We witness those changes when a learner—which means a person of any age who is interacting with his or her environment—demonstrates some new cognitive or other capacity, perspective, or behavior.

R. P. Keeling et al., We’re Losing Our Minds
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Higher learning is then transformational in more than one way. Changing one’s mind occurs through changes that happen in one’s brain; it means that the intellectual growth and personal and social development that occur in college are based on changes in students’ brains as well. In other words, the huge variety of inputs that stimulate learning, from reading to watching a performance to doing a scientific experiment, induce activity in interconnected regions of the brain, and that activity can, if sufficiently powerful and sustained, lead to changes in the structure or function of brain tissue. Such changes are then manifest in students through observable differences in their demonstrated knowledge, attitudes, skills, or behaviors. Instances of learning, aggregated and integrated and extended over time, are the foundation for the gradual, progressive emergence of each distinctive human person—the process of growth and maturation across multiple dimensions that we call human development. The successive phases and stages of human development, which represent the accumulation of changes resulting from many interactions between persons and the world around them, are in fact generated by multitudes of changes in the cells, circuits, and networks of the brain.

The key point is that learning is ultimately a result of the interaction of the brain and the environment. While some basic templates for the core fundamentals of human capacity are hardwired, those templates do not suffice for the full development of a human being. The ability to walk, for example, is based in the genetically determined structures and functions of our brains. But developing those capacities nonetheless requires practice, which means repetitive interactions with the environment—we do, after all, have to learn to walk. Cognitive competency in reading, using language, and doing arithmetic similarly requires many engagements with formal and informal learning experiences. Those multiple interactions, which may include the kinds of repeated, intentional experiences that we call practice, in turn cause increasingly precise and streamlined neurobiological events—changes in the brain that support the achievement of competency and, given sufficient time and intensity of effort, expertise.

From a neurobiological perspective, expertise is efficiency; being an expert at something means that one’s brain has adapted—both structurally and functionally—to allow that thing to be done with higher levels of efficiency. The more efficient the brain is at a task—say, playing