The Premedical Curriculum, Artificial Intelligence, and How the Mind Works

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In this column, I continue the discussion about the premedical curriculum that we began in the last issue. The traditional curriculum, with its specific requirements in the natural sciences, including organic chemistry and calculus, is the subject of constant scrutiny. Several respected medical educators have advocated greater flexibility, and have suggested that eligibility for admission to medical school should be based primarily on acquisition of certain scientific competencies rather than on knowledge of specific facts.[1] Their recommendation also envisions devoting more time to the humanities, as well as to the behavioral and social sciences, with somewhat less emphasis on the natural sciences.[2]

In the previous issue, I offered the contrary suggestion that the traditional curriculum, including organic chemistry—an infamous bane of premedical students—has values that may not seem obvious.[3] Admittedly, however, my opinion drew heavily from the educational experiences of my own generation, and I felt it important to be sure it wasn't outdated. In this column, I explore the topic further, in light of present-day concepts of neural networks and artificial intelligence.

These advanced but seemingly esoteric technologies draw upon an understanding of how the mind works, so before you turn the page, let me assure you that the following discussion is surprisingly relevant to a discussion of the best approach to premedical education.

NEURAL NETWORKS, ARTIFICIAL INTELLIGENCE, AND THE BRAIN

We're all familiar with Big Blue, the supercomputer that defeated then reigning world chess champion Gary Kasparov in 1997. It did so by brute force, using its immense calculating capacity to search through all possible future moves to find the best one. (It's estimated that Big Blue searched 200 million positions/second, while Kasparov probably searched 5/second.[4]) But despite this discrepancy in raw computing power, Kasparov defeated Big Blue the first time they played in 1996. Even when he lost in '97 after Big Blue was upgraded, he was able to play at virtually the same level as the supercomputer. Why? Because he didn't have to consider all the infinite number of possibilities; he had the human brain's capacity to narrow down the options to the most promising paths, by virtue of having learned from his previous experience.

Since then, the world of computing has changed. Advanced digital systems, so-called "neural networks" such as Google's Deep Mind or IBM's Deep Blue and Watson, can now process information in ways that copy the human brain, meaning they can "learn." These neural networks consist of layers of multiple, interconnected processing units, roughly similar to networks of biological neurons connected by synapses. In the human brain, repeated activation of neural synapses strengthens them. We "know" or "remember" something we have learned before, by re-using synapses that we have previously activated and strengthened.

Similarly, a neural network, after being "trained" with specific inputs that are associated with certain outputs, can recognize patterns (or strategies) that have been successful in the past and are likely to work in the future, and, like the brain, it will enhance those connections while removing ineffective ones.

One practical application of this ability to recognize patterns is facial recognition, which until now has been a difficult and imperfect task for a conventional computer. No matter how rapidly it calculates facial measurements such as the distance between the pupils, a conventional computer cannot compete with a human's ability to recognize a face instantly as a pattern. Now, thanks to neural networks, facial recognition is advancing rapidly.

In the medical realm, pattern recognition has opened new vistas in automated reading of X-rays. Similarly, automated reading of photographs to identify skin cancers is nearing clinical application, as reported recently in *Nature* by a group at Stanford University.[5] For the purposes of our discussion, one of the study's findings is especially relevant.

Though they didn't emphasize it in their paper, the Stanford researchers discussed a finding they called "profound" in a conversation with Siddhartha Mukherjee, the oncologist/best-selling author of *The Emperor of all Maladies*, who reported it in *The New Yorker* in an article titled *The Algorithm Will See You Now.*[6] In the first iteration of their study, they started with a totally naïve neural network. But they found later that if they started with a network that had already been trained to recognize some *unrelated* feature (say, dogs vs. cats), it learned to recognize skin cancers faster and better. Mukherjee concluded, "Perhaps our brains function similarly. Those *mind-numbing* exercises in high school — factoring polynomials, conjugating verbs, memorizing the periodic table — were possibly the opposite: *mind-sensitizing.*"

There are many examples of the human brain working that way. It's well-documented that speaking two languages makes it easier to learn a third.[7] As pointed out in *Psychology Today*, neuroimaging studies suggest that language processing is not restricted to single sites in the brain but is spread across various parts.[8] Apparently, certain neural pathways in the human brain can be used for multiple tasks if they are properly trained. For multilingual speakers, the same areas of the brain serve different languages, but the use of the native or the dominant language is optimized and more automatic.

A subject like organic chemistry, with its study of the structure and shape of organic molecules, is an intense exercise in pattern recognition. Even if the specific molecular structures memorized to pass exams are soon forgotten, the pathways that were activated to recognize those patterns provide a vital mental tool. As digital neural networks that use learning algorithms assume greater responsibility for medical diagnosis and therapy, physicians must maintain complementary capabilities, or risk becoming superfluous in many circumstances.

As a schoolboy, I recall being obliged to study many subjects that seemed irrelevant to my interests, and I remember protesting about them. My teachers always turned me away with the same response: "It will sharpen your mind."

At the time, it seemed an evasive brush-off.

I no longer think so.

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