**Divided Attention**

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By David Glenn

Imagine that driving across town, you've fallen into a reverie, meditating on lost loves or calculating your next tax payments. You're so distracted that you rear-end the car in front of you at 10 miles an hour. You probably think: Damn. My fault. My mind just wasn't there.

By contrast, imagine that you drive across town in a state of mild exhilaration, multitasking on your way to a sales meeting. You're drinking coffee and talking to your boss on a cellphone, practicing your pitch. You cause an identical accident. You've heard all the warnings about cellphones and driving—but on a gut level, this wreck might bewilder you in a way that the first scenario didn't. Wasn't I operating at peak alertness just then? Your brain had been aroused to perform several tasks, and you had an illusory sense that you must be performing them well.

That illusion of competence is one of the things that worry scholars who study attention, cognition, and the classroom. Students' minds have been wandering since the dawn of education. But until recently—so the worry goes—students at least *knew* when they had checked out. A student today who moves his attention rapid-fire from text-messaging to the lecture to Facebook to note-taking and back again may walk away from the class feeling buzzed and alert, with a sense that he has absorbed much more of the lesson than he actually has.

"Heavy multitaskers are often extremely confident in their abilities," says Clifford I. Nass, a professor of psychology at Stanford University. "But there's evidence that those people are actually worse at multitasking than most people."

Indeed, last summer Nass and two colleagues published a study that found that self-described multitaskers performed much worse on cognitive and memory tasks that involved distraction than did people who said they preferred to focus on single tasks. Nass says he was surprised at the result: He had expected the multitaskers to perform better on at least some elements of the test. But no. The study was yet another piece of evidence for the unwisdom of multitasking.

Experiments like that one have added fuel to the perpetual debate about whether laptops should be allowed in classrooms. But that is just one small, prosaic part of this terrain. Nass and other scholars of attention and alertness say their work has the potential to illuminate unsettled questions about the nature of learning, memory, and intelligence.

As far back as the 1890s, experimental psychologists were testing people's ability to direct their attention to multiple tasks. One early researcher asked her subjects to read aloud from a novel while simultaneously writing the letter A as many times as possible. Another had people sort cards of various shapes while counting aloud by threes.

Those early scholars were largely interested in whether attention is generated by conscious effort or is an unwilled effect of outside forces. The consensus today is that there are overlapping but neurologically distinct systems: one of controlled attention, which you use to push yourself to read another page of Faulkner, and one of stimulus-driven attention, which kicks in when someone shatters a glass behind you.

But those scholars also became intrigued by the range of individual variation they found. Some people seemed to be consistently better than others at concentrating amid distraction. At the same time, there were no superstars: Beyond a fairly low level of multitasking, everyone's performance breaks down. People can walk and chew gum at the same time, but not walk, chew gum, play Frisbee, and solve calculus problems.

In a famous paper in 1956, George A. Miller (then at Harvard, now at Princeton) suggested that humans' working-memory capacity—that is, their ability to juggle facts and perform mental operations—is limited to roughly seven units. When people are shown an image of circles for a quarter of a second and then asked to say how many circles they saw, they do fine if there were seven or fewer. (Sometimes people do well with as many as nine.) Beyond that point, they estimate. Likewise, when people are asked to repeat an unfamiliar sequence of numbers or musical tones, their limit on a first try is roughly seven.

And that is under optimal conditions. If a person is anxious or fatigued or in the presence of an attractive stranger, his working-memory capacity will probably degrade.

What Miller called the informational bottleneck has been recognized as a profound constraint on human cognition. Crudely speaking, there are two ways to manage its effects. One is to "chunk" information so that you can, in effect, pack more material into one of those seven units. As Miller put it, "A man just beginning to learn radiotelegraphic code hears each dit and dash as a separate chunk. Soon he is able to organize these sounds into letters, and then he can deal with the letters as chunks. Then the letters organize themselves as words, which are still larger chunks, and he begins to hear whole phrases." That sort of process is obviously central to many kinds of learning.

The second method for managing the bottleneck—and the one that concerns us here—is to manage attention so that unwanted stimuli do not crowd the working memory. That might sound simple. But as the Swedish neuroscientist Torkel Klingberg explains in his recent book *The Overflowing Brain: Information Overload and the Limits of Working Memory* (Oxford University Press), scholars are far from agreement about how to describe the relationship between attention and working memory. Does a poor attention system cause poor working-memory performance, or does the causation sometimes work in the other direction?

One common metaphor is that controlled attention acts as a "nightclub bouncer," preventing irrelevant stuff from getting into working memory. A few years ago, Klingberg and a colleague conducted brain-imaging experiments that suggested that a region known as the globus pallidus seems to be highly active when people successfully fend off distraction.

"Why is it that some people seem to reason well and others don't?" asks Michael J. Kane, an associate professor of psychology at the University of North Carolina at Greensboro. "Variability in working-memory capacity accounts for about half the variability in novel reasoning and reading comprehension. There's disagreement about what to make of that relationship. But there are a number of mechanisms that seem to be candidates for part of the story."

One of those seems to be attentional, Kane says. "The view that my colleagues and I are putting forward is that part of the reason that people who differ in working-memory capacity differ in other things is that higher-working-memory-capacity people are simply better able to control their attention."

In other words—to borrow a metaphor from other scholars—people with strong working-memory capacities don't have a larger nightclub in their brains. They just have better bouncers working the velvet rope outside. Strong attentional abilities produce stronger fluid intelligence, Kane and others believe.

Attention and distraction are entangled not only in reasoning and working memory, but also in the encoding of information into long-term memory.

In 2006 a team of scholars led by Karin Foerde, who is now a postdoctoral fellow in psychology at Columbia University, reported on an experiment suggesting that distraction during learning can be harmful, even if the distraction doesn't seem to injure students' immediate performance on their tasks.

Foerde and her colleagues asked their subjects to "predict the weather" based on cues that they slowly learned over many computer trials. For example, seeing an octagon on the screen might mean that there was a 75-percent chance of rain on the next screen. The subjects would never be told the exact percentage, but gradually they would learn to infer that most of the time, an octagon meant rain.

During one of their four training runs, the subjects were distracted by a task that asked them to count musical tones while they did the forecasting. At first glance, the distraction did not seem to harm the subjects' performance: Their "weather forecasts" under distraction were roughly as accurate as they were during the other three trials.

But when they were asked afterward to describe the general probabilistic rules for that trial (for example, a triangle meant sunshine 80 percent of the time), they did much worse then they did after the undistracted trials.

Foerde and her colleagues argue that when the subjects were distracted, they learned the weather rules through a half-conscious system of "habit memory," and that when they were undistracted, they encoded the weather rules through what is known as the declarative-memory system. (Indeed, brain imaging suggested that different areas of the subjects' brains were activated during the two conditions.)

That distinction is an important one for educators, Foerde says, because information that is encoded in declarative memory is more flexible—that is, people are more likely to be able to draw analogies and extrapolate from it.

"If you just look at performance on the main task, you might not see these differences," Foerde says. "But when you're teaching, you would like to see more than simple retention of the information that you're providing people. You'd like to see some evidence that they can use their information in new ways."

If single-minded attention is vital to learning, how far should college instructors go to protect their students from distraction? Should laptops be barred at the classroom door?

One prominent scholar of attention is prepared to go even further than that.

"I'm teaching a class of first-year students," says David E. Meyer, a professor of psychology at the University of Michigan at Ann Arbor. "This might well have been the very first class they walked into in their college careers. I handed out a sheet that said, 'Thou shalt have no electronic devices in the classroom.' ... I don't want to see students with their computers out, because you know they're surfing the Web. I don't want to see them taking notes. I want to see them paying attention to me."

Wait a minute. No notes? Does that include pen-and-paper note-taking?

"Yes, I don't want that going on either," Meyer says. "I think with the media that are now available, it makes more sense for the professor to distribute the material that seems absolutely crucial either after the fact or before the fact. Or you can record the lecture and make that available for the students to review. If you want to create the best environment for learning, I think it's best to have students listening to you and to each other in a rapt fashion. If they start taking notes, they're going to miss something you say."

Give Meyer his due. He has done as much as any scholar to explain how and why multitasking degrades performance. In a series of papers a decade ago, he and his colleagues determined that even under optimal conditions, it takes a significant amount of time for the brain to switch from one goal to another, and from one set of rules to another.

"I've done demonstrations in class," Meyer says, "whereby they can see the costs of multitasking as opposed to paying attention diligently to just one stream of input."

He might, for example, ask students to recite the letters A through J as fast as possible, and then the numbers 1 through 10. Each of those tasks typically takes around two seconds. Then he asks them to interweave the two recitations as fast as they can: "A, 1, B, 2," and so on. Does that take four seconds? No, it typically requires 15 to 20 seconds, and even then many students make mistakes.

"This is because there is a switching time cost whenever the subject shifts from the letter-recitation task to the number-recitation task, or vice versa," Meyer says. "And those extra time costs quickly add up."

Several other scholars of attention, however, concede that they haven't tried to set firm rules about laptops in class.

"I've thought about having a special laptop section in my lecture hall," says Kane, the psychologist at Greensboro. "That way students wouldn't have to be distracted by their neighbors' screens if they don't want to be." Beyond that, however, Kane is reluctant to move. Many students do legitimately take notes on laptops, and he doesn't want to prevent that.

Stanford's Nass, likewise, allows laptops in his classes, though he feels sheepish about that choice, given his research. "It would just seem too strange to ban laptops in a class on computers and society," he says.

Many other scholars say instructors should make peace with the new world of skimming and multitasking. N. Katherine Hayles, a professor emerita of English at the University of California at Los Angeles, has argued in a series of essays that the new, multimedia world generates "hyper attention"—which is different from, but not necessarily worse than, attention as traditionally understood. In a media-rich environment, she believes, young people's brains are getting better at making conceptual connections across a wide variety of domains.

"One of the basic tenets of good teaching is that you have to start where the students are," Hayles says. "And once you find out where they are, a good teacher can lead them almost anywhere. Students today don't start in deep attention. They start in hyper attention. And our pedagogical challenge will be to combine hyper attention with deep attention and to cultivate both. And we can't do that if we start by stigmatizing hyper attention as inferior thinking."

Nass is skeptical. In a recent unpublished study, he and his colleagues found that chronic media multitaskers—people who spent several hours a day juggling multiple screen tasks—performed worse than otherwise similar peers on analytic questions drawn from the LSAT. He isn't sure which way the causation runs here: It might be that media multitaskers are hyperdistractible people who always would have done poorly on LSAT questions, even in the pre-Internet era. But he worries that media multitasking might actually be destroying students' capacity for reasoning.

"One of the deepest questions in this field," Nass says, "is whether media multitasking is driven by a desire for new information or by an avoidance of existing information. Are people in these settings multitasking because the other media are alluring—that is, they're really dying to play Freecell or read Facebook or shop on eBay—or is it just an aversion to the task at hand?"

When Nass was a high-school student, decades ago, his parents were fond of an old quotation from Sir Joshua Reynolds: "There is no expedient to which man will not resort to avoid the real labor of thinking." That is the conundrum that has animated much of his career.

"I don't think that law students in classrooms are sitting there thinking, Boy, I'd rather play Freecell than learn the law," Nass says. "I don't think that's the case. What happens is that there's a moment that comes when you say, Boy, I can do something really easy, or I can do something really hard."