Are BetterBrains Better?

Penn neuroscientists Martha Farah and Anjan Chatterjee believe the answer is more complicated than you think.

BY TREY POPP

PHOTOGRAPHY BY CANDACE DICARLO

It was somehow appropriate that it started with a clock-radio alarm. There were two overarching constants in Chris Miner's life: Every slumber was a product of pure exhaustion and every awakening was rude. It wasn't his private equity job. That merely consumed the daylight and dinner hours. It was the fact that getting home at nine or ten at night marked the beginning of a second shift. Ever since he'd started studying for the GMAT for business school, which meant an additional few hours of intellectual exertion with little more than his commute as a spell of rest, Miner felt like a circuit breaker full of shorts.

So he remembers the morning he first heard about modafinil the way a man lost in the forest remembers the sound of a search party's shotgun blast. A news segment about the drug, marketed under the brand name Provigil as a treatment for narcolepsy and excessive daytime drowsiness associated with obstructive sleep apnea, detailed recent experimental evidence of its effects on healthy subjects. The take-home lesson was enticing. Modafinil not only boosted their mental alertness and stamina, it also appeared to enhance their performance on several learning- and memory-related tasks.

Miner hit up Wikipedia in the following days for more information. He learned the Air Force had used the drug to keep pilots alert and vigilant for 40 hours without sleep. Although there was scant research on modafinil's long-term safety, its stated side effects seemed minimal. He ordered a package of 200-milligram pills from a Canadian Internet pharmacy. He hoped the drug would help him study and focus.

"It did," he told me in September during a break between his Wharton MBA classes. (Chris Miner is a pseudonym. Like other students and faculty who spoke to me about their use of cognitive-enhancing drugs, he did so on the condition of anonymity.) "And it was inexpensive. So I used it. I took the GMAT, got a decent score, and then I forgot about it—put it in my desk along with my scientific calculator as something I didn't need at that point in time."

The need resurfaced when he came to Wharton. "There was all this stuff I had to ramp up on very quickly that I just didn't understand. So I placed an order again." This time he tried Ritalin, an older stimulant doctors have used to treat attention-deficit hyperactivity disorder (ADHD) since the 1960s. Judging from the Urdu script on the Novartis packaging delivered to Miner's mailbox, these particular pills either came from Pakistan or were diverted at some point on their way to a pharmacy there.

"I subsequently learned that I'd actually seriously broken the law by directly having a hand in having that stuff imported off-prescription," Miner told me. Diversion of prescription drugs for unauthorized use is a felony punishable by prison. "That's what bothers me most of all."

Though he prefers modafinil, Miner noticed the same thing about Ritalin that strikes virtually everyone who has tried it as a study aid. "Flipping open an accounting book—about the most boring book you can find—I said, *Wow, this is really interesting! I'm enjoying this!* ... And that's when I realized something unusual was going on."

In some respects, the unusual thing about Chris Miner's experience is that he found it that unusual.

A study published in 2005 estimated that some 7 percent of American college students had used prescription stimulants without medical supervision to augment their academic performance. At some universities the figure was as high as 25 percent. The students have company. In a 2007 *Nature* article titled "Professor's Little Helper," University of Cambridge neuroscientists Barbara Sahakian and Sharon Morein-Zamir wrote, "In academia, we know that a number of our scientific colleagues in the United States and the United Kingdom already use modafinil to counteract the effects of jetlag, to enhance productivity or mental energy, or to deal with demanding and important intellectual challenges."

Shortly after the article appeared, the journal conducted an online poll in which one in five respondents said they had used drugs like Provigil, Ritalin, or Adderall, another stimulant, for non-medical reasons. About a quarter of that group reported daily use.

If your goal was to provoke a lot of righteous consternation, you could do worse than to jump on a report suggesting that scientists and professors are doping at a rate that makes the professional cycling circuit look chaste. Yet the knee-jerk dismay over the prospect of "artificial" brain enhancement has lately met its match in a pair of Penn neuroscientists who are doing much to reshape the contours of the debate. Their names are Martha Farah and Anjan Chatterjee, and although each has a different perspective on the quest for better brains, both are convinced that the ethical quandaries it raises are at once more daunting and less intuitive than many people realize.

THE PROMISE AND PERIL OF COSMETIC NEUROLOGY

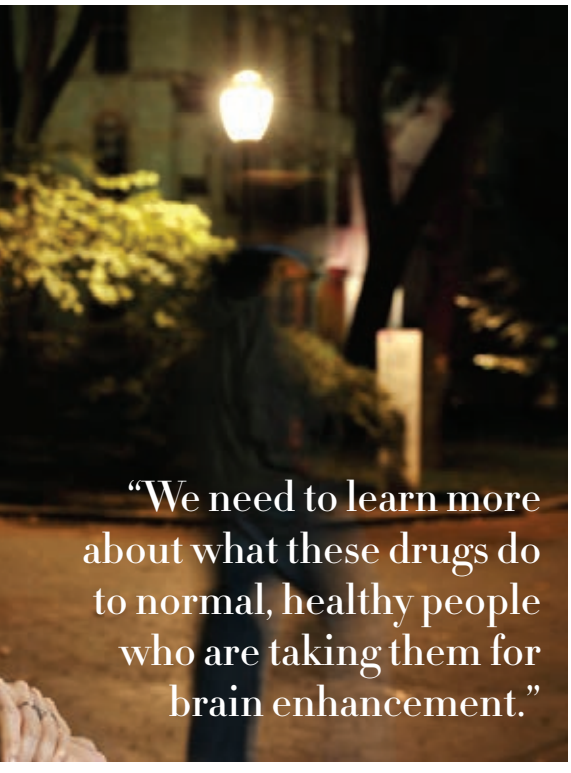
"Most of us would love to go through life cheerful and svelte, focusing like a laser beam at work and enjoying rapturous sex at night."

When it comes to self-evident truths, you'd have to comb through a lot of back issues of *Nature Neuroscience* to beat the one Martha Farah posited in its November 2002 edition. In academic terms, it was a little outside of the Penn psychologist's area of expertise. Farah, the Walter H. Annenberg Profes-

sor of Natural Sciences and director of Penn's Center for Cognitive Neuroscience, was better known for her work on the neural underpinnings of vision, reading, and face recognition ["The Fragile Orchestra," March|April 1998]. But her aim in this paper wasn't to delve into sexual performance or laser-like focus at the synapse level. It was to answer a seemingly simpler question: So why don't we go ahead and do it?

After all, there were pills on the market designed to bring about each condition. Viagra and Prozac were only the two best known. "In normal individuals," Farah observed, Ritalin and Adderall "induce reliable changes in vigilance, response time and high cognitive functions, such as novel problem-solving and planning." An experiment on a different drug, belonging to a new class of compounds known as ampakines, she added, found that it improved the performance of healthy human subjects on several memory tests.

What's more, trends suggested that next-generation drugs targeting those and other areas might vanquish the worries that have traditionally discouraged healthy people from taking pills. "Until recently," Farah wrote, "psychotropic medications had significant risks and side effects that made them attractive only as an alternative to illness. With our growing understanding of neurotransmission at a molecular level, it has been possible to design more selective drugs with better side-effect profiles."



Around the time Farah became interested in the ethical implications of this, Anjan Chatterjee started contemplating the practical ones. As little as five years earlier, when decisions around drug prescriptions rested more or less exclusively with doctors, they may have been less intimidating. But as any physician could have told you, those days were over. The FDA's 1997 decision to allow direct-to-consumer advertising of prescription drugs, coupled with the proliferation of medical information on the Web, had created a new kind of patient, one who came to the doctor armed with specific ideas and requests. Chatterjee, a practicing neurologist and professor of neurology at the School of Medicine, knew how this dynamic could drive demand for drugs to treat illness. A drug that promised a superior alternative to normality, he intuited, might change the practice of neurology in a more profound way.

This past April, Chatterjee laid out a hypothetical scenario drawn in part from his experience seeing patients whose concerns sometimes straddle the line between therapy and augmentation. The occasion was a media seminar that basically served as a sneak preview of the Center for Neuroscience and Society, which opened in August with Farah as its academic director (see sidebar on page 34). Chatterjee is one of the associate directors. He shared a clinician's view of our cognitive future. It closely followed one he'd outlined in the *Journal of Medical Ethics*, which (taking the liberty of compression) went like this:

A well-to-do middle-aged executive walks into my clinic complaining of memory lapses that, upon further examination, seem to stem from stress or mild depression. I prescribe a selective serotonin reuptake inhibitor that makes him feel quite well and restores his professional performance. After a while he comes in again, this time complaining about the frequency with which the right word for a sentence seems just beyond the tip of his tongue. I suggest a cholinesterase inhibitor, explaining that the FDA doesn't approve it for such a use, but that it may help. It does. Now he begins to think more expansively. His company is vying for a contract from the Saudi Arabian government, and he thinks learning Arabic will give him an edge over his competitors. I point out that there's some data that amphetamines improve neural plasticity, so that combining one with a crash course in the language might help him learn it more quickly. Excited about the plan, he leaves for Saudi Arabia—with an Ambien to help him rest on the plane and some modafinil to make him alert when he lands—impresses the royal family with his Arabic, and comes home triumphant with the contract in his hand.

As someone who went into medicine to treat the sick, Chatterjee is plainly unsettled by this prospect, which he has dubbed "cosmetic neurology." But he thinks it's inevitable, and that now is the time for clinicians to begin contemplating how their roles may change in the face of "patients" whose essential complaint is that they're all-too-ordinary. Chatterjee thinks cosmetic neurology is likely to edge into mainstream acceptability much the way cosmetic surgery has. Moreover, it will be harder to belittle someone for getting, say, a memory enhancement than a nose job or a tummy tuck. People will just come to see such things the way Chris Miner sees modafinil—as something that's "as much a part of your tool kit as a graphical calculator and a notebook."

To be sure, the pharmaceutical industry is a long way from cramming Arabic fluency into a capsule. Even the notion that an amphetamine like Ritalin constitutes a meaningful learning aid flies in the face of evidence that its effects are probably modest at best for people who are already functioning at a high level. But Chatterjee points out that in some settings, even modest effects can have outsized impacts.

"To give you an example, I was giving a talk about this in a graduate seminar in the bioethics program, and there was one student who objected to my saying that this was an issue," he recounted. "Her feeling was that since the advantages [of cognitive-enhancing drugs] were so small, this was never going to be

a really big deal. Before I could even answer her question, there were three other students in the seminar who objected. It turned out all three students were in law school. And their immediate point was that, to them, what they cared about was getting a decent clerkship that summer, or an internship at a prestigious law firm. And that any little advantage that got them into that would have really long-term consequences."

What mainly worries Chatterjee and Farah is that the present drugs of choice for American undergraduate users—primarily Ritalin and Adderall, which are the most widely available on campuses through legitimate prescriptions for ADHD—carry substantial risks.

"The pills that people are using," Farah says, "including students at Penn and a lot of other colleges, are not ideal cognitive enhancers. Probably the biggest drawback is that they are addictive. It's not to say that a student who occasionally uses some illegally obtained Adderall to get a last-minute term paper written is necessarily going to become addicted, but they are running a risk, and, sad to say, a certain fraction of people who use them will end up addicted."

If and as cognitive-enhancing drugs become safer, however, Farah believes that many of the other objections that have been raised to them will prove unconvincing.

One of the most common is that using them amounts to cheating, or a way to "gain without pain," as Farah puts it. But she finds this argument wanting in a society that's "full of shortcuts to looking and feeling better," and which doesn't begrudge vegetable haters their vitamin supplements, or college applicants their Kaplan test-prep courses.

Moreover, a drug like modafinil really isn't a shortcut at all, but a way to extend and intensify effort—which is generally lauded in our society. As Chris Miner told me about his Wharton workload, "If I'm feeling lazy, I'll sleep six or seven hours a night. Otherwise I'll sleep four hours a night. And if I only sleep four hours a night I'll use modafinil."

Of course this raises another question. What if everyone else in your firm—or your kid's classroom—elects to follow the path Chris Miner has chosen? You may feel you have no choice but to follow suit, simply to meet a standard of normalcy that has been revised sharply upward.

NEUROSCIENCE FOR POETS (AND LAWYERS, AND ECONOMISTS…)

In 2008, when Indian police accused a 24-year-old woman named Aditi Sharma of poisoning her fiancée, investigators placed 32 electrodes on her head and read aloud their version of the events leading up to the crime. The electrodes recorded the inner workings of her brain, which were computer-processed into a series of images purporting to distinguish whether Sharma had "experiential knowledge" of the events or had merely heard about them. Prosecutors submitted the scans as evidence in court, where the judge endorsed them as proof of Sharma's guilt, convicting Sharma of murder.

Two years earlier, a group of American researchers and entrepreneurs used functional magnetic resonance imaging (fMRI) to measure the impact of Super Bowl advertisements on the brains of some viewers. (Memo to FedEx: that "Caveman" spot was repulsive.)

And during the run-up to the last American presidential election, *The New York Times* ran a Sunday op-ed by some of the same people, who now claimed to have used fMRI to unravel the mysteries of how voters viewed the major candidates. Accompanied by the seeming authority of colorful brain scans, the article revealed that swing voters either loved or hated John Edwards, viewed Mitt Romney with anxiety, and were "battling unacknowledged impulses" to like Hillary Clinton.

"I suspect that most of the *New York Times*-reading cognitive neuroscientists of the world spent some of their Sunday morning grousing to their breakfast companions about junk science and the misapplication of functional brain imaging," Martha Farah wrote the next day in a blog post. "Having just finished my own grousefest, I would like to undertake a slightly more constructive task–distinguishing among what I consider to be good and bad reasons for skepticism about the [op-ed authors' conclusions], and suggesting a way to validate this sort of work."

In a nutshell, that's Farah's goal for Penn's new Center for Neuroscience and Society, which draws its faculty from the schools of Arts and Sciences, Medicine, Law, and Engineering and Applied Science. In recent years, neuroscience has become increasingly relevant to fields from economics to political science to criminal law. Yet while brain imaging and other neuroscience tools can provide insights into what makes people tick, they've also proven to be rich with potential for misinterpretation and overstated claims.

"Our goal is to take non-scientists and equip them with enough understanding of neuroscience that they can work with it intelligently and confidently," Farah said this summer. "The idea is to improve the speed with which neuroscience can be taken up by these different professions, and improve the quality of the work being done."

The center's inaugural endeavor was to host "Neuroscience Boot Camp," a weeklong crash course attended by a few dozen lawyers, journalists, academic economists, political scientists, anthropologists, and a novelist. By the time they broke for a cocktail social halfway through, the participants were able to discuss critiques of the examples above with remarkable fluency. Cognitive enhancement was also a topic hot on everyone's lips.

In addition to Farah and Anjan Chatterjee, the center's leadership includes associate director Stephen Morse, the Ferdinand Wakeman Hubbell Professor of Law as well as a professor of psychology and law in psychiatry at Penn. Joe Powers, a psychologist who has worked in the non-profit and pharmaceutical sectors, is executive director.

"We are fortunate at Penn to have the largest and most accomplished group of scholars anywhere in the world working on issues of neuroscience and society," Farah said. "Every sphere of life in which the human mind plays a central role will be touched by these advances."

This presents a thorny challenge, but again, perhaps not an unprecedented one in a world where round-the-clock BlackBerry vigilance has become a baseline job requirement in some fields. "Clearly coercion is not a good thing," Farah allows. "Yet it would seem at least as much of an infringement on personal freedom to restrict access to safe enhancements for the sake of avoiding indirect coercion of individuals who do not wish to partake."

Farah and Chatterjee have also weighed the issue in terms of distributive justice. Presumably cognitive-enhancing drugs or devices would be more available to the haves than to the have-nots, potentially exacerbating the gulf between them. But Americans, both note (if with a measure of unease), have proven to be unusually tolerant of such inequities. And besides, the advantage conferred by 200 milligrams of modafinil is probably far smaller than the benefit of, say, private schooling.

But isn't there something different about an advantage that actually changes the chemistry of your brain?

"That's not so clear," Chatterjee replies. "Think about being in a place where you have decent nutrition versus a place where you don't, or growing up in an environment where you feel safe versus one where basic safety is an issue and life is full of stress. Those things have direct impacts on neuronal organization and neural structure [see sidebar on page 36]. What makes it qualitatively different? I think as you keep going down the line, it becomes harder and harder to say."

When I later put the same question to Farah, she toasts it with a cup of coffee, her own cognitive enhancer of choice. "To the extent that there are problems with this idea of enhancing your brain with pharmaceutical products, the problem surely is not that it's artificial—that it's changing your mental state by ingesting a substance—because clearly we do that all the time."

TURN ON, TUNE IN, REV UP

"We've been changing our consciousness ever since we realized we had consciousness," says Jonathan Moreno, the David and Lyn Silfen University Professor of the history and sociology of science. "Peyote, sex, hyperventilating—there are all kinds of ways. We're doing it all the time. That's what humans do."

Perhaps it is human nature to tinker with human nature. If so, the ways we choose to tinker have much to tell us about how far and quickly our priorities can drift. Any survivor or student of the 1960s knows that drug-induced mind expansion is nothing new. Still, you have to marvel at Moreno's first off-the-cuff example. What does the long, strange trip from peyote to Provigil tell us about ourselves?

Julie Lyzinski, director of Penn's Office of Alcohol and Other Drug Program Initiatives, says that the University has been gathering data on prescription-stimulant misuse on campus for three years. So far the results have more or less mirrored her personal observations. Part of her job is to conduct interventions with students. "Our numbers are fairly low for abuse outside of a prescription, but it's pocketed within certain groups," she says. They aren't the same groups that tend to serve as hypothetical examples in the neuroethical debate. In Lyzinski's experience, chronic users tend to have mediocre grades and poor time-management skills, and use stimulants to catch up.

They are also more likely than their peers to use other prescription drugs to counteract the effects of stimulants. "So we have the benzodiazepines—the anti-anxiety medications—which obviously are sedatives. And ironically, that helps deal with the stress of not having time-management skills."

Lyzinski doesn't worry very much about summa cum laude students popping Provigils to get a leg up on the magnas, because she thinks the real issue lies elsewhere.

"We're all taught that we can reach for the moon and get the stars, you know," she sighs. "So students are encouraged to be involved in so many different activities, when maybe the way they work best is to scale it back a little bit, spend more time focusing on what needs to happen, and then move forward from there. But we don't set any limitations for ourselves, and we have to keep coping with that very fast, multitasking environment. And that's not a healthy environment for the brain anyway."

Yet it's the one we live in, and reach for the moon we do. Given the expense—and for some, the challenge—of an elite education, it can seem hard to justify doing anything else. Chris Miner exemplifies this. Given the Wharton MBA program's policy of grade non-disclosure, he has little to gain from besting his classmates. But that's not the point. "I think what sets me apart from my peer group is that I find this school very difficult. First of all, because I don't have much business background, unlike most people here. And second,

THE OPPOSITE OF ENHANCEMENT

The more we learn about the brain, the clearer it has become that all kinds of things change it. On one level, this is so intuitive it borders on the banal; after all, why else do we send our kids to school, or make sure they don't eat lead paint? But our increasing ability to actually measure those changes, and to unravel the mechanisms that bring them about, has given rise to some unsettling observations. One of the most provocative comes from Martha Farah's research on the impact of poverty on brain development.

Like a lot of people who get interested in brain development, Martha Farah came to the topic through parenthood. But it wasn't exactly having a child that fired her curiosity. It was having babysitters. Most of hers came from the other side of the proverbial tracks, and as she got to know them, stark differences became evident between her life and theirs. "Nowhere were the differences more dramatic," Farah has written, "than in the realm of child development. Their daughters and sons and nieces and nephews began life with the same evident promise as my daughter and her friends. Yet as the years went on, I saw their paths diverge."

When we got together at a café down the block from her Center City home, I asked Farah about the research this observation had inspired. For the past several years she has been studying several groups of low-income and middle-income children—from kindergarten age through high school—in an effort to get to the bottom of a phenomenon that has perturbed social scientists for decades: the persistence of poverty across generations.

The most recent phase of her work has involved administering cognitive tests to a group of low socioeconomic-status children whose home lives have been documented in detail as part of a different longitudinal study. Farah has grown increasingly convinced that the circumstances of their upbringing have specific impacts on different parts of their brains.

"What we've been able to determine," she says, "is that the kids who grew up in families with relatively little cognitive stimulation [as indicated by the presence of things like toys and books in the home] grow up to have relatively less well-developed language abilities."

Another finding drilled a little deeper. "Kids who grew up in families with more stress—and less parental nurturance—grew up to have worse memory abilities," Farah says. "That might seem like a really weird, inexplicable relationship, but it turns out that it's very consistent with research that's been done with animals, in which it's been shown that early parental nurturance buffers the developing brain against the effects of stress hormones that tend to impair the part of the brain that's responsible for learning and memory."

Her studies are part of a growing body of work that Farah believes may "recast the disadvantages of childhood poverty as a bioethical issue" rather than a strictly economic one.

"The thing is," she adds, "as far as the effects of poverty on brain development go, we don't know to what extent they are reversible. So I think it would be making a big assumption to say, *Oh, this kid grew up poor; the reason they are not doing well in school is that their brain was changed by the experience of growing up poor, and so don't expect much of them.* It would be making a big assumption that they couldn't be helped by the appropriate kinds of remediation. [We may equally well discover] that brains that have undergone one kind of an experience at an early age need another kind of experience at a later age to achieve their full potential. In which case we could use the neuroscience as a sort of rationale for offering them various kinds of experiences that make for something enhancing, or enriching."

This line of research throws the typical debate over enhancement into sharp relief. As Farah noted in a recent book chapter, "Neuroethicists have rightly called attention to the ethically problematic ability of drugs to change who we are, for example by the effects of certain molecules on certain receptors. It is metaphysically just as perplexing, and socially at least as distressing, that an impoverished and stressful childhood can diminish us by equally concrete physical mechanisms, such as the impact of early life stress on medial temporal memory ability through neuroendocrine mechanisms."

because I actually take it really seriously, and a lot of business-school students don't, at all. I really care about academics, and I want to master subjects, as opposed to just get a B," he explains. "It's not so I can go from a 3.7 to a 3.8. That's immaterial. It's more a strong belief that I'm paying a lot of money to be here, and to develop some useful skills.

"I fully understand that on balance, one is better off not doing it," Miner concedes. "It's just a necessary evil. And I've rationalized it for myself."

Whatever the merits of that argument, it is probably the most common justification among users of cognitive-enhancing drugs. Modafinil and other pills basically enable people to meet expectations that otherwise seem impossible–whether it's a professor staying tuned into an academic meeting after a long-haul plane trip, or a student who doesn't want to choose between fulfilling course requirements and extracurricular ones. That this in turn reinforces those same expectations is a perverse result, but perhaps an inevitable one in a society that esteems achievement above all else.

TROUBLESHOOTING OUR COGNITIVE FUTURE

Last December, Martha Farah joined six other academics in authoring a Nature *commentary titled "Toward responsible use of cognitive-enhancing drugs by the healthy."* It called for the "presumption that mentally competent adults should be able to engage in cognitive enhancement using drugs." Medications like Ritalin and modafinil, "along with newer technologies such as brain stimulation and prosthetic brain chips," they posited, "should be viewed in the same general category as education, good health habits, and information technology–ways that our uniquely innovative species tries to improve itself."

Anjan Chatterjee is more hesitant to make this step; when the *British Medical Journal* asked him to argue in favor of endorsing Ritalin as a performance-enhancer for a point-counterpoint feature in June, he elected to write the contra position instead. Yet his fatal-

ism and the feeling that "there are no straightforward answers" about pharmacologic enhancers have convinced him of the need for scientific investigation of their efficacy and risks.

In that respect he concurs with Farah, whose imprint was evident in the *Nature* piece's insistence that "an evidence-based approach is required to evaluate the risks and benefits of cognitive enhancement."

"I've gotten a certain amount of flack for not condemning these drugs," Farah says. "But I feel like we don't really know enough. We need to learn more about what these drugs do to normal, healthy people who are taking them for brain enhancement."

In other words, Farah wants to move the debate over cognitive enhancement into a new phase in which experimental evidence—not philosophical rumination—will determine the appropriate uses and limits of new drugs and devices. Recently she and Chatterjee teamed up to take a step in this direction, tackling the contentious but unsettled question of whether stimulants enhance focus at the cost of creativity.

As usual, *The Onion* got there first. "Ritalin Cures Next Picasso," the satirical newspaper proclaimed in a 1999 headline.

> WORCESTER, MA—Area 7-year-old Douglas Castellano's unbridled energy and creativity are no longer a problem thanks to Ritalin, doctors for the child announced Monday. "After years of failed attempts to stop Douglas' uncontrollable bouts of self-expression, we have finally found success with Ritalin," Dr. Irwin Schraeger said. "For the first time in his life, Douglas can actually sit down and not think about lots of things at once." Castellano's parents reported that the cured child no longer tries to draw on everything in sight, calming down enough to show an interest in television.

Swap out Ritalin for Adderall, and that's the basic proposition Farah and Chatterjee decided to test.

"Individuals who tend to be creative tend to also be a little spacey—a little subject to distraction, not good at maintaining their focus on a single thing for a long time," Farah explains. "So if all these college kids who are going to be the leaders and workers of tomorrow are developing these thinking styles that are very narrow and focused, because they're doing their work on Adderall and similar drugs, that could have the terrible effect of decreasing overall the amount of creativity we have in our workforce."

A small experiment involving healthy subjects, Adderall, and laboratory tests of creativity—which Farah allows "may sound like an oxymoron" but are "actually not-bad methods that cognitive scientists have developed"—yielded somewhat surprising results. "For two of the tests we found no effect whatsoever," Farah says. "In one task it actually improved people's performance. And in another task it improved the performance of students who had initially scored low on creativity, but actually *impaired* the performance of the people who had initially scored high." She says ongoing work has shown this pattern to be a common one, that in some circumstances, cognitive-enhancement may serve to equalize differences, not amplify them. "I wonder to what extent these ambitious young college students who are taking Adderall, thinking it's going to help them do well, are actually impairing their performance," she muses. "If they're already at the high end, they may be screwing themselves up."

It is not hard to imagine other ways a research-based program of risk-benefit analysis might turn the cognitive-enhancement debate on its head. Jonathan Moreno pointed me toward a recent report titled "Opportunities in Neuroscience for Future Army Applications." It discussed a 2008 finding that transcranial magnetic stimulation—a noninvasive method of using high-frequency magnetic fields to alter neural function—enhanced visuospatial attention. "They go so far in that report," Moreno says, "to say that in the middle term—which is sort of 10 years—you could get an in-vehicle transcranial magnetic stimulator." He adds, "The concept is applicable to civilian drivers too: a biosensor that can tell whether you were fading or not focusing, and a stimulator that can give you a little zap."

If a prosthetic brain device proves safe and effective at maintaining alertness in fighter pilots for long stretches of wakefulness, one might argue on public-safety grounds that long-haul truckers be required to use it. "If superior performance by the few is deemed necessary for the greater good," Chatterjee observed in his *BMJ* piece, "[medical] residents might be forced to take enhancements after being on call to mitigate cognitive deficits brought on by sleep deprivations. Perhaps doctors older than 50 would be required to pharmacologically stave off their fraying cognitive edges." There is no telling how far such an approach might creep. If the effectiveness of a memory-enhancing drug turns out to be a function of uninterrupted use, the license to practice surgery might be made contingent on its continued ingestion by surgeons who relied on it during their training. Alternatively, if there proves to be a cognitive tradeoff between increased memory abilities and problem-solving skills, which some research seems to indicate, maybe those same surgeons should be compelled to disclose the contents of their medicine cabinets to patients or medical insurers.

Those scenarios seem unlikely in a society that counts liberty and the right to privacy as bedrock values, but our current experience with off-label stimulant use suggests that the pressure to enhance need not come from above. "I don't think there are leaders who are rallying folks to take an interest in enhancement," Farah says. "I think it's grassroots, and it's driven by a kind of striving or competitive mindset." And a striving mindset can persuade its owner to do just about anything. In the rather stunning words of one respondent to the *Nature* poll, "As a professional, it is my duty to use my resources to the greatest benefit of humanity. If 'enhancers' can contribute to this humane service, it is my duty to do so."

Says Jonathan Moreno, "Unless people are persuaded the downside is too great, people are going to move ahead and do this." What they actually stand to gain or lose is the next question that faces us. In the meantime, the only thing we can be reasonably sure of is that regardless of whether these hypotheses are tested in the laboratory, there are already people who are willing to test them on themselves.◆