

# YOUR BRAIN ON SKIS

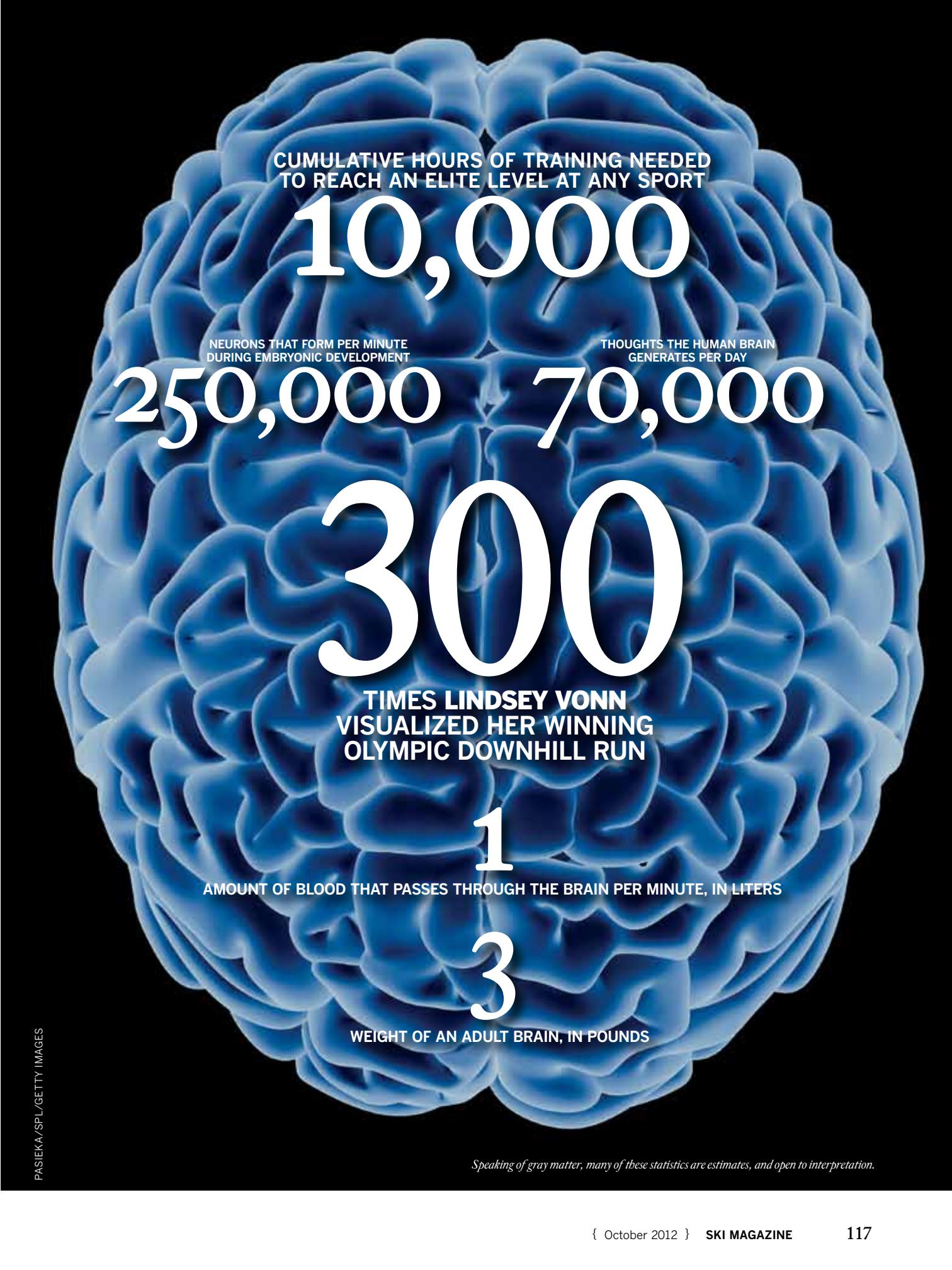


WHAT HAPPENS IN THAT SIX FEET BETWEEN THE  
COULOIR WALLS DEPENDS ON WHAT HAPPENS IN THE SIX  
INCHES BETWEEN YOUR EARS.

*By Michael Bebar*

To see first-hand what the slope  
looks like from an athlete's  
perspective, turn to page 124,  
where pro skier Reggie Crist  
takes us on a mental tour of  
Las Leñas, Argentina.





CUMULATIVE HOURS OF TRAINING NEEDED  
TO REACH AN ELITE LEVEL AT ANY SPORT

10,000

NEURONS THAT FORM PER MINUTE  
DURING EMBRYONIC DEVELOPMENT

250,000

THOUGHTS THE HUMAN BRAIN  
GENERATES PER DAY

70,000

3000

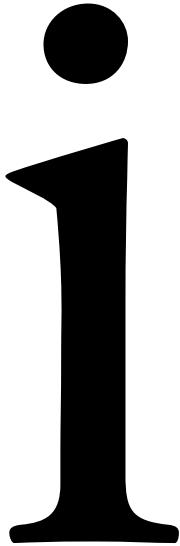
TIMES LINDSEY VONN  
VISUALIZED HER WINNING  
OLYMPIC DOWNHILL RUN

1

AMOUNT OF BLOOD THAT PASSES THROUGH THE BRAIN PER MINUTE, IN LITERS

3

WEIGHT OF AN ADULT BRAIN, IN POUNDS



I'm at Silverton Mountain, Colo., crippled with fear. Standing on the lip of a heinously steep couloir known as Meatball—a six-foot-wide chute hemmed with serrated crags sharp enough to disembowel an SUV—I try contemplating a line but soon sit down in the snow. My guide has toured me through some of Silverton's most formidable terrain and I never flinched. Now I'm paralyzed.

Fear arises in the brain from tiny, almond-shaped bundles of neurons called amygdala. Ignited by an external trigger—a precipitous couloir will do—the amygdala dumps adrenaline into the bloodstream and jacks up the pulse. It fires without permission, a subconscious hijacker channeling primal instincts: fight or flight. I choose flight, but my guide offers an alternative. "I'll go first," he instructs. "Then you follow, making your turns exactly where I do." I reluctantly agree, and the demanding cognitive effort it takes to mimic his every move quiets my anxiety.

David Heeger, a neuroscience professor at New York University's

Center for Neural Science, explains that my guide was exploiting what are called mirror neurons. Heeger, who investigates how the brain computes visual input, recounts a notable experiment from 2008 in which test subjects were asked to play rock-paper-scissors against a videotaped opponent, and then just observe the opponent. Using functional magnetic resonance imaging (fMRI) to track the real-time fluctuation of blood as it ebbed and flowed through the brain, scientists noticed that it didn't matter whether subjects were playing or observing; their brain activity was virtually identical. "Our brains respond the same way when we watch someone do something as



**FEARLESS FEATS**

» Alain Robert free-climbs the world's second tallest building—Taiwan's Taipei 101. (2004) » Robbie Knieval, Evel Knieval's son, jumps his motorcycle across part of the Grand Canyon. (1999) » **Annie Edson Taylor becomes the first person to ride Niagara Falls in a barrel and survive—on her 63rd birthday. (1901)** » Harry Houdini barely escapes from being buried six feet underground. (1915)

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when we do it ourselves," says Heeger, an accomplished skier who has himself dropped the Meatball couloir.

The result is twofold. "When you are skiing and instructed to follow, it gives you something to focus on, which distracts you from things that would otherwise make you afraid. The mirror neurons then take your observations and map them onto the circuitry in your brain that would normally perform the same action. After doing this for a while, your brain learns [the skill] and you no longer need to watch."

The discovery of mirror neurons has led scientists a step closer to solving an enduring puzzle: How does that three-pound gelatinous pink organ figure into

our success (or failure) in sports?

Today, thanks to a cadre of impassioned "noodle nerds," a few clues are beginning to emerge. Geneticists have recently identified strands of DNA linked to fearlessness. Psychologists are pondering the power of the subconscious. Neuroscientists can now explain why the old skier's adage "Look two turns ahead" works. "We are beginning to understand and put together how the brain controls very complex, dynamic behaviors like skiing," Heeger says.

**Medical imaging equipment remains too fragile and bulky to let neuroscientists see what I'm thinking**

**tip** » A single run tailing an expert skier down tricky terrain provides a benefit similar to solo skiing that run repeatedly; it's like practicing without all the practice.



### BRAIN FOOD

» Your brain cells require twice as much energy as any other cell in your body—energy which travels to the brain, via blood vessels, in the form of glucose. **Feeding your brain is as important to performance as feeding your body, and luckily the same diet is good for both.** The key, unsurprisingly, is balance. Choose carbs low on the glycemic scale, and pair them with protein and unsaturated fats. Graze throughout the day to avoid spikes in blood sugar.

while I'm charging bumps at Mary Jane. Instead, I head to Marina del Rey, Calif., where I meet Leslie Sherlin, chief science officer and vice president of research and development for Neurotopia. The five-year-old company, based in a maroon-paneled office building with darkly tinted windows, markets a procedure it calls "performance brain training," and I've made an appointment for an overhaul. My brain will be mapped to assess three key traits: speed, stress, and focus. "We've tried to construct metrics that will capture the essence of your performance," says Sherlin, who looks a lot like Neil Patrick Harris. Afterward, I'll play video games designed to correct any shortfalls.

At Neurotopia, a receptionist directs me into an exam room where Donnie Hale is waiting. He's Neurotopia's senior technician for quantitative electroencephalography (QEEG), which records and compares neural impulses from various regions in the brain. Hale invites me to sit in a "zero gravity" recliner that ensures "complete relaxation, with no muscle activity." Next he places a red and blue nylon cap over my skull. It's embedded with 19 electrodes and uses proprietary software to filter out background noise. (Blinking and swallowing, for instance, generate unwanted garble.) "Now take a deep breath," Hale says. "Relax your shoulders, your neck, your jaw. Close

**My task is to push either of the buttons when the center square is dimmed. I say I nail it. Hale is clearly skeptical. Of the 35,000 brains Sherlin has mapped, only two got a perfect score.**

While it might sound specious, the training is grounded in an established therapy called neurofeedback, used not only in sports but to treat depression, insomnia, ADHD, and drug addiction. Neurotopia's clients include the U.S. Ski Team, NASCAR drivers, and a medley of extreme athletes, such as Canadian freeskier Kaya Turski, 24, who has won three slopestyle championships at the Winter X Games. "I had had a rough year," Turski later tells me, "having gone through two ACL reconstructions and a dislocated shoulder. My fears were taking over. So I did the brain training, which definitely made me feel more competent and focused and able to reset my mind."

your eyes, and let everything go."

For the first eight minutes, my job is easy: lie back and chill. Then, for the next eight minutes, Hale instructs me to keep my eyes open. Lastly I get a handheld plastic console with two black buttons—a left and a right. In the center are nine uniformly arranged squares, backlit with red LEDs. For 20 minutes, all nine squares will illuminate simultaneously or in rapid-fire succession. My task is to push either of the buttons when the center square is dimmed, which occurs randomly. Having slugged enough java at breakfast to fill a kiddie pool, I nail it. "Got 'em all," I boast to Hale. He is clearly skeptical. To create a baseline for its protocol, Sherlin

alone has mapped the brains of more than 35,000 adults, including 500 elite athletes. "In all of those, we've only had two people [an L.A. Lakers basketball player and an NCAA golfer] get a perfect score," Hale says.

It'll take a day for Neurotopia's software to crunch my brain data and condense it into a readable format. "We will find your unique strengths and weaknesses," explains Michael Gervais. Gervais is a Neurotopia science advisory member and the director of high-performance psychology at Pinnacle Performance Center, which provides brain training to, among others, the U.S. Olympic Team, Red Bull North America, the NFL, and the U.S. military. "We've spent a lot of time studying the brightest brains in sports to come up with protocols to help you perform in high-stakes environments. You are going to get a unique signature of how your brain operates. And from that we're going to tell you the areas we want to tighten and the areas we want to turn down."

**tip** > Meditate. Sit in a straight-backed chair and light a candle. Concentrate on the flame and try to keep your mind focused on what you see. Start with five minutes and work up from there.

## YOUR BRAIN ON SKIS

**It's certainly possible that Neurotopia** can make me a better skier, if only because the brain affects athletic performance more than anything else. "Think of the brain like the surface of a pond," says Bradley Hatfield, a professor of kinesiology at the University of Maryland who studies the cerebral dynamics associated with high-level motor performance. "If you throw a pebble anywhere in that pond, it will ripple throughout. Everything is interconnected. So that ripple will eventually go to the area of motor planning and control. The pebble is going to cause disruption, whether it's minor or major. And if it's major, you're looking at a choke."

If every pebble in Hatfield's pond makes waves, then fear is a cannonball.

Dan Freigang, a sports psychologist who works with the U.S. Ski Team, concurs. "The minute you stare down a mogul field and your fingers tighten up around the poles and you start to get cold, that is an anxiety response," he tells me. "Your brain chemistry changes. Blood flow changes. And your amygdala start firing." This isn't necessarily a deal-killer. "A little bit of fear is a good thing," Hatfield acknowledges. It keeps you from doing stupid things. "It's the lack of management of it that's problematic. Too much can interfere with timing and the appropriate levels of force and tension in the muscles."

For some, fearlessness is embedded in the DNA. In the mid-1990s, scientists isolated the serotonin transporter gene. The gene manifests in two forms, called alleles, which differ in length. Those who carry the shorter allele spook far more easily. "From a dispositional nature, they are more likely to be responsive to fear-listening cues and then have the whole downstream process of greater excitement in the brain," says Hatfield. A good coach can teach those cursed with the shorter allele (you can be tested for it) how to

conquer their sissy sides. "However, all things being equal, the athlete who does not carry it is more likely to be the cool-headed competitor on the slopes."

Not born with Shane McConkey's genes? This doesn't necessarily thwart your aspirations of becoming a freeskiing deity. Mental imagery has been shown to help silence fear and alleviate anxiety. Olympic gold medalist Lindsey Vonn claimed to have visualized her winning downhill run in the 2010 Vancouver Olympics more than 300 times before exploding through the starting gate. "Visualization reduces uncertainty," says Hatfield. "It's like walking into a situation where you already know the lay of the land."

Another effective tactic, suggests David Eagleman, a neuroscientist at Baylor College of Medicine in Houston, Texas, is to stop thinking so much.

"A little bit of fear is a good thing," Hatfield acknowledges. It keeps you from doing stupid things. "It's the lack of management of it that's problematic."

He directs the Eagleman Laboratory for Perception and Action, where he contemplates the neural mechanics of time, a theme explored in his newest book, *Incognito: The Secret Lives of the Brain*. "For professional athletes, the whole game is to get the conscious mind out of the way," he tells me. "Everything goes more smoothly when you let it run on this automated circuitry."

Automation in skiing occurs whenever you plan your turns in advance. "What you are doing is getting the information into the system, and then letting the system take care of it," says Eagleman. It's only when you overthink a situation that trouble ensues. Doing



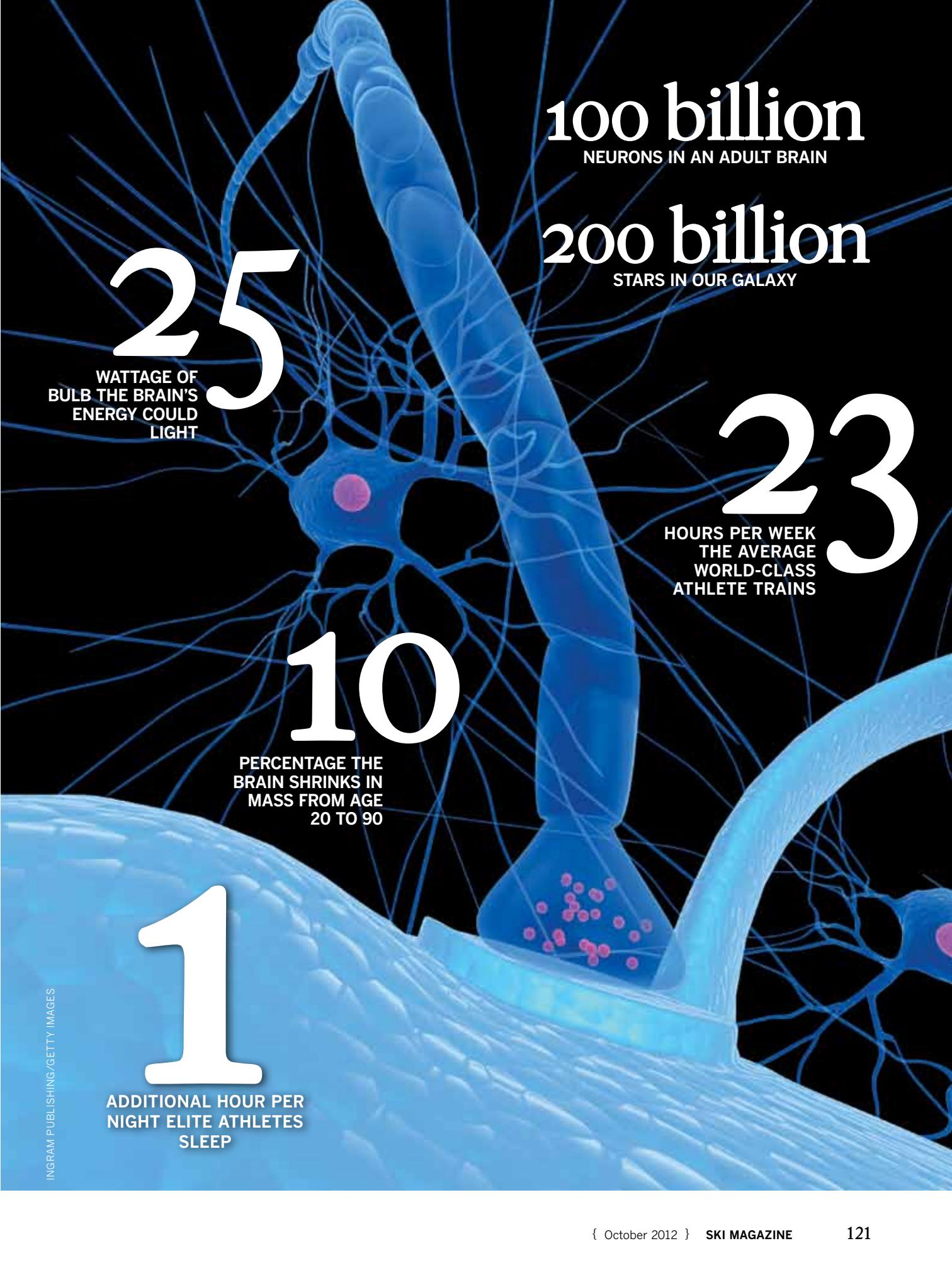
### STAY SMART

» At the age of 30, the brain's neurons begin to lose their connections, which are crucial to processing information. However, research shows that the brain remains adaptable at any age. **Cardio exercise is perhaps the best offense, pumping oxygen-rich blood where it matters most** and improving high-level cognitive function. Try something new too; it creates connections between the neurons, vital to mental agility.

so diverts your focus and introduces unwanted clutter. In his book, Eagleman likens it to a pianist whose concentration is momentarily derailed. He writes, "Once you begin deliberating about where your fingers are jumping on the keyboard, you can no longer pull off the piece." Skiing is analogous. "You are in the zone [when] there is almost no conscious input," he says. "You are riding on top of this machinery that you've trained during thousands of hours of practice."

I've had moments like this skiing my standby stash, Outer Mongolia in Vail's Back Bowls. I'll be cruising solo, floating through the silent forest on snow so light that my boards seem

**tip** > Avoid "paralysis by analysis": Stop thinking so much. Plan your turns in advance so your body can operate on autopilot.



**100 billion**  
NEURONS IN AN ADULT BRAIN

**200 billion**  
STARS IN OUR GALAXY

**25**

WATTAGE OF  
BULB THE BRAIN'S  
ENERGY COULD  
LIGHT

**23**

HOURS PER WEEK  
THE AVERAGE  
WORLD-CLASS  
ATHLETE TRAINS

**10**

PERCENTAGE THE  
BRAIN SHRINKS IN  
MASS FROM AGE  
20 TO 90

**1**

ADDITIONAL HOUR PER  
NIGHT ELITE ATHLETES  
SLEEP

## YOUR BRAIN ON SKIS

airborne, when suddenly: rapture. I am no longer thinking, only moving without time or place. The sensation is always fleeting, though I want it to last forever. But it's during these rare instances when I glimpse how it must feel to have your mind-body connection honed, like a seasoned athlete's, to visceral perfection.

**Freigang, a sports psychologist** who works with the U.S. Ski Team, tells me about Hebb's law. It describes a transformation in the brain that happens when a cluster of neurons is repeatedly energized. Eventually, those neurons will grow and multiply and begin to fire faster and more predictably. Hebb's law would be evident in an fMRI brain scan of a professional skier, whose brain would show more neural activity than that of a novice. "Experts' brains are considerably more complex," says Freigang. "The neurons branch out, like a growing tree, every time they practice." To achieve this, a once-a-week skier like me would have to log dozens of back-to-back days—or undergo intense brain training in numerous sessions at Neurotopia.

When I return for my follow-up, Sherlin delivers my "neuroperformance profile" on a single sheet of paper adorned with multicolored bar graphs. Hale was right: I missed six squares during the button-assault test. All of them were "commissions," meaning I pushed when I shouldn't have, an indication of obsessive overanalysis. This jibes with my "focus endurance" score, which is extremely high. "You have an incredible strength for paying attention," Sherlin informs me. "It's almost as good as it gets. You can sustain focus for a long period of time and can rule out distractions quite easily." This gift, he thinks, might "predispose" me to being "good at my job," but it spells bollocks for skiing. My parents got me started skiing

nearly four decades ago, and since then I've spent thousands of hours on the slopes. By now, explains Sherlin, my motor cortex is hardwired to ski—like riding a bicycle or going for a jog—and will operate on autopilot if I let it. Only I don't. On the hill, I'm like Eagleman's pianist, micromanaging my subconscious rather than leveraging years of learned instincts. Shrink calls it "paralysis by analysis."

"The speed index is your next strongest," continues Sherlin. "This is your brain's processing ability, like its shutter speed. It regulates how quickly you can experience information from the environment and then relay it to the motor cortex." The speed score surprises me because I suck at video games and most toddlers have better hand-eye coordination. But I'll take it.

The stress index is where I hit real

"Think of the brain like the surface of a pond. If you throw a pebble anywhere in that pond, it will ripple throughout. Everything is interconnected."

trouble. "This is the difference between when you are in your baseline state and when you are in your activation task." The index measures variability, and I have virtually none. My brain barely stirs when forced to confront the unexpected. Sure, I'll be the passenger who saunters out of a fiery plane crash, coolly clutching my Pepsi and pretzels. But in sports this can be a handicap. "For skiing, it would mean you are coming in too flat," concludes Sherlin. "When stimulus is going really fast, you want an increased arousal level so that you can respond quicker."

Sherlin is confident that brain training can cure my deficits. We get started right away. I sit in front of a



### A MIND THAT MOVES

» A human brain can be connected to a computer that interprets signals for an external device. Most current brain-computer interfaces are neuroprosthetics—robotic limbs and wheelchairs that move by thought—but applications seem limitless. **Imagine cars with no steering wheels, lights with no switches, computers with no keyboards.** Pretty cool.

large flatscreen TV while Hale wires my scalp with electrodes. The QEEG is patched into video-game software that I will apparently control solely with my thoughts. The first round has me piloting a rocket ship through a corkscrewing tunnel. Initially nothing happens. Then, after several minutes of psychic determination, the engine sputters to life. Hale has tweaked the game parameters so that only those brainwaves associated with focus will propel the ship. And if those brainwaves spike acutely, it means I'm overanalyzing, which kills the engine. Hale wants me to focus ... but only a little. Next is a stock-car race set in an Aztec swamp. (Both

**tip** > Visualize. Close your eyes and see yourself skiing down a run you're afraid of. By imagining it, you reduce uncertainty and therefore become less afraid.

games were developed by Somatic Vision, one of several companies that market neurofeedback software.) The course is fraught with distractions— inexplicable explosions, abrupt detours, and screeching pileups. When I try ignoring the mayhem, which Hale knows I'm good at, my vehicle stops. It won't move if I get too frazzled, either. The objective is to elicit a stress response that forces me to maintain a mindset somewhere between complacency and panic.

After my half hour with Hale, the length of a typical session, he shows me snippets of brainwaves he recorded, noting where my focus and stress impulses fired within the desired training parameters. It seems I'm already progressing (the dearth of ski-themed games notwithstanding). Gervais recommends 20 or more

ability to control thinking. Researchers used fMRI to observe changes in participants who underwent brain-training exercises and as a result were better at performing high-level mental tasks. For a motor-skill sport such as skiing, many scientists believe that neurofeedback is almost certainly productive. At a minimum, it can teach you how to relax and focus. And that's a very good start because, as Gervais points out, "Your mind controls your brain and your brain controls your body. And those two things together control your performance."

**As for my performance, I'm eager to see if neurofeedback will make any noticeable difference on the slopes. A few weeks later, I head up to Arapahoe Basin to find out. It's May (A-Basin is legendary for its extended season)**

I'll be cruising solo, floating through the silent forest on snow so light that my boards seem airborne, when suddenly: rapture. I am no longer thinking, only moving without time or place.

sessions to reap the biggest benefits.

To be sure, there are those who doubt the efficacy of neurofeedback. They argue that QEEG electrodes aren't refined enough to isolate impulses emanating from distinct regions in the brain. Reversing this inexact output for training, they say, is a haphazard approach at best. Others question whether the skills are transferable to the real world—from a comfy recliner in a dimly lit room to the precipice of a Silverton couloir.

Even so, a 2011 study conducted at the University of British Columbia and published in the journal *NeuroImage* last year was the first to show that neurofeedback could enhance the

and by midmorning the temperature has scooted past 60 degrees. Much of the double-black terrain is already closed for the year, and I worry that the remaining blues won't be tough enough to test my new neural prowess. But the balmy weather creates a different kind of challenge: knee-wrenching swaths of gummy slush. It's impossible to visibly discern sticky snow from firmer spring corn. But feeling it is easy—a sudden, invisible force yanks my leg backward, as if I've skied into spring-loaded bear trap. The sensation is unnerving and kills my concentration.

On the next run, I recall the stock-car video game at Neurotopia. The underboot thrashing at A-Basin reminds



#### GET ZEN

» Neurotopia's brain training essentially teaches you how to focus. Meditation provides similar results.

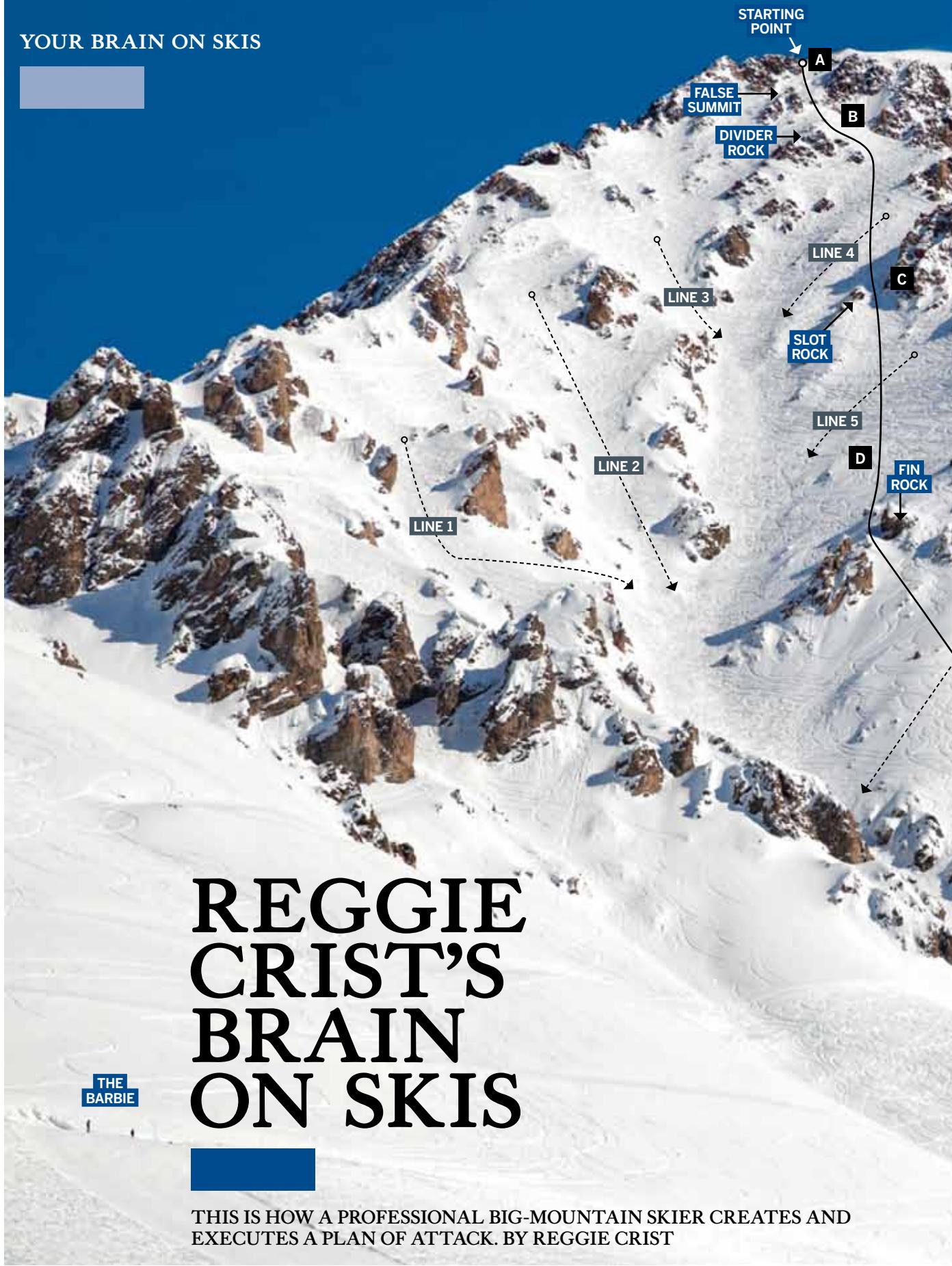
**Studies show meditation increases gray matter, which aids in information processing, and white matter, crucial for coordinating communication between regions of the brain.** Meditation also produces alpha brainwaves, present during relaxation and, in elite athletes' brains, during performance.

me of getting blindsided by errant drivers on the Aztec swamp course. I remember that Hale wanted my brain to acknowledge unforeseen trouble but stay steadily focused on driving. Trying the same thing on the hill—consciously embracing the harrowing slush bombs while letting my ingrained instincts handle the rest—makes the whole experience remarkably more fluid and enjoyable. Has Neurotopia rewired my brain? Or am I merely redoubling my effort to concentrate?

I skate onto the Lenawee Mountain lift for another lap. After loading the poky triple, I crane my head backward to let the potent alpine sun warm my face. I can smell sunscreen and pine. Though I did not expect one therapy session to markedly improve my skiing, simply being aware of how my brain works—with its specific proficiencies and deficits—has proven helpful. After 20 sessions, who knows? Meatball couloir could be all mine. ●



Listen to the pros—they know what they're doing. Turn the page for Reggie Crist's lesson on getting in the zone in Las Leñas, Argentina.



# REGGIE CRIST'S BRAIN ON SKIS

THE BARBIE



THIS IS HOW A PROFESSIONAL BIG-MOUNTAIN SKIER CREATES AND EXECUTES A PLAN OF ATTACK. BY REGGIE CRIST



## **1. RECONNOITER**

Find a vantage point with a wide view of the entire slope you want to ski. Experienced skiers sometimes call this spot “the barbie,” a term that refers to the amount of time you should spend inspecting a line—at least enough to fire up a barbecue. I can see the entire face of Eduardo’s from my barbie on the road.

## **2. ASSESS**

Acknowledge all potential lines before choosing the best one based on your ability, your goals, and the current conditions. Make mental notes of the slope’s aspect, fall line, exposure, and objective hazards that could force you to improvise.

## **3. CHOOSE A STARTING POINT**

From the barbie, make note of physical features that will help you recognize your starting point when you get to it. Your first turns will be your most consequential, so pick an entry that will inspire confidence, not fear or doubt.

## **4. MAP KEY LANDMARKS**

Making a mental plan of your run establishes confidence; when you know where you’re going, you’re more likely to ski fluidly and aggressively. From my scouting point, I can see a gas pipeline at the summit, and I decide I’ll start my descent just skier’s left of it. After dropping onto the slope, I’ll have to keep my momentum up so I can crest the False Summit before turning above the Divider Rock—skier’s right toward Lines 1 to 3 or skier’s left toward Lines 4 to 6.

## **5. ESTIMATE DISTANCES**

From my scouting location, I like to guess the number of turns it will take to get from one landmark to the next. This is one of the most difficult skills to master because perceived distances can change depending on your scouting location. Terrain features such as the Slot Rock will force many tighter turns; Line 5 offers room for a few big turns.

Eduardo’s in Las Leñas, Argentina, is famous for its relentless pitch and complex terrain options, and it’s one of Crist’s favorite runs anywhere.

Get real. Turn the page. 



**POINT A:**

Terrain always looks different when you're staring down at it between your ski tips. The entry is thinner than I expected, so I need to search for the deepest snow. The south-facing aspects are more shaded in the Southern Hemisphere and typically hold the best snow. I rehearse my line, take a few deep breaths, rock forward, and let gravity take control.



**GASEX PIPELINE**



**DIVIDER ROCK**



**SLOT ROCK**



**FIN ROCK**



**WHALE TAIL**

**POINT B:**  
My plan was to stay skier's right of the Divider Rock, then drop into Line 1. But after I regain the ridge of the False Summit, my first glance around the Divider Rock reveals colder, better snow conditions to skier's left, so I'll react accordingly. I'm fewer than 10 turns into my run, and I've already improvised.

**POINT C:**  
I remember this small Slot Rock from my mental map. I can either drop to the right of it to ski a short fall-line pitch into the Main Vein or I can thread the needle into the sustained pitch of Line 5, where I can milk a few wide-open GS turns. I thread the needle and open it up for a few turns in the untracked.

**POINT D:**  
The fall line wants to suck me into the Main Vein, which drains into the gully, but I'm not done playing yet. I remember a small gateway just below the Fin Rock that will lead me to the open snowfield at the bottom of Line 6. I'll bang a hard left under the Fin Rock for some hidden pow stashes.

**POINT E:**  
From my scouting point, I saw the tasty-looking couloir between Lines 6 and 7, and the Whale Tail rock that would be my landmark. When I see it on my descent, I know I can cross over the top to seek out the final shady chute. I recall from my distance estimates that I have only four or five more turns until I reach the Exit Gully.

**tip** > There comes a time when your legs start screaming and the fatigue of brain-strain sets in. The best remedies are more powder turns and less thinking. Exhale at the apex of each turn, dig deep, and keep charging.