ELEMENTS

WHAT ARE DREAMS FOR?

Converging lines of research suggest that we might be misunderstanding something we do every night of our lives.

By Amanda Gefter
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Illustration by Lina Müller

In the late nineteen-nineties, a neuroscientist named Mark Blumberg stood in a lab at the University of Iowa watching a litter of sleeping rats. Blumberg was then on the cusp of forty; the rats were newborns, and jerked and spasmed as they slept. Blumberg knew that the animals were fine. He had often seen his dogs twitch their paws while asleep. People, he knew, also twitch during sleep: our muscles contract to make small, sharp movements, and our closed eyes dart from side to side in a phenomenon known as rapid eye movement, or REM. It's typically during REM sleep that we have our most vivid dreams.

Neuroscientists have long had an explanation for our somnolent twitches. During REM sleep, they say, our bodies are paralyzed to prevent us from acting out our dreams; the twitches are the movements that slip through the cracks. They're dream debris—outward hints of an inner drama. Human adults spend only about two hours of each night in REM sleep. But fetuses, by the third trimester, are in REM for around twenty hours a day—researchers using ultrasound can see their eyes flitting to and fro—and their whole bodies seem to twitch. When a mother feels her baby kick, it may be because the baby is in REM sleep. Once born, babies continue to spend an unusual amount of time in REM, often sleeping for sixteen hours a day and dreaming for eight.

Increasingly, these facts struck Blumberg as odd. In adults, dreams are offshoots of waking life: we have experiences, then we dream about them. But a baby in the womb hasn't had any experiences. Why spend so much time in REM before you have anything to dream about? According to the dominant theory, the rats' twitching eyes were supposedly looking around at dream scenery. But the rat pups were just days old; their eyelids were still sealed shut, and they'd never seen anything. So why were their eyes—and their whiskers, limbs, and tails—twitching hundreds of thousands of times each day?

Blumberg decided to put the dream-debris theory to the test. He surgically removed the rats' cortex—the brain region, involved in visual imagery and conscious experience, where dreams were believed to originate—leaving only the brain stem, which controls subconscious bodily functions, intact. The sleeping pups continued to twitch exactly as before. "There was no way that twitching was a by-product of dreams," Blumberg told me, when we spoke last fall.

Now in his sixties, Blumberg is the chair of the Department of Psychological and Brain Sciences at the University of Iowa. He has spent the past twenty years studying sensorimotor development—the process through which an infant's brain links up with its body. Twitches had long been overlooked by sensorimotor researchers. "If you've been told since Aristotle that they're remnants of dreams—well, who wants to study a remnant?" he said. But, in fact, the science of dreams was far from settled. Freudians believed that they contained repressed wishes dredged from the dark corners of psychic life; many neuroscientists have seen them as random brain chatter. Some theories have suggested that dreams consolidate our memories, others that they help us to forget. With twitches, Blumberg had identified a new thread in the mystery of dreaming. By pulling, could he unravel the whole?

For centuries, how we think about dreams has shaped how we think about minds. On the night of November 10, 1619, René Descartes dreamed that he was stumbling down the street pursued by ghosts. His right side was weak, and a whirlwind spun him violently on his left foot; he limped past a man whom he suddenly realized he knew, then turned to speak to a different man, who told him to go see Monsieur N., who had something to give him. Descartes knew what it was: a melon.

A lesser thinker might have seen in this dream a craving for cantaloupe. But, to Descartes, its vividness seemed to suggest a clear disjunction between the body and the mind: in dreams the body lies dormant while the mind runs free. Today, scientists often draw a similar distinction, albeit between the body and the brain, rather than the immaterial mind.

This notion was bolstered by early sleep science. In 1953, when two scientists at the University of Chicago, Eugene Aserinsky and Nathaniel Kleitman, discovered REM sleep, they found that it was accompanied by surprisingly high levels of activity in the brain—as if the dreaming brain had woken up while the body remained sleeping. In the following years, the American sleep scientist William Dement and the French neuroscientist Michel Jouvet each observed that, when cats enter REM, they lose all muscle tone. The same is true for humans—the result, Jouvet discovered, of inhibitory signals, sent by the brain to the spinal cord, that paralyze the body. When this paralysis fails, it results in REM behavior disorder, in which people may talk, kick, and even act out violently in their sleep. When it persists, we experience "sleep paralysis," in which we wake up unable to move. When the system works as it should, Jouvet wrote, we enjoy "paradoxical sleep": our brains come alive with wild visions as our bodies go motionless between the sheets.

Researchers attempted to determine whether the paralyzed body could influence the dreaming brain. They pumped the odor of peppermint into sleepers' noses, hoping to create scented dreams, to no effect. They taped dreamers' eyes open and showed them various objects—a coffeepot, a handkerchief, an ironic "Do Not Disturb" sign—hardly anyone reported dreaming about them. The brain is less responsive to sensory input during REM sleep, which is why even a blaring alarm clock can fail to wake us.

By the late nineteen-seventies, the idea of a total "input-output blockade" between body and brain during REM sleep had emerged. J. Allan Hobson, the late Harvard Medical School psychiatrist, proposed that dreams were constructed when random signals from the brain stem were interpreted by the cortex as signals from an outside world. "Dreaming is no longer mysterious," he declared. And yet the theory couldn't explain why we dream what we dream, or why we feel what we feel when we dream it. In the following decades, scientists challenged, revised, and even rejected Hobson's theory, but they largely retained its core assumption about the severed connection between brain and body.

"I've been collecting videos of all kinds of cool animals sleeping," Blumberg told me. His collection includes monkeys, pigeon chicks, jumping spiders, and fetal sheep. There are the quivering antennas of honeybees, and the fidgeting fists of kangaroos. In one video, a sleeping octopus kaleidoscopes from one camouflage to another as the muscles controlling its chromatophores move beneath its skin. The videos attest to the apparent universality of twitching: not only do many animals twitch in REM but they start before they're born.

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After finding that sleep twitches in early development aren't caused by activity in the cortex, Blumberg increasingly wondered whether it might be the other way around—perhaps the twitches were sending signals to the brain. Hardly anyone had considered this possibility, because it was assumed that the blockade would keep sensations out. It took Blumberg and his team years to build equipment capable of getting clean brain recordings from tiny, wriggling pups, but eventually, they were able to implant electrodes into rat pups' brains, recording their neural activity while high-speed cameras captured their twitching.

The results were startling. "I could explain it in words, but it might help to see what it looks like," Blumberg said, pulling up a video on his screen. It showed the front paw of a sleeping rat pup, hanging limp. "We assigned a different sound to each neuron in the brain that we're recording from," he explained. When he started the video, the paw began to twitch—and, with each twitch, musical notes resounded from different neurons in the brain. The effect was like a church organ playing underwater; chords rolled then subsided. An electrode readout made the order of events clear: first the pup moved, then the brain responded. Bursts of activity in the sensorimotor cortex, which coördinates movement and sensation, followed the twitches. The body and brain weren't disconnected. The brain was listening to the body.

In a series of papers, Blumberg articulated his theory that the brain uses REM sleep to "learn" the body. You wouldn't think that the body is something a brain needs to learn, but we aren't born with maps of our bodies; we can't be, because our bodies change by the day, and because the body a fetus ends up becoming might differ from the one encoded in its genome. "Infants must learn about the body they have," Blumberg told me. "Not the body they were supposed to have."

As a human fetus, the thinking goes, you have nine months in a dark womb to figure out your body. If you can identify which motor neurons control which muscles, which body parts connect, and what it feels like to move them in different combinations, you'll later be able to use your body as a yardstick against which to measure the sensations you encounter outside. It's easier to sense food in your mouth if you know the feeling of a freely moving tongue; it's easier to detect a wall in front of you if you know what your extended arm feels like unimpeded. In waking life, we don't tend to move only a single muscle; even the simple act of swallowing employs some thirty pairs of nerves and muscles working together. Our sleep twitches, by contrast, are exacting and precise; they engage muscles one at a time. Twitches "don't look anything like waking movements," Blumberg told me. "They allow you to form discrete connections that otherwise would be impossible."

While he spoke, I stared, mesmerized, at the rat pup's twitching paw. Blumberg suspects that it was twitching "to build its sense of self." The theory, he pointed out, turned the rationale for REM paralysis on its head: the paralysis isn't there to stop the twitches but to highlight them. It's a process that's most important in infancy, but Blumberg thinks this might continue throughout our lives, as we grow and shrink, suffer injuries and strokes, make new motor memories and learn new skills. Blumberg plays the drums, and, when he learns a new rhythm, he wonders whether sleep is involved. "You struggle and struggle for several days, then one day you wake up and start playing and boom—it's automatic," he said. "Did sleep play a role in that? If I had been recording my limb movements, would I have seen something interesting? That keeps me up at night."

Throughout the years, I've sometimes recorded my dreams in notebooks. After talking to Blumberg, I pulled out an old one and flipped through it. Some were full-fledged narratives. (My car, of its own volition, drives me to the woods to see a rare species of duck; when I arrive, the duck has been murdered, and I'm accused of the crime.) Others were just images. (A billboard shows a man squatting over a bidet with a confused and frightened look on his face; he's shouting, "Get my wife!") Sometimes I'd written down only enigmatic sentences: "Shark bird flew into my mouth." How did tiny muscle movements, supposedly designed to wire up my sensorimotor system, result in such demented stuff? By what twisted route does one go from a twitch to a shark bird?

For clues, I consulted "Dreaming," by Jennifer Windt, a philosopher of mind at Monash University, in Australia. In the course of eight hundred pages, Windt seeks to answer big questions: What kinds of experiences are dreams? Why do they feel so strange yet so meaningful? What can they tell us about consciousness? She synthesizes the philosophy and science of dreams, encountering the input-output blockade everywhere she looks. In dreams, Hobson writes, our brains create "an impressively rich state of consciousness" without any information from the senses. According to the neuroscientist Christof Koch, in his book "Consciousness," paralysis in dreams proves that "behavior is not really necessary for consciousness"—"the adult brain, even if cut off from most input and output, is all that is needed to generate that magical stuff, experience."

When Windt began her research, she told me, she, too, was convinced that "dreaming shows that everything we're experiencing is a product of the brain." As she dug deeper, however, she found a number of studies suggesting that our bodies can in fact shape our dreams. Eventually, she stumbled upon Blumberg's experiments. ("I was really excited when I found his work," she said.) Research suggests that dreaming brains still register the erratic heart rate, variable breathing, and fluctuating blood pressure that are typical during REM sleep. Some scientists believe that a dreaming brain may be keyed into the body's vestibular system, which uses organs in the inner ears to detect accelerations and rotations, telling us how we're positioned and whether we're moving. Without visual cues, the system can't tell the difference between gravity and acceleration, making it difficult to detect whether you're lying still horizontally or standing vertically and moving. When I consulted my dream notebook, I saw that I was upright and moving in nearly every dream I'd recorded; even when I was seated, I was still being moved—by a train, an airplane, or, in one case, a demonically possessed swivel chair.

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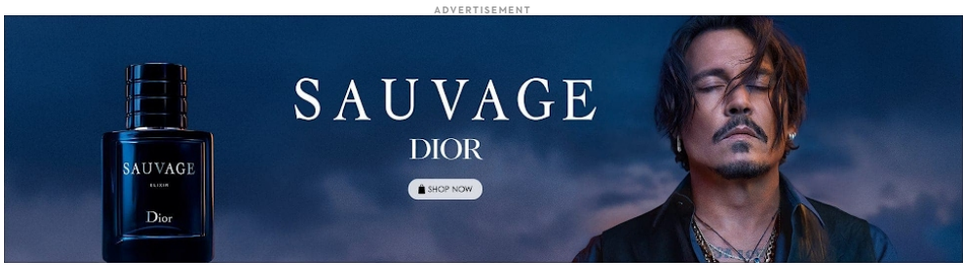

Twitches could add to the confusion in another way. In waking life, our brain easily identifies sensations created by our own movements because it sees those movements coming. But, when we dream, we stop anticipating, and we have no way to figure out what's coming from where. Perhaps we don't want to anticipate those sensations because, according to Blumberg, the whole point of twitching is to learn what those sensations are, so that we can find out what it feels like to move our own bodies. A dreamer is in a situation akin to someone suffering from schizophrenia—an illness often marked by a profound difficulty in distinguishing between self and other. Healthy people can't typically tickle themselves, but people with schizophrenia can; yet researchers have found that, if healthy people woken from REM sleep tickle themselves, they often respond to their own touch as if it's someone else's. We seem to be confusing self with other. "That's at the core of dream experience," Windt said.

Meanwhile, dreams are often intimate and meaningful; snippets from the day work their way into our dreams, mixed with places and things long forgotten. Memories, too, have long been thought a product of the brain, but are increasingly understood as also tied to the body. Using eye-tracking technology, researchers have shown that people make the same eye movements when they look at an object and when they later recall it; instructing them to train their gazes on a fixed point hinders their visual recall. Another series of experiments has shown that people more easily and accurately call up autobiographical memories when their body postures and hand positions align with those in the memory. In REM, Windt suggested, it could be that "a certain muscular sensation prompts a certain memory, which prompts related memories, and all of that gets synthesized into something new."

It's through recognizing the contributions of the body, Windt said, that we can begin to understand why dreams feel the way they do. Take Descartes's dream, in which he was terrified, limping, and whirled in a vortex before meeting his acquaintance. Emotions tend to run high in dreams, perhaps because our heart rates are so often irregular in REM. The vortex in which Descartes was caught could reflect ambiguous signals from his vestibular system; his encounter with the man could flow from his brain's baffled attempt to draw a line between self and other. Finally, Descartes's difficulty walking could well reflect the fact that his real-life legs are paralyzed. He leans to the left—which, by all accounts, is the side on which he is sleeping.

In 1968, Philip K. Dick published "Do Androids Dream of Electric Sheep?," a dystopian detective story that questioned how we can tell a person from a machine. The title suggested that the difference might depend on dreaming. (Dick was haunted by his own dreams, and believed that some other version of himself, perhaps a dream-self, was the author of his books.) The idea of dreaming androids was both fanciful and logical. It conjured the idea of an artificial being for whom body and mind were integrated on an unconscious level, like our own.

In 2013, Blumberg published a paper in *Current Biology* titled "Twitching in Sensorimotor Development from Sleeping Rats to Robots." In it, he asked, "Can twitching, as a special form of self-generated movement, contribute to a robot's knowledge about its body and how it works?" As it happened, the idea was already being put to the test. Some years earlier, a team of roboticists including Josh Bongard, now at the University of Vermont, set out, with support from NASA, to create a robot that could adapt after an injury—an ability that would be extremely useful if it should get stuck or damaged on a distant planet. Early in the work, the team was struck by a dilemma. "If you're caught in a rock slide or something really bad happens, most of the actions you could perform are going to make things worse," Bongard told me. A stuck robot might be better off not moving—and yet it can't get out of danger until it figures out what's happened to it.

The roboticists came up with a clever solution: twitches. When it's stuck, their four-legged robot, nicknamed the Evil Starfish, moves the mechanical equivalent of one muscle at a time. Input from the twitches is used by its software to create different interpretations of what is happening; the software then orders new twitches that might help disambiguate the scenarios. If the robot finds that it's suddenly tilting thirty degrees to the left, it might entertain two interpretations: it's either standing on the side of a crater, or missing its left leg. A slight twitch of the left leg is enough to tell the difference.

In work published in *Science*, in 2006, the team showed that their Evil Starfish robot could essentially learn to walk from scratch by systematically twitching to map the shape and function of its body. When the team injured it by pulling off its leg, it stopped, twitched, remapped its body, and figured out how to limp. Watching the robot twitch, a fellow-researcher commented that it looked like it was dreaming. The team laughed and thought nothing of it until the fall of 2013, when Bongard met Blumberg when he gave a talk on adaptive robots. Suddenly, the idea of a dreaming robot didn't seem so far-fetched. "Dreaming is a safe space, a time to try things out and retune or debug your body," Bongard told me.

Are the robots really dreaming? If to dream is to make sense of ambiguous bodily signals, then the answer is yes. But, for us, dreams are a deeper kind of synthesis. As she sleeps, it's as if a person, her brain, and her body converse imperfectly; their delirious miscommunication is the dream.

Not long after I spoke to Windt, I dreamed that I was standing in the kitchen of my childhood home. My Labrador retriever, who in real life died thirteen years ago, walked over and leaned against my leg. I looked down at her, into her eyes, and stroked the side of her face. When I awoke, I was shaken. The feeling of her weight against my thigh and the texture of her cheek, like crushed velvet, were sensations so specific that I could never have recalled them in conscious memory even if I'd tried. I lay in bed, grateful for whatever confusion had parsed my sleeping self into me and the dog I'd loved—whatever pattern of eye movements had conjured up her earnest face; whatever buried motor memory had played my twitching fingers across her cheek. ♦

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