SCIENCE

A New Test for an Old Theory About Dreams

When a sleeping animal's eyes twitch beneath its eyelids, is it looking around a dream world?

By Ed Yong

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When Massimo Scanziani's daughter was young, he'd often see her eyes twitching beneath her eyelids while she was sleeping. These rapid eye movements (or REMs) are so obvious, Scanziani told me, that he can hardly believe that they were described just seven decades ago. In 1953, Eugene Aserinsky and Nathaniel Kleitman identified a special phase of sleep when neurons were abuzz and eyes were shut but flitting about. During this phase, now called "REM sleep," people tended to have vivid dreams. Maybe, Kleitman suggested, the eye movements reflected "where and at what the dreamer was looking" in their virtual world.

Several researchers tested this "scanning hypothesis" in the '50s and '60s by waking sleeping volunteers when their eyes twitched and asking them what they had just dreamed. Perhaps unsurprisingly, these crude methods failed to produce consistent results. But despite alternative explanations—maybe the movements lubricate the closed eye or arise from random brain activity—the scanning hypothesis remains popular. And through a clever experiment involving mice, Scanziani and his colleague Yuta Senzai, who are both neuroscientists at UC San Francisco, think they've finally shown that eye twitches are a direct line into an inner dream world.

As a mouse moves, a group of neurons in its brain tracks the direction of its head, acting like an internal compass. Some of these neurons fire when the mouse turns left; others buzz when it turns right. By analyzing a mouse's activity, a scientist can tell you where it is facing without ever looking at the rodent itself. And during REM sleep, even though a mouse's head isn't moving, its head-direction cells still fire as if it were exploring.

Scanziani and Senzai reasoned that, by recording the activity of these neurons with implanted electrodes, they could work out where sleeping mice are looking in their dream worlds. They then showed that the signals from this internal compass matched the movements of the rodents' eyes (which they could track because mice often sleep with their eyes slightly open). When a mouse seems to move its head around in its dream, its eyes flick in the same direction, to the same degree, and at the same moment. "The rodent is certainly exploring the environment in its dream," Scanziani told me. "By looking at its moving eyes, we have a window into its dreaming brain."

These results suggest that "in their dreams, mice are *attending* to the events unfolding before them and interacting with them actively, intentionally, and dynamically," says David Peña-Guzmán, a philosopher at San Francisco State University and the author of *When Animals Dream*. Many philosophers would regard that as "a clear indicator of consciousness," he told me.

But other sleep researchers are not convinced that Scanziani and Senzai showed what they think they showed. Sara Aton, a neuroscientist at the University of Michigan, told me that head and eye movements are so tightly coupled when mice (and humans) are awake that you wouldn't expect them to suddenly disconnect during sleep. That they remain linked doesn't tell us whether mice are perceiving a dream world, let alone gazing about it. "We simply can't read that out from the brain," Aton said. Mark Blumberg, a neuroscientist at the University of Iowa, agrees. "The link to dreams is gratuitous," he told me. Scanziani and Senzai "assert that they're peering into the virtual world of dreams, but they haven't done so—nor can they."

At first glance, this might seem like a semantic argument: "I can say that we're looking at coordinated activity of distinct parts of the brain occurring during REM sleep that strongly resembles the activity that the brain has when it's awake, or I can call it a dream," Scanziani said. But those things *aren't* necessarily identical, and Blumberg argues that equating them could distract us from understanding the role of REM sleep.

He notes that when eyes move during this phase, other body parts twitch too, including limbs and whiskers. These movements look like more evidence of dreams spilling into reality—sleeping dogs chasing imagined rabbits—but they might represent something simpler. Blumberg argues that the brain uses REM sleep to test-drive the body. The brain pings the neurons that control muscles, creating twitches; it then collects sensory information from those moving limbs. By testing those connections during times of stillness, it can refine and recalibrate the network to work more efficiently during times of wakeful chaos. According to this view, REM-phase movements aren't about dreams at all. They're the work of a brain that's learning how to more effectively pilot a body.

This explanation better accounts for aspects of REM sleep that don't easily fit with the scanning hypothesis. For example, people who are born blind still move their eyes during sleep, even though they don't dream visually and clearly aren't looking around. Also, the REM phase of sleep is longest in newborn humans, mice, and other mammals whose infants are relatively helpless at birth. These are exactly the individuals whose brain would need the most time to get to grips with their body. By contrast, if the twitches are linked to dreams, "why would newborns twitch so much when they have so little to dream about?" Blumberg said.

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Since its discovery, REM sleep has been associated with dreaming (even though we dream in non-REM sleep too). And because dreams are so fascinating, they became the focus of our attempts to understand REM—the sun that other hypotheses orbit around. But what if they aren't central? Scanziani told me that dreams might arise because the brain replays memories after "a long day of experiences" to better organize what it has learned, or "generates and explores possibilities to help us make better predictions when we're awake." This is essentially what the test-drive hypothesis argues, except here, the brain is just testing the connections within *itself,* rather than those with the rest of the body. It's intuitive to see the dreams and twitches of REM sleep as connected phenomena. But perhaps they're two independent reflections of a brain that's relentlessly recalibrating.