Dream States

Although we rarely remember our nighttime reveries, they may hold the key to consciousness

BY CHRISTOF KOCH

In Christopher Nolan's film *Inception,* an architecture student designs nested environments in which people's dreams will take place. In this scene, a city street folds in on itself.

IF YOU HAVE SEEN THE RECENT Hollywood blockbuster *Inception,* a movie that does to dreaming what *The Matrix* did for virtual reality, you may have been holding your breath as Ariadne, an architecture student, folded the streets of Paris over herself like a blanket. This stunning sequence, an homage to M. C. Escher, is testimony to the bizarre nature of dreams. Watching it made the neuroscientist in me reflect on what dreams are and how they relate to the brain.

The first question is easy to answer. Dreams are vivid, sensorimotor hallucinations with a narrative structure. We experience them consciously—seeing, hearing and touching within environments that appear completely real (though curiously, we do not smell in our dreams). Nor are we mere passive observers: we speak, fight, love and run.

Dream consciousness is not the same as wakeful consciousness. We are for the most part unable to introspect—to wonder about our uncanny ability to fly or to meet somebody long dead. Only rarely do we control our dreams; rather things happen, and we go along for the ride.

Everyone dreams, including dogs, cats and other mammals. But sleep lab data reveal that people consistently underreport how often and how much. The reason is that dreams are ephemeral. Memory for dreams is very limited and largely restricted to the period before awakening. The only way to remember a dream is to immediately recall it on waking and then write it down or describe it to another person. Only then does its content become encoded in memory.

Although we often have trouble remembering dreams, our dreaming selves have full access to our pasts. In dreams we recall earlier episodes from our lives, and we often experience intense feelings of sadness, fear, anxiety or joy. Perhaps it was this heightened emotionality that led Sigmund Freud to speculate that dreams serve as wish fulfillment. Regardless, the answer to my second question—how and why does the brain manufacture dreams?—remains a fundamental mystery. But psychologists and brain scientists have recently renewed their interest in this everyday surreal activity.

Perchance to Dream

In 1953 Nathaniel Kleitman of the University of Chicago and his graduate student Eugene Aserinksy discovered that slumber, which had been considered a single continuous period of down time, contains recurring periods in which the sleeper's eyes move about, heartbeat and breathing become irregular, most voluntary muscles are paralyzed and brain activity (as measured by electrocardiography) is heightened. These fast, low-voltage brain waves resemble the ones that occur during wakefulness. This state became known as rapid eye movement (REM) sleep, to distinguish it from deep sleep.

When people are woken from REM sleep, they usually report vivid dreams. Such reports do not occur when people are roused from non-REM sleep. Thus arose the close association between REM sleep and the oneiric state. For many years experts associated dream consciousness with the distinct physiology of the brain during REM sleep.

But in the past several decades that understanding has begun to slowly shift. When people who are woken from deep sleep are asked "What was passing through your mind just before you woke up? " rather than the more biased "Have you been dreaming?" a more nuanced picture emerges.

In the early phases of deep sleep, and during short daytime naps, which consist of pure non-REM sleep, people report vivid hallucinations that are shorter, more static and more thoughtlike than the dreams that occur during REM sleep. These visions are typically more like snapshots than narratives and do not include a self. Yet a minority of these non-REM dream reports are indistinguishable from REM dreams.

It is also notable that sleep-walking and nightmares occur in deep, not REM, sleep. Thus scientists have had to revise the belief that the REM state is an external manifestation of the subjective dream state.

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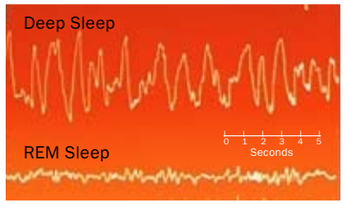

Brain waves are slow and even during periods of deep sleep, faster and more variable during REM sleep. Early research linked dreams to REM sleep, but scientists now know that dreams occur in both states.

Further evidence comes from the study of brain-damaged patients by neuropsychoanalyst Mark Solms of the University of Cape Town in South Africa. When a part of the brain stem known as the pons is destroyed, people no longer experience REM sleep. But only one in 26 of such patients reports a loss of dreaming, and nobody has ever reported loss of dreaming from limited pons damage.

The regions critical for dreaming are not in the pons. They include the visual and audiovisual regions in and near the temporoparietal-occipital junction in the neocortex. Destruction of small portions of these areas leads to the loss of specific dreaming dimensions. For example, a stroke, tumor or other calamity in the cortical region necessary for color or motion perception will leach hue or movement from dreams.

Moreover, medications that manipulate dopamine levels strongly affect dreaming while leaving the REM sleep cycle unaffected. L-dopa, the most popular medication for patients with Parkinson's disease, increases the frequency and vividness of dreams, whereas antipsychotic drugs that block dopamine reduce dreaming.

The dissociation of dreaming from REM sleep serves as a conceptual clearing of the deck for neuroscientists such as myself. Now we can focus on the neuronal causes of conscious mental activity, whether in a dreaming or wakeful state, without being confused by extraneous factors such as REM or non-REM sleep that, it turns out, do not pertain to subjective experience per se.

The Mind-Body Problem

Why am I so confident that I experience anything while dreaming? Maybe I am really unconscious while slumbering and merely confabulate my dreams when I wake up.

This is unlikely for many reasons. The bizarreness and vividness of dreams is distinct from normal experience and therefore unlikely to be "retrofitted" Indeed, people with memory deficits do not report fewer dreams. Additionally, the length of dream reports correlates well with time elapsed in REM dreams.

And more evidence comes from people with a pathology known as REM sleep behavior disorder, who lack the muscle paralysis (known as atonia) that is a hallmark of REM sleep. They act out their dreams, on occasion, causing damage to themselves or their bed partners, and most important, their actions match their dream reports. For example, when they say they have dreamed about walking, they moved their legs during REM slumber.

Dreams are of great interest to the student of the mind-body problem, because they bear witness that the brain alone is sufficient to generate consciousness. We dream with eyes shut in the dark, disconnected from the outside world. The brain regions responsible for basic sensory perception are deactivated. Nor is behavior necessary, as we are motionless except for our breathing and eye movements. Thus, dreaming supports the old philosophical brain-in-the-vat idea that saw its modern renaissance in *The Matrix*.

Cognitive neuroscientists have recently learned to decode some simple mental states—in essence, a primitive form of mind reading. When scientists ask people to view one of two images—a portrait or a photograph of a house—or to imagine either a face or a house, they can tell from brain analyses which of the two the person is seeing or imagining.

Once such techniques become more sophisticated, they could be put to use in dream work, so that in addition to studying the physiology of the dreaming brain, investigators will be able to read out the content of the dream itself. Then neuroscience will be in a much better position to answer the age-old questions that have fascinated everyone from oracles and shamans to Freud and, more recently, science-fiction enthusiasts, namely: Why do we dream, and what do our dreams mean? M

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(Further Reading)

- **Dreaming and the Brain: Toward a Cognitive Neuroscience of Conscious States.** J. Allan Hobson, Edward F. Pace-Schott and Robert Stickgold in *Behavioral and Brain Sciences,* Vol. 23, pages 793–842; 2000.
- **Dreaming and REM Sleep Are Controlled by Different Brain Mechanisms.** Mark Solms in *Behavioral and Brain Sciences,* Vol. 23, pages 843–850; 2000.
- **Dreaming and the Brain: From Phenomenology to Neurophysiology.** Yuval Nir and Giulio Tononi in *Trends in Cognitive Sciences,* Vol. 14, pages 88–100; 2010.