The Mysteries and Benefits of Sleep

The task looks as simple as a "Sesame Street" exercise. Study pairs of Easter eggs on a computer screen and memorize how the computer has arranged them: the aqua egg over the rainbow one, the paisley over the coral one -- and there are just six eggs in all.

Most people can study these pairs for about 20 minutes and ace a test on them, even a day later. But they're much less accurate in choosing between two eggs that have not been directly compared: Aqua trumped rainbow but does that mean it trumps paisley? It's hazy -- that is, until you sleep on it.

In a study published in May, researchers at Harvard and McGill universities reported that participants who slept after playing this game scored significantly higher on a retest than those who did not sleep. While asleep they apparently figured out what they didn't while awake: the structure of the hierarchy that linked the pairs.

"We think what's happening during sleep is that you open the aperture of memory and are able to see this bigger picture," said the study's senior author, Matthew Walker, a neuroscientist now at the University of California, Berkeley. He added that many such insights occurred "only when you enter this wonder-world of sleep."

Scientists have been trying to determine why people need sleep for years. They know that sleep loss makes you more reckless, more emotionally fragile, less able to concentrate and almost certainly more vulnerable to infection. They know, too, that some people get by on as few as three hours a night, even less, and that there are hearty souls who have stayed up for more than week without significant health problems.

Now, a small group of neuroscientists is arguing that at least one vital function of sleep is bound up with learning and memory. A cascade of new findings, in animals and humans, suggests that sleep plays a critical role in flagging and storing important memories, both intellectual and physical, and perhaps in seeing subtle connections that were invisible during waking.

The theory is controversial, and some scientists insist that it's still far from clear whether the sleeping brain can do anything with memories that the waking brain doesn't also do, in moments of quiet contemplation.

Yet the new research underscores a vast transformation in the way scientists have come to understand the sleeping brain. Once seen as a blank screen, a metaphor for death, it has emerged as an active, purposeful machine, a secretive intelligence that comes out during periods of dreaming and during the netherworld chasms known as deep sleep. "To do science you have to have an idea, and for years no one had one; they saw sleep as nothing but an annihilation of consciousness," said J. Allan Hobson, a psychiatry professor at Harvard. "Now we know different."

The evidence was there all along. Infants make sucking motions when asleep, and their closed eyelids quiver. But it wasn't until the early 1950s, in a lab at the University of Chicago, that scientists recorded and identified what was happening. Eugene Aserinsky, then a graduate student in physiology, reportedly was monitoring sleep and waking in his 8-year-old son, using electronic leads stuck to the boy's head, connected to a brain-wave detecting machine. He had attached two leads to the boy's eyelids as well, so he could tell whether his son woke up. One night he noticed percolating wave patterns that showed the boy had awoken. But he hadn't.

Aserinsky confirmed the activity in others, and in 1953 he and his adviser, Nathaniel Kleitman, published the finding in a now famous paper in Science. They later called the odd, unconscious state rapid eye movement, or REM, sleep.

"This was really the beginning of modern sleep research, though you wouldn't have known it at the time," said William Dement, then a medical student in Kleitman's lab and now a professor of psychiatry and sleep medicine at Stanford University. "It took years for people to realize what we had."

Dement, infatuated with Freud's theories about dreams, quickly threw himself into the study of REM. He found that it was universal and occurred periodically through the night, alternating with other states. He gave them names: Stages 3 and 4, or deep sleep, when electrical waves roll as slow as mid-ocean swells; Stage 2, an intermediate stage between REM and deep sleep; and Stage 1, light sleep. He also confirmed the link between REM and dreaming.

Yet Dement, Hobson and others found in their studies scant evidence to confirm that dreams were the disguised, forbidden wishes described by Freud. They found instead a tangle of apparent anxieties, fantasy and vivid, often nonsensical replays of events that showed few verifiable patterns or measurable function.

They had hit a wall, and sleep research dropped back into a void. Then in 1994, a research team in Rehovot, Israel, led by Avi Karni found that depriving people of REM sleep undermined memory of patterns they had learned the day before, while depriving them of deep sleep did not.

Since then study findings suggest that the sleeping brain works on learned information the way a change sorter does on coins. It seems first to distill the day's memories before separating them into categories. It then bundles them into readable chunks, at different times of the night.

Dreams still defy scientific measurement but they, too, have a place in the evolving theory of sleep-dependent learning. It is likely during REM, some scientists argue, that the brain proceeds to mix, match and juggle the memory traces it has preserved, looking for hidden connections that help make sense of the world. This process could account for the cockeyed, disjointed scenes that occur during dreams.

It also might account for that golden gift often attributed to a night's sleep: inspiration.

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