To Sleep, Perchance to Sing
Most of us are familiar with the boost in mental acuity that follows a good night’s rest. Some of this increase can be attributed to our gaining ground on the epidemic of sleeplessness, but that’s not the whole story. For learning and memory in particular, some of this brain boost comes from an active process that’s unique to sleep. The process—known as “memory consolidation”—helps cement what we learn.

In a finding that adds a new wrinkle to our understanding of how sleep influences learning and memory, CSHL theoretical neuroscientist Partha Mitra (left) and his colleagues have discovered that sleep helps young birds master the art of song, but it does so in a surprising way.

The study reveals that when zebra finches first wake up, they are actually dramatically worse singers than they were the day before. Moreover, individual birds that are the least tuneful during their “morning rehearsals” eventually become the best singers of all.

“We study birdsong as a way of uncovering neurological principles that might apply to brain development, learning, and memory across-the-board, including in humans,” says Partha.

The study examined the effect of sleep on song learning in young zebra finches. Individuals of this species are active in the daytime, do not sing in darkness, and develop their song during a critical window of “brain plasticity” between one and three months after hatching.

In order to learn to sing, it’s known that young birds must hear an adult song, and through practice, develop their own version of the tune by comparing their vocalizations to a memory template of the song that they “hear in their heads.” In fact, University of Chicago researchers have found that zebra finch brain regions involved in song learning are active while the birds are asleep (see front cover). Until now, however, there has been no direct evidence that sleep affects song learning, and if so, how.

“Sleeping birds may be dreaming they’re singing, but without actually hearing the result, it’s difficult for them to know what mistakes they’re making. In any case, by recording their singing when they are awake, we’ve learned quite a bit.”

To collect the data used in the study, City College New York behavioral neuroscientists Ofer Tchernichovski and Sébastien Derégnaucourt recorded every vocalization—approximately a million syllables per bird—made by 12 young male zebra finches over several months as the birds imitated and perfected their own renditions of recorded adult male zebra finch songs.

Typically, researchers collect and analyze only sporadic recordings of birdsong. “But some time ago, Ofer and I thought, ‘Why not record all of the songs and see what we find?,’” says Partha. The team also wrote custom software for converting the huge quantities of data into simple measures of birdsong quality.

Surprisingly, instead of showing gradual improvement in which they might wake up each day and “pick up where they left off” in their vocal abilities, many of the birds displayed dramatic nighttime degradation in the quality of their songs. However, their song quality improved after intense morning rehearsal to the point where by the end of each new day, their singing was indeed better than the day before.

The study yielded another counterintuitive result, namely, that birds which ultimately learn to sing better than others actually awaken each morning as poorer singers than their ultimately less tuneful counterparts.

“We have more work to do to explain this ‘one step back, two steps forward’ effect of sleep on the brain circuits that govern vocal learning. But a useful analogy for now is the tempering of steel, in which to gain its ultimate structure and strength, the metal is first weakened,” says Partha.

Vocal learning in songbirds bears similarities to human speech acquisition: Novice birds go through a period of “screeching” before learning to imitate songs accurately (see images above), much as babies babble before grasping words. Therefore, to explore the significance of their birdsong discoveries to human development, Partha hopes to study the vocalizations of infant children.

“We won’t influence or disturb them in any way,” assures Partha. “We will simply record their vocalizations over time. Maybe we’ll see interesting sleep effects—who knows?” Only time, and a good night’s rest, will tell. Christopher Mims