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# Unlocking the Memories Inside our Minds

*~ By investigating the phenomenal memory of chickadees, Dmitriy Aronov, PhD, brings a fresh approach to studying how our own brains remember. Now he's being recognized as one of the nation's top early-career scientists. ~*

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NEW YORK — Though its brain is no bigger than a raspberry, the chickadee has a memory that would put any Jeopardy contestant to shame. It likes to save its food for later, hiding seeds in in tree bark and other places for safe keeping. A single bird can, in one day, store as many as 7,000 bits of a food — each in a different spot — and remember many of those locations for weeks.

This remarkable ability has caught the attention of Dmitriy Aronov, PhD, a young neuroscientist and principal investigator at Columbia's Mortimer B. Zuckerman Mind Brain Behavior Institute. Dr. Aronov is studying the powerful memory of chickadees to learn more about how memory works in our own brains. He was recently named a Robertson Investigator, a prestigious honor granted by the New York Stem Cell Foundation that gives $1.5 million over five years to help Dr. Aronov build his lab and develop his research program.

"I would like to understand memory in its purest form," says Dr. Aronov, who is also an assistant professor of neuroscience at Columbia University Irving Medical Center. "Every waking moment of our lives, our brains form memories of our experiences — from the most mundane to the most cherished. And truly deciphering the details of that process, at the level of individual neurons in the brain, has proven daunting."

One reason memory has proven challenging to study, Dr. Aronov argues, is in part tied to how it is investigated. The brain's headquarters for learning and memory lies in a region called the hippocampus. The hippocampus is critical for forming episodic memories, which include memories of peoples, places and events. To tease apart the inner workings of this brain region, scientists often conduct experiments with mice and rats. These rodents are good at forming memories; they can learn to pull levers for food and to run through complicated mazes. But they have to be trained to perform these tasks.

The kind of memory involved in learning these tasks is different from the kind of memories we form about our daily experiences, says Dr. Aronov.

"The memories we make every day about our surroundings don't require any training at all," he says. "As a result, it is difficult to link the process of storing and recalling memories to specific, neural activity within the hippocampus itself."

Looking for a new way to study episodic memory, Dr. Aronov turned to chickadees. Their ability to remember where they stored a piece of food requires no training; it is spontaneous, like remembering a time you saw a shooting star or where you put your keys.

"This was the behavior that I had been searching for," says Dr. Aronov. "By caching and then retrieving food items, the birds are effectively telling the observer what they remember and when. This is in stark contrast to traditional model organisms, such as mice and rats, where it is much harder to know exactly what an animal remembers at a given moment in time."

To study chickadees in the lab, Dr. Aronov and his team built an indoor environment inspired by their home in the woods.

They designed an arena with a large number of niches spread out across its floor. These provide chickadees with inviting spots to cache food, such as sunflower seeds. To hide its contents from view, each niche is covered, requiring the birds to remember which sites contained their seeds, and which were empty. Birds can flit around between niches, hiding and retrieving seeds as they would do in the wild, while hidden cameras monitor the birds as they go about their business. These recordings are then fed into a computer algorithm that tracks the birds as they are caching and retrieving seeds.

"This allows us to map the birds' natural behavior — caching and salvaging food — that is not driven by training, but by pure memory," said Dr. Aronov.

With his research still in its early stages, Dr. Aronov will soon begin monitoring the brain activity of these birds. This brain data will help the researchers understand how the hippocampus represents the bird's natural environment. He then hopes to trace how the hippocampus communicates with other brain regions, and how those regions may be influencing the animals' memories.

Understanding the chickadee's exceptional memory, he says, could help us understand how humans form memories.

"The bird brain is much smaller and simpler than that of a human, which makes it easier to study in detail," says Dr. Aronov. "That being said, the brains of birds are similar enough to those of mammals that we should be able to learn lessons we can extrapolate to mammals, including humans."

When Dr. Aronov arrived at Columbia and the Zuckerman Institute in 2016, he received strong initial support for his vision. Though studying a new animal model can be risky, he was greeted with excitement by fellow faculty eager to see what he and his lab could discover with their unconventional approach.

Now, buoyed by this new support from the New York Stem Cell Foundation, Dr. Aronov can further expand his research. As a Robertson Investigator, he hopes to develop a paradigm for studying chickadees in the lab, laying the groundwork for other neuroscientists looking to expand their investigations into memory.

Ultimately, what fascinates Dr. Aronov the most about the brain is what is hardest to see: the thoughts and memories that create worlds inside of our heads.

"There's an entire universe inside our brain that's as big as the universe outside," he says, "and the only limits to what we can experience inside our minds is our imagination. How our brain, this three-pound structure sitting atop our shoulders, makes this all possible is the ultimate question that I am trying to answer."

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