

A single day of competition in the wild is encoded in the songbird brain, finds study

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A female tree swallow (*Tachycineta bicolor*). Credit: Roger Hangarter, Indiana University

Fighting among social animals is common as they compete for the resources they need to survive and reproduce. A winner and a loser will inevitably result from these interactions, but do these challenges also leave an unseen, lasting mark?

From past work, researchers know that [competition](#) changes gene activity in the brain and can even increase aggression, seemingly preparing an individual for future fights. But how does a social challenge continue to affect an individual well after the interaction has ended? No prior experiments have tested how this unfolds among [wild animals](#), and females remain conspicuously absent from studies of competition.

A recent study by researchers at Indiana University found that competition among free-living female songbirds changed the activity of important energy- and aggression-related genes in the brain. Some of these effects even lasted two full days after competition had ended.

Furthermore, several of these changes in gene activity were related to epigenetic marks, which chemically modify DNA so that genes are turned on or off without changing the genetic code—a mechanism capable of linking past experience with future behavior.

These results give important insight into how social experiences are encoded in the brain and how they can have long-lasting effects.

"The project was born out of wanting to extend earlier, mostly laboratory

work, from bees and mice and fish, but apply it to dynamic and interactive competition in the wild—genuine competition that occurs as animals fight for the resources they need as they struggle to reproduce," said Kimberly Rosvall, assistant professor in the IU Bloomington College of Arts and Sciences' Department of Biology.



An aggressive social interaction between two tree swallows. Credit: Elizabeth George, Indiana University

The study, funded by an NSF grant and an NIH training fellowship, was performed with a population of wild tree swallows that breed in artificial cavities—nest boxes provided by Rosvall's lab. These songbirds are obligate secondary cavity-nesters, meaning they need a cavity to reproduce but, unlike a woodpecker, they cannot excavate one themselves.

"This puts incredible pressure on these [female birds](#) to compete for a cavity," said Alexandra Bentz, a postdoctoral fellow in the Rosvall lab and the lead author of the study. "We wanted to know how that competition affects the brain and what, if any, lasting effects we might see."

The research team experimentally increased competition using a method similar to the childhood game of musical chairs. Once the birds settled at nest boxes in early spring, the researchers reduced the number of available boxes while the birds were roosting in trees overnight. When they returned in the morning, the females had to aggressively compete for the remaining boxes.

Within 24 hours, the research team reversed the experiment, returning boxes and easing competition. Females were collected during the peak of competition or two days after the end of the competitive period and compared to controls captured at other sites.

The researchers then measured genome-wide changes in gene expression and epigenetic marks in socially relevant brain regions. They found that

genes related to energy mobilization were expressed more highly in females during competition, but cellular maintenance processes had lower expression days after competition. This hints at a trade-off between meeting the energetic demands of competition at the expense of self-maintenance.

Genes in aggression-related pathways (e.g., dopamine synthesis) were also more highly expressed days after competition had ended and epigenetic changes were found in pathways related to hormonal signaling, suggesting those [genes](#) were transcriptionally poised to respond to future competition.

Results of the study, published in the *Proceedings of the National Academy of Sciences*, demonstrate the potential for a single day of competition to have lasting effects in ways that may prime individuals for success in future social instability.

"I'll never forget the moment when we realized the experiment had worked," Rosvall said. "The team was spread over multiple field sites and our cell coverage was shoddy, but suddenly all of our group texts went through and we realized that each team member had accomplished their goals. After years of planning, that joy was incredible. Seeing the results only added to the feeling."

"It's exciting to think about how a totally normal competitive event for these birds—fighting for a territory—can have these lasting and potentially beneficial effects on their brain, 'socially priming' them to better handle competition in the future," Bentz added. "To see competition leave a mark on the genome of the brain that outlasts the event itself is pretty amazing."

More information: Alexandra B. Bentz et al., "Experimental competition induces immediate and lasting effects on the neurogenome

in free-living female birds," *PNAS* (2021).

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