Variations in sex steroid gene expression can predict aggressive behaviors

June 6 2012

Researchers studied the behaviors of free-living dark-eyed juncos during breeding season to measure variations in aggressiveness. Credit: Indiana University: Kimberly Rosvall

An Indiana University biologist has shown that natural variation in measures of the brain's ability to process steroid hormones predicts functional variation in aggressive behavior.

The new work led by Kimberly A. Rosvall, a postdoctoral fellow and assistant research scientist in the IU Bloomington College of Arts and Sciences' Department of Biology, has found strong and significant relationships between aggressive behavior in free-living birds and the abundance of messenger RNA in behaviorally relevant brain areas for three major sex steroid processing molecules: androgen receptor, estrogen receptor and aromatase.

"Individual variation is the raw material of evolution, and in this study we report that free-living birds vary in aggression and that more aggressive individuals express higher levels of genes related to testosterone processing in the brain," she said. "We've long hypothesized that the brain's ability to process steroids may account for individual differences in hormone-mediated behaviors, but direct demonstrations are rare, particularly in unmanipulated or free-living animals."

Rosvall said the study shows that aggression is strongly predicted by individual variation in gene expression of the molecules that initiate the genomic effects of testosterone. The new work, "Neural sensitivity to sex steroids predicts individual differences in aggression: implications for behavioral evolution," was published today in Proceedings of the Royal Society B.

The findings are among the first to show that individual variation in neural gene expression for three major sex steroid processing molecules predicts individual variation in aggressiveness in both sexes in nature, results that should have broad implications for understanding the mechanisms by which aggressive behavior may evolve.

"On the one hand, we have lots of evidence to suggest that testosterone is important in the evolution of all kinds of traits," Rosvall noted. "On the other hand, we know that individual variation is a requirement for natural selection, but individual variation in testosterone does not always predict behavior. This conundrum has led to debate among researchers about how hormone-mediated traits evolve."

To find such strong relationships between behavior and individual variation in the expression of genes related to hormone-processing is exciting because it tells scientists that evolution could shape behavior via changes in the expression of these genes, as well as via changes in testosterone levels themselves.

The team measured natural variation in aggressiveness toward the same sexes in male and female free-living dark-eyed juncos (Junco hyemalis) early in the breeding season. The dark-eyed junco is a North American sparrow that is well studied with respect to hormones, behavior and sex differences. By comparing individual differences in aggressiveness (flyovers or songs directed at intruders) to circulating levels of testosterone and to neural gene expression for the three major sex steroid processing molecules, the researchers were able to quantify measures of sensitivity to testosterone in socially relevant brain areas: the hypothalamus, the ventromedial telencephalon and the right posterior telencephalon.

Their results suggest selection could shape the evolution of aggression through changes in the expression of androgen receptor, estrogen receptor and aromatase in both males and females, to some degree independently of circulating levels of testosterone. They found, for example, that males that sing more songs at an intruder have more mRNA for aromatase and estrogen receptor in the posterior telencephalon, and also that males and females that dive-bomb an intruder more frequently have more androgen receptor, estrogen receptor and aromatase mRNA in brain tissues including the medial amygdala, an area of the brain that's known to control aggression in rodents and other birds. mRNA are single-stranded copies of genes that are translated into protein molecules.

The work reveals there is ample variation in hormone signal and in gene expression on which selection may act to affect aggressiveness. It also establishes a prerequisite for the evolution of testosterone-mediated characteristics through changes in localized gene expression for the key molecules that process sex steroids, and suggests that trait evolution can occur with some degree of independence from circulating testosterone levels.

"Researchers have thought this was probably the case for about a hundred years, based on a lot of really important work that uses experimental manipulations like castration or hormone replacement," Rosvall said. "But very few people have looked to see if individuals actually do vary in expression of these genes, and whether this individual variation means anything, in terms of an animal's behavior. Our work shows that it does."

The new insights into how neuroendocrine mechanisms of aggression may be modified as populations diverge into species also offer opportunities for future research, including trying to determine whether genes that are up- or down-regulated in response to environmental stimuli may be the same genes that contribute to the evolution of certain traits and characteristics.

Provided by Indiana University

Citation: Variations in sex steroid gene expression can predict aggressive behaviors (2012, June 6) retrieved 25 April 2024 from
https://phys.org/news/2012-06-variations-sex-steroid-gene-aggressive.html