The evolutionary basis of self-control

A large-scale investigation by an international team of collaborators has tracked the drivers of the evolution of self-control across multiple species of mammals.

Self-control, defined in the study as the ability to inhibit powerful but ultimately counterproductive behavior, is involved in diverse decision-making processes. In primates, for example, sharing food with kin, bypassing previously rewarding foraging sites in order to search for food in a new area or refraining from feeding or mating in front of a higher-ranking individual are all behaviors that require self-control.

A team of researchers led by Evan MacLean (Duke University, Durham, NC) quantitatively compared the cognitive performance of 567 individuals representing 36 species on two problem-solving tasks requiring self-control. In the first experiment, animals were trained to access food through the side opening of an opaque cylinder, and then they were tested with a clear cylinder containing food to see if they would overcome the urge to reach directly toward the visible food and instead use the side route to reach the food.

In a second test, animals were repeatedly shown a row of three cups placed on their sides so that the animals could see inside the cups. The first cup contained food while the other two were empty. The animals were trained to reach for the first cup to gain the food reward. Next, they were shown the cups again, but this time with the food in the second cup. Animals that resisted the impulse to automatically reach for the first cup as they had been trained were thought to have more self-control.

Both absolute and relative brain size have been proposed as mechanisms supporting the evolution of advanced cognitive abilities, but this study confirmed that absolute brain volume best predicted performance across species (*Proc. Natl. Acad. Sci. USA* doi:10.1073/pnas.1323533111; published online 21 April 2014). Species with the largest brain volume, rather than largest volume relative to body size, showed the greatest self-control.

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With respect to primate cognitive abilities, both social and dietary complexities have been proposed as the primary selective pressures driving evolution. Within the primate species that were tested, dietary breadth (the number of different types of foods that were eaten by the species) was a strong predictor of species differences in self-control, but social group size was not. The results provide a critical step toward understanding how evolutionary shifts in brain volume and dietary complexity underlie cognitive abilities throughout the animal world.

Kara Rosania

LACK OF SLEEP IMPAIRS COURTSHIP IN FLIES

Many young animals, whether human, rat or fruit fly, need lots of sleep. The existence of this trait across diverse taxonomic groups implies some fundamental importance, and some scientists are intrigued enough to take a closer look. What mechanisms allow young animals to sleep so much? And what happens if they sleep less?

To address these questions, Amita Seghal and colleagues (Perelman School of Medicine at the University of Pennsylvania, Philadelphia) first measured sleep parameters in fruit flies of different ages. Young flies, which had just emerged from the pupal stage, slept almost 17 hours per day, and only 20% of them woke up in response to a 30-second pulse of light. In comparison, mature flies (8–10 days after emergence) slept about 12 hours per day, and 80% of them woke up in response to the same 30-second light stimulus (*Science* **344**, 269–274; 2014). Young flies were also more resistant to experimentally induced sleep deprivation.

Seghal's team next tried to identify the pathways regulating this age-based difference in sleep among fruit flies. They found that dopaminergic neurons were hypoactive and that levels of dopamine in the brain were >30% lower in young flies compared with mature flies, in keeping with previous indications that dopamine promotes wakefulness in fruit flies. They further identified a specific subset of dopaminergic neurons that is hypoactive in young flies: those that have projections to the dorsal fan-shaped body, a region of the fly brain that is known to promote sleep. Reduced dopaminergic input to this region allows it to maintain greater activity, leading to longer sleep time and more resistance to arousal and sleep deprivation in young flies.

Finally, the research group evaluated the effects of hyperactivation of dopaminergic neurons on young flies. Sleep deprivation in young flies is known to cause developmental abnormalities including impairment of courtship behavior. Seghal's group confirmed that excitation of dopaminergic neurons in young flies caused lasting deficits in courtship behavior: "the flies spend less time courting," Seghal said in a press release. Sleep-deprived flies had a copulation frequency of <20% compared with almost 70% in control flies. Sleep deprivation specifically impaired neuronal growth in a brain region involved in the olfactory system of flies.

Although it's not known how they may relate to human behavior, the findings "provide the first mechanistic link between sleep in early life and adult behavior," according to Seghal.

Monica Harrington