The Cognitive Defender: How Ground Squirrels Assess Their Predators
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Ground squirrel 09 flagged her fluffed tail from side to side as she explored the area around a burrow where we had last seen a rattlesnake. She then traveled to a burrow where her adult son from a previous year was living, followed by five of her pups. Squirrel 09 left her youngsters there as she began traveling to and fro several times, alternately looking for the snake at the original location and returning to interact with her babies. On some of these excursions, she was accompanied closely by one or more of her pups, who often followed in a tight little "flock". Finally, 09 spotted the snake and approached it very closely, tail flagging, jumping back, and reapproaching repeatedly. One pup had followed her to the snake, and as the mother continued to deal with the snake, two more pups joined them, and later a fourth. Our concern for the young squirrels intensified as they also began to confront the snake, behaving much as their mother did. Surprisingly, 09 did not step forward to protect her babies when one of them approached the snake. However, she was most consistently the closest squirrel to the snake, and her presence there appeared to keep the pups out of this dangerously close region.

As the snake continued its exploration of the area, 09 led four of her pups back to her son's burrow and all five went underground there. A little later, a fifth youngster arrived at the same burrow, wobbly, limping, and not using its left forepaw, apparently snake bitten. We never saw this pup again after its mother emerged to lead it into the burrow. Subsequently, 09 re-emerged and resumed her search for the snake, which was no longer in view. During this time, some of her pups intermittently accompanied her, perhaps endangering themselves again. After more than an hour of dealing with this snake, mother and pups could no longer locate it. They gradually calmed down, and began to feed in preparation for the coming night. But, their problems were not over. The snake harassed this family for three more days, killing a second pup, and blind-siding 09 by delivering a sublethal bite to the side of her face where she had earlier lost her sight.

My research program has long emphasized predatory contexts like this one in order to explore the behavioral abilities of California ground squirrels (*Spermophilus beecheyi*). This rattlesnake episode highlights the challenges that ground squirrels face in dealing with the problems they naturally encounter. Here, the maternal ground squirrel had to juggle at least three different tasks, i.e., keeping herself safe while also protecting her pups and managing the behavior of the rattlesnake. The best way for squirrels to proceed in such situations depends on the details of the threat they face, and they must apply their cognitive systems to the task of uncovering those details and finding a way to proceed, as we will see below. Using predatory contexts ensures that I am studying behavior in situations that are meaningful to my animals, in an evolutionary and ecological sense. In this way, I maximize my chances of discovering behavioral processes that have been most strongly shaped by natural selection and individual experience during development. Toward that goal, I have studied the antipredator activities of ground squirrels as they deal with the variety of predators that have historically been important to them, including not only rattlesnakes, but also gopher snakes, coyotes, bobcats, red-tailed hawks, and golden eagles.

These different classes of predators use different hunting techniques favoring different antipredator strategies. Avian predators pose the most immediate threat to squirrels, appearing suddenly and launching rapid aerial attacks. More slowly moving mammalian predators pose threats of intermediate urgency, and very slowly moving, ambush-hunting snakes pose the least immediate threat. Ground squirrels vary their antipredator behavior to these different threats in ways that reflect a tradeoff between self-preservation and acquisition of additional information about the predators (Coss and Owings 1985; Owings and Hennessy 1984). Activities that facilitate assessment require getting close to and maintaining sensory contact with the predator, which increase the squirrel's vulnerability to the predator. Activities that reduce a squirrel's vulnerability, for example by minimizing conspicuousness, often involve staying farther away