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# **The Cognitive Animal**

## **Empirical and Theoretical Perspectives on Animal Cognition**

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# 5 The Ungulate Mind

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*Bovine: 1. Of, relating to, or resembling a ruminant mammal of the genus Bos, such as an ox, cow, or buffalo. 2. Sluggish, dull, and stolid.*

—*The American Heritage Dictionary of the English Language, 3rd ed.*

As the definition of bovine suggests, many see a cow standing in barnyard muck, its head lowered, a rope of drool hanging from its mouth, and conclude that the space between its ears is filled with bone, or perhaps air. A horse that has traveled the same path many times is likely to shy away in fright when it encounters a newspaper or other new object near the path. These and other common observations support the general view that the ungulates are a fairly dim lot. Clever Hans excepted, no ungulate is or has been the subject in tests of cognitive ability. However, ungulate brains are not conspicuously small (Eisenberg 1981), so we might ask whether there is an underappreciated mental ability in the group. I am going to argue that the ungulates are smarter than previously believed, but that their cognitive abilities are specialized, and most likely are limited to just a few kinds of situations. Like vervet monkeys (Cheney and Seyfarth 1990), ungulates appear to have domain-specific cognitive ability. However, these domains are conspicuously different than those that brought about the intelligence of monkeys and us.

Intelligence and predictive cognitive ability are ecological adaptations. For monkeys and other primates, the relevant aspect of the ecology, that part of the animals' environment that selects for mental ability, is the social environment. Monkeys and apes appear to gain fitness advantages by being able to predict the actions of other group members, and by their ability to use social signals to manipulate the behavior of conspecifics (de Waal 1982). Perhaps because of anthropocentrism, this social intelligence hypothesis, as it is called, has dominated discussion on the evolution of cognition. However, I think that other

ecological domains may be the drivers of intelligence in other taxa. Just as other environments may select for sensory abilities that are alien to us (e.g., echolocation in bats, electric field communication in mormyrid fishes, and magnetic field orientation in birds and bees), so other environments may select for cognitive abilities that we may not immediately recognize as such.

In the ungulates, two aspects of ecology are likely to create selection for specialized cognitive ability. These aspects are predation on young and the dynamics of polygynous mating systems. I am going to discuss ungulate cognition from the perspective of my observations on pronghorn antelopes (*Antilocapra americana*) (Byers 1997), but I do not think that pronghorn represent a special case. Many other ungulates live in similar ecological circumstances, have almost identical behavioral traits, and are likely to have similar sets of cognitive traits.

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## Predation on Young and What Mothers Do about It

Generally, the ungulates avoid being eaten by predators either by being large bodied or fast runners, or both. For many of the fast ungulates, such as pronghorn, all deer, and many species of antelopes, the young are not fast runners when they are born. A specialized strategy called "hiding" has evolved (FitzGibbon 1990; Lent 1974). Hiding represents coordinated behavior of the mother and her young. Shortly after birth, the mother leads the tottering infant away from the birth site, then signals to it to move away. The infant walks a short distance and reclines. Now the incredible part of the hiding strategy begins. The infant remains motionless and refrains from urinating or defecating for 3–4 hours, until the mother returns. Upon the mother's return, the infant sucks in a load of milk that

would kill a follower ungulate (Carl and Robins 1988), and it urinates and defecates into the mother's mouth in response to her licking. The adaptive value of hiding is that it conceals the location of the slow infant from predators. The concealment depends on coordinated behavior of the mother and the infant. The infant must recline and remain motionless, and the mother must somehow not give away the location of the hidden infant.

What does it mean to "not give away" the location of the infant? First the mother must remain sufficiently far from the infant so that her own location is not a valuable search clue to a predator. Second, a mother should not, by her activity, indicate that she is about to return to her infant. Third, the mother should not reveal the location of the infant by looking directly at it more often than would be expected by chance. When Karen Byers and I tested these hypotheses (Byers and Byers 1983), we found that pronghorn mothers were amazingly effective in fulfilling conditions one and two, but were somewhat imperfect in their tendency to look in the infant's direction too much.

Impressive as these aspects of mother performance were, none seemed to demand cognition as an underlying mechanism. However, we also observed that mothers did something even more sophisticated than the activities described (Byers 1997). In the half-hour before returning to the infant, mothers often engaged in what looked startlingly like a search for hidden predators. A mother with an infant hidden midway up a slope might run to the bottom of the slope, look up and down the dry creek bottom, then run to the top of the slope to stare intently for several minutes before returning to the infant. Mothers that acted like this gave the impression that they anticipated the return to the infant and that they were searching for danger in advance. There is certainly plenty of danger in most years on the National Bison Range in Northwestern Montana, my study site; 75–100 percent of each year's crop of fawns succumbs to either coyotes

or golden eagles (Barrett and Miller 1984; Byers 1997).

One spring I observed an incident that strongly reinforced the notion that mothers had some kind of conscious anticipation of returning to the infant. On a rainy, blustery day I watched a mother who was across a ravine, about half a mile away. As she approached her hidden twins, she was suddenly startled by two golden eagles, flying fast and low over the ridge top. The mother ran away from her fawns and stood, craning her head back, to watch the eagles as they circled overhead. Pronghorn hold their heads back like this only when they are looking at golden eagles. The motion is odd looking and unambiguous. The eagles searched for several minutes, then flew away. The mother waited about 30 minutes, then moved toward her fawns. She was only a few meters away from them when the eagles suddenly reappeared, flying across the ridge top about 1 m above the ground. Once again, the mother jumped away and watched the eagles as they again circled overhead. Once again, the eagles did not find the fawns and departed after several minutes. (Incidentally, the failure of the keen-eyed eagles is testimony to perfection in the hiding behavior of the fawns; not even a tiny ear flick occurred while death circled just overhead.)

Now the mother waited for another half-hour before she moved toward her fawns. Just before she reached them, she stopped, then craned her head back and moved it from side to side, as if looking at eagles overhead. However, the eagles were not present. The mother quickly stepped to her fawns and led them out of sight over the ridge top. In this instance it is almost impossible to avoid the conclusion that the mother anticipated her return to the fawns, remembered the eagles as a threat, and thus searched for them before signaling the fawns to move.

Other evidence that pronghorn mothers have a kind of conscious planning comes from my observations of their interactions with coyotes that are actively searching for a hidden fawn. Moth-

ers always seem to know exactly where the fawn is, and they use this knowledge to determine the proper course of action against a searching coyote. As I indicated, the mother is usually far from the fawn (on average, 70 m). Thus when a coyote approaches and begins to search, the optimal response is not simple. The optimal response will prevent the coyote from detecting the fawn while preserving the option of actively defending the fawn, should the coyote detect it.

The course of action that will accomplish these goals depends upon the locations of the mother, fawn, and coyote, and upon the path that the coyote's movements predict. To see this, envision yourself at 12 o'clock, your hidden fawn at 6 o'clock; the coyote now enters at 3 o'clock, trotting toward 6. If you are a pronghorn mother, you will run to the center of the clock, in front of the coyote. You will then flash your big white rump patch and will prance away in a manner designed to cause the coyote to give chase. Now suppose that you and the fawn are positioned again at 12 and 6, but now the coyote enters at 5, trotting toward 10. The coyote is actually closer to the fawn than it would have been in the preceding example, but now a pronghorn mother likely will simply stand and watch the coyote. I have witnessed these types of interactions scores of times, and always the mother displays the ability to extrapolate from the coyote's path, never showing alarm or an attempt to distract or lure unless the coyote is on an interception course. Under intense pressure, with the life of a helpless infant on the line, pronghorn mothers display a level of cool restraint greater than most humans could maintain. They are able to do this because of their superb ability to remember the exact location of a distant spot and to predict whether the path of another animal will intercept that point.

It is instructive to compare this calculated behavior, which relies on planning and anticipation, with that of killdeer parents, which also practice a distraction display. I have provoked many killdeer displays and have observed none of the re-

straint and anticipation that pronghorn mothers show. For killdeer (*Charadrius vociferus*), the distraction display seems to be triggered simply by my approach within a certain distance. No matter what my path, if I reach the minimum approach distance, the parents swing into their loud distraction display. Thus, the responses of killdeer parents to a threat show no sign of conscious planning or intent, but the actions of pronghorn mothers, in a very similar situation, show restraint and apparent calculation that seems to be driven by a kind of conscious planning.

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### Planning and Anticipation by Males

And now to the guys: Are they the pelvic-brained morons that the proponents of the "testosterone dementia" concept advance? My observations of pronghorn males suggest that they do indeed care about little except copulation, but that they can be impressively clever as they pursue this elusive goal. To show how they operate, I need to explain a little about the pronghorn mating system.

Females come into estrus once a year and within a population, 90 percent of the estruses occur in a 10-day period, usually in mid-September. For about 2 weeks there is a kind of controlled pandemonium in which females move among potential mates, apparently looking for evidence of vigor, while males attempt to hold and hide groups of females (Byers et al. 1994). Each female makes a sampling visit to several males, which have been solitary and site faithful since May. The female groups that males try to control thus are temporary aggregations; individual females move independently.

Each female moves at an increasing rate as she approaches estrus, and she always leaves a male that fails to defend an adequate perimeter around his group. As a female approaches sexual receptivity, she allows a male to advance toward her, then to attempt to mount, then to mount without intromission over a long, gradually

building sequence that typically lasts 24–36 hours. Finally, the female braces back against the male when he mounts, and this allows him to probe for intromission. A male ejaculates immediately as soon as he gains intromission.

The most successful males are those that are able to maintain control over large groups of females for many consecutive days during the rut (Byers et al. 1994; Byers 1997). A successful male may begin his morning by moving through his harem, checking each female for signs of estrus, and directing courtship toward those that smell right. If the checking reveals no females in estrus, the male probably will move away from the female group to scent mark and stare into the distance. If he detects another male, he usually announces his presence with a loud “snort-wheeze” vocalization, and he may chase the other male(s) out of sight. Returning to the harem, he is likely to find that females are starting to drift apart and away; he uses mild threatening gestures to move them back together and usually into his special hiding place. This cycle, which represents essentially continuous activity for the male, may be repeated several times between 7:00 and 11:00 A.M.

When one or more females in the harem comes into estrus, the level of activity becomes much more intense. Other males are drawn to the harem, probably by an odor that the females release. The harem male now courts intensely, runs aggressively at approaching males, sprints back to his harem to court, and so on. In these situations, when one or more females is close to accepting a copulation, and a ring of other males is tightening around the group, male stamina and vigor count for a lot, but male tactical sense is equally important.

Tactical sense is needed to assign priority of performance to mutually exclusive but equally important tasks (chasing males, courting females, reassembling and compacting the harem). Tactical sense also is needed to make decisions about the motion vector that will deal most effectively with spatially distributed threats (a ring

of males, each at a different distance and on a separate path around the harem). I have witnessed scores of such situations when the harem male was faced with a daunting array of challenges and possibilities, and I have always been impressed by the ability of the males to choose what appears to be the rationally best course of action out of many possible actions. Often, I have watched a male suddenly pause when faced with a difficult choice, and stand motionless for several seconds as a melee began to erupt around him, then abruptly take action. It was difficult for me to avoid the interpretation that the male was in some way *thinking* about what to do next. An alternative interpretation is that the male was waiting for more information before taking action, but with either interpretation, we are left with an animal that appears to be engaged in a kind of conscious planning of activity. On several occasions, I have observed males lose the opportunity to copulate owing to what I saw as a “stupid” decision. A male might persist in chasing a rival far away when the defended female was very close to accepting copulation. However, such observations are very rare, and their rarity demonstrates that pronghorn males are far more than stimulus-response machines.

My tentative conclusions about pronghorn thinking did not arise from a research program that was designed to study cognition. I was interested in observable behavior and its relation to fitness. However, thousands of hours of observation in nature thrust certain observations upon me. My field observations, of course, can only be suggestive. They do not prove that pronghorn ever think about what they are doing. Worse still, it is difficult for me and probably for most researchers to think of the proper experiments that might produce such proof. Observations such as mine, however, do broaden our view of which species out there are thinking, and of why they might be doing so. There are many ungulate species like pronghorn (Estes 1974, 1991; Gaillard et al. 1998) that face the same challenges that I have described here.

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