CLEVER AS A FOX

ANIMAL INTELLIGENCE AND WHAT IT CAN TEACH US ABOUT OURSELVES

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Chapter 1

A Dim and Clouded Eye

Perched at the tip of a stunted pine, a Clark's nutcracker gathers a bit of warmth from the morning sun. Most of the tree on which she sits is buried under layer upon layer of snow, and although the green rush of spring has already come to the foothills below, here, near the summit of the tallest peaks, the freeze is still on. Nothing stirs. The nutcracker breaks the silence with a jay-like 'Caw!', listens for the echo, then preens first one wing and then the other. The palette from which her feathers are colored was borrowed from this desolate winter landscape: gray from the boulders, black from the bark of the trees, white from the snow.

Cocking her head to one side, she glances at a protruding rock to her left, glides down to the snow, and begins to dig. In a few minutes she has tossed aside enough snow to expose a patch of ground. She digs in the frozen earth and retrieves a cache of a dozen pine seeds, which she slips from her beak into the expandable pouch that lies along the inside of her throat, designed by nature just for this use. Back up to the surface of the snow, she takes a quick bearing from the rock and the tree, hops a few steps closer to the rock, and digs again. When two more caches have been emptied, her pouch is full; in silhouette she looks as though she has swallowed a golf ball. She leaves the snow and alights on the tree. After a brief rest, she abandons her perch, flying up the slope and over the barren crest of the mountain toward a thick stand of pines miles away, where her nest lies. There she will feed her nestlings the pine seeds – the only meal on the mountain until spring ascends from below to overcome winter.

The nutcracker buried the seeds during the previous summer and fall, making thousands of caches over miles of terrain. Her custom-designed bill allowed her to break open pinecones before they were even ripe, giving her a jump on the other birds and rodents that are partial to pine seeds. In selecting seeds for caching, she weighed each one in her bill and clicked it with her mandibles, listening for the telltale hollow sound of a rotten kernel, judging the seed's density and quality like a fussy shopper lifting and squeezing a grapefruit at the market. After the quality control check, she pouched the seeds and flew as far as fourteen miles from the harvest site to terrain better suited for long-term seed storage. When burying the seeds, she avoided areas prone to drifting and chose instead southward-facing slopes where the sun would shrink the snow. After she put a cache of four or so seeds in the ground, she covered them with some dirt and perhaps a leaf for camouflage.

For several months this was how she spent her days: harvesting, selecting, transporting, and caching the fall seed crop. In an average year, she would make about 12,000 caches, storing as many as 80,000 seeds. She made each cache, noted its location, and flew away. She did not return until winter had wiped everything else off the menu.[1]

A bird with a brain the size of a cashew remembering thousands of locations for months at a time? Most of us have trouble remembering where in the parking garage we left our car a few hours ago. Now imagine drifts of snow covering the signs indicating floor numbers and lettered zones. And yet, experiments have shown conclusively that Clark's nutcrackers (and other bird species) use their memory, and not some lazy trick, to recover buried seeds.[2] Their lives depend on it. The diet of the nutcracker nestlings is

[1] Vander Wall and Balda, 1981.
[2] Kamil and Balda, 1985; Vander Wall, 1982.

entirely pine seeds, and only Mom and Dad know where the seeds are hidden. If nutcrackers couldn't remember where they stored their food, there soon would be no more nutcrackers.

Are you skeptical that the nutcracker could have such impressive intellectual abilities? We want to examine that skepticism and use it to begin to understand some of the questions of comparative animal intelligence. Why is it surprising that a bird might have a better memory than an elephant, or even you? What can the story of the nutcracker and our reaction to it tell us about the nature of intellectual ability in people and in animals, about the nutcracker's adaptation to the harsh realities of its niche, and about the biases we apply and the partial truths and naked lies we accept when we look inside the minds of other creatures?

The Intellectual Line-up

Suppose I told you the cache-and-carry story again, but with a different cast: A chimpanzee sits on a tree limb deep in an emerald green forest. After a quick look around, he climbs down and begins digging in the ground at a nondescript spot. He eventually uncovers a small pile of nuts of a kind that ripened during the previous rainy season. Taking two nuts from the cache, he covers the rest with leaf litter. Later in the day, he has similar snacks from other cache sites made weeks before.

Most of us find it easier to believe that a chimpanzee could remember where he left his lunch than to believe the same of a bird. (In fact, primates – humans excluded – don't make food caches.[3]) There are many reasons for this bias toward the chimpanzee, some valid, some not. As an example of an invalid reason, consider the ancient notion of a Great Chain of Being. The central idea, still very active in the popular mind, is that all beings can be ranked along a single dimension indicating their proximity to God. The Great Chain looked something like this in its original form: God,

[3] Vander Wall, 1990.

angels, man, woman, apes, horses, cats, birds, turtles, frogs, fish, bugs. Because the beings nearer the top of the Chain are closer to perfection, they have more of the goods in all domains, including intellectual ability.

While some sections of the Great Chain of Being are being dismantled (that man-over-woman business is on the way out), the idea has persisted that a linear ranking of animals is possible. The use of 'higher' and 'lower' to describe species is an example, where 'higher' might refer to mammals (like us) and 'lower' to squishies and crunchies (such as crayfish and cockroaches – not much like us). The metaphor of an evolutionary chain or ladder carries with it the assumption that evolutionary change brings improvement, that comparing a fish to a person is like comparing a Model T to a Porsche. But that's not how evolution appears to work; there is no support for such unidimensional scaling in modern evolutionary theory. If you buy into the modern view of how species arise, then an automatic judgment (based on perceived distance from the primordial soup) that a chimpanzee is necessarily brighter than any bird is pure prejudice. Don't feel too badly about it: the prejudice is widely shared.

Despite scientific evidence, simple classification schemes like the Great Chain of Being have strong appeal even in modern times, rooted as they are deep in our cultural and religious soil. They continue to influence what we believe in our hearts long after our minds have been won over by an elegant theory or the sheer weight of data. In this book, we will return to this idea repeatedly; our perceptions of the intellectual status of other species will always be a joint product of real scientific knowledge and the fuzzier forces that mold all human endeavors: values, personal and cultural histories, emotions.

The ancient scholar Plutarch, in an essay titled 'The Cleverness of Animals', staged a debate about which group of animals was intellectually superior, those living on land or those living in the sea. During the warmup to the central argument, one team defended the idea that animals had intellectual abilities of any kind. This was a touchy subject in ancient Greece because the power to reason was inextricably linked to moral purpose. Plutarch's position was, however, clear:

> There are . . . many animals which surpass all men, not only in bulk and swiftness, but also in keen sight and sharp hearing; but for all that man is not blind or crippled or earless. We can run, if less swiftly than deer; and see, if less keenly than hawks . . . In the same way, then, let us not say of beasts that they are completely lacking in intellect and understanding . . . what we should say is that their intellect is feeble and turbid, like a dim and clouded eye.[4]

This argument seems logically sound. It begins with the premise that humans are at the intellectual pinnacle of creation. Even without the philosophical link to the Great Chain of Being, most people would readily agree that humans can think circles around any other species. Sure, dolphins and chimps and even nutcrackers might be smart, but none ever earned a Rhodes scholarship or designed a suspension bridge. When it comes to intellect, humans have the sharp, unclouded eye. Plutarch then asserts that, like humans, other species can think, but that their thinking is like seeing with cataracts. Perhaps if we could develop the cognitive equivalent of a standard vision test, we could line up all the creatures from the ark below us according to their abilities. That lineup might even replicate the Great Chain of Being and we wouldn't then have to apologize for our species biases.

But is vision a good metaphor for intelligence? There are different types of eyes engineered to capture different portions of the spectrum for different purposes. A standard vision test, fair to all, would be much harder to develop because a single factor, such as acuity, might not capture all that is relevant to performance, and might not itself constitute a single dimension. Plutarch's dialogue implies that intelligence is a monolithic capacity, that differences among species are always quantitative: variations in

[4] Plutarch, Moralia XII, p.343.

amount rather than kind. However, many scientists have argued, especially recently, that intelligence is not a single entity: it's apples and oranges (and perhaps apricots and bananas as well). To grasp the mental abilities of the owl, the pussycat, the tortoise, and the hare and to weigh them side by side will require a commitment to unraveling the nature of intelligence. As will become obvious in the next chapter, few topics in the history of psychology have generated more controversy.

It's All Relative

Ironically, but not accidentally, there is an aspect of the Great Chain of Being that does, at least in part, support the assumption that a chimpanzee will be brainier than a bird: evolutionary continuity. Crudely, the argument runs like this: we know we are smart. Chimps are a lot like us in many ways, birds are not. Therefore, chimps are more likely to be smart than are birds. The logic is not infallible, but there are scientifically sound reasons for believing that closely related species will tend to be more similar (in their bodies, their behavior, and their minds) than more distantly related species. When a new species emerges, it resembles, in most respects, the species from which it was derived. Even people with little formal understanding of genetics can make fairly accurate judgments of relatedness among common species. A mountain lion is clearly just a big kitty. A zebra is a horse with a fancy paint job. A squirrel is an upholstered rat. We are good at detecting family resemblance and using that resemblance to draw conclusions about behavior and mental ability. We know apples don't fall far from trees. We can use this knowledge of relatedness to help understand how intelligence, or the lack of it, is distributed across the animal kingdom.

On the other hand, we only have to think about our own families to realize that even closely related individuals (or species) sometimes differ remarkably. Chimpanzees may be our closest cousins and be more similar to us than any bird, but no one would ever mistake one for a human. Species differ, and the differences can usually be seen, measured, and quantified. If what distinguishes this species from that species is, say, a longer limb or a bushier tail, then we can reliably measure that trait in related animals and try to correlate the differences with things we know might favor or discourage that trait during natural selection. Perhaps longer limbs improve running speed and that bushy tail is effective as a desert sunshade. By comparing species, we can infer how the forces of genetic heritage on one hand and unique environment on the other have altered animal bodies, pushing and pulling species up, out, and along the arbors of the evolutionary tree.

But studying the evolution of ear shape in bats or skull width in rats is one thing, and understanding the evolution of cleverness quite another. If we want to use the concepts of relatedness and adaptation in our hypotheses about which animals are smarter than others, then we have to devise methods that can detect similarities and tease apart differences in intelligence. How do we do that? The first step is to clearly define intelligence (see chapter 2). Then we have to design tests that measure intelligence as it is defined and put the selected species through their paces (see chapters 2 and 5). Finally we have to figure out how performance on the tests relates to ecological pressures and evolutionary history (see chapters 7 and 8). Imagine making a career out of studying events that happened, ever so slowly, millions of years ago (the evolution of the creatures alive today) and the relationship between those events and attributes you cannot ever hope to see directly (mental abilities), which are produced by a structure that doesn't fossilize very well (the brain). How the methods of evolutionary science may be applied to the study of comparative intelligence is one of the most vexing issues of modern behavioral biology.

Of course many types of science rely on long chains of inferences in their constructions of local reality; after all, who has seen a black hole? My message is not that a science of the evolution of intelligence is impossible but rather that we must be ever mindful of the delicacy of the enterprise. If we are building a house of cards, let's be sure we recognize it as such. The assumptions lurking behind conclusions we draw about animal intelligence must be examined again and again. When we see a chimpanzee thoughtfully studying his own face in a mirror, what questions should we be asking in order to learn what his behavior says about his mind? About the differences, and similarities, between his mind and our own? And when we see the nutcracker retrieving long-buried seeds, how do we ask questions of her that are open-minded, that don't rely entirely on how far away her branch of the evolutionary tree is from ours?

A Case of Mistaken Identity

One consequence of our extravagant intelligence is that we run the risk of exaggerating its significance in the game of Life. The vast majority of people in developed nations spend nearly all their time steeped in a complex, varied, and ever-mutating material and intellectual culture. We are so in love with the fruits of our intellect that few of us ever pause long enough from the enjoyment of novels, board games, speed dialing, Web surfing, radio talk shows, and Monday night football to ask what all this brain power is really for. Yet if we are to engage in an impartial analysis of animal intelligence, we must then consider what good it does any animal to be smart. Given our own mental abilities it is hard for us to imagine that there are advantages to being a bit slow on the draw. Nevertheless, many wildly successful species have gotten by perfectly well on fewer neurons than legs. For natural selection to favor a high I.Q., the additional energy-consuming brain matter has to pay its way; being smart must translate into a concrete competitive advantage realized in the only currency that evolution recognizes: survival of more kids.

Throughout this book, the question of the function of intelligence arises. For the moment, I want to take an end run at the question, to try out the idea that one of best ways to learn about something is to see it fail. I want to tell a story of animal stupidity.

Several years ago I lived in a village in central Wales comprised of 300 sheep farmers. I was there studying the Eurasian dipper, a perching bird (like a robin, wren, or sparrow) that makes its living in an unusual way: by diving into rushing streams to hunt for bugs. My research question was simple and fundamental: how do young dippers, who have just fledged, learn to master both air and water, and capture prey that are both agile and cryptic?[5] The first thing I had to do was find nests and figure out when the young dippers were scheduled to fledge. Dipper nests are large, mossy igloos built directly over running water, pitched on a cliff face or under a bridge. They are either impossible to see, impossible to reach, or both. When the nest gets too crowded and it's time for the young to leave, they take a baptismal plunge into the current, and end up bobbing like bath toys under the faucet as the tub fills.

It was mid-May and breeding season was in full swing. I had awoken at four A.M., filled my Thermos with tea, grabbed my gear, and headed for the river. An hour later, I was sitting inside a hide, waiting for dawn to break so the show could begin. The target of my attention was a dipper nest cleverly camouflaged on a moss-covered cliff on the opposite bank. Because this was only a feeder stream for the main river, I could cross the water in one giant step. I had a very good seat for the show. My goal was to keep track of how the parents were divvying up the responsibilities of a nestful of kids. I knew the male was playing house with two other females (dippers are supposed to be monogamous!), and I wanted to see if his philandering was shortchanging any of the females or their nestlings.

The first two hours passed uneventfully. Both the male and female dippers were shuttling back and forth from the main river to the nest, delivering mouthfuls of larvae to the chicks. At the same time, I also had the pleasure of watching a pair of gray wagtails feeding their nestlings, stashed away on the same cliff face only an arm's length from the dipper nest. Wagtails are sleeker and have longer tails than the portly dipper, but their diets overlap so the two species are often found in close proximity.

[5] Yoerg, 1994, 1998.

Soon something strange began occurring. On his way to his own nest with a beakful of goodies, the male wagtail began using the top of the dipper nest as a landing pad before making a lateral move to his own nest. As he passed in front of the mouth of the dipper nest, the dipper nestlings burst into a chorus of begging. For them, seeing movement at the nest opening is like hearing the doorbell when pizza has been ordered. It means food has arrived.

Initially, the wagtail continued to feed his brood, in exactly the way evolution had so carefully designed him to do. Then, I began to notice a slight hesitation in his flight as he passed in front of the begging dippers. Finally the unbelievable occurred: the wagtail approached the dipper nest with his beak crammed full of insects and landed, not on the dome of the nest, but at the opening. The dipper chicks greeted him with raucous begging and he obligingly stuffed the nearest gaping mouth.

Over the next twenty minutes, the male wagtail fed the dipper brood nine times. I was astounded. The first rule in winning the game of natural selection is to help only yourself and those related to you. The second rule is that if you can't do that, for God's sake don't help anyone else! But there was that wagtail, deftly catching bugs and flies and stuffing them into mouths belonging to another species. Between eleven A.M. and noon, the wagtail made three-quarters of all the deliveries to the dipper nest. I watched as often as I could over the next few days. During every hour of every observation period the wagtail fed the dipper chicks more often than the combined effort of the dipper parents. Not surprisingly, visits by the male wagtail to his own nest fell off, and were only partially compensated for by the female wagtail.[6]

While inside the hide, I hardly had a moment to reflect on the significance of the drama; keeping track of the movements of four birds at two nests used all of my processing capacity. At night when the birds were asleep I wondered where all this would lead. Would the wagtail continue feeding the dippers once they had

[6] Yoerg and O'Halloran, 1991.

fledged? (Both wagtail and dipper parents do this.) What would become of those dipper nestlings, the product of a fortuitous cross-fostering experiment? Would they hanker for the winged diet of their wagtail benefactor? Would they find themselves unaccountably attracted to lady wagtails when breeding season came around again? Unfortunately, I never found out. Four days after I first saw the wagtail's misguided behavior, both nests were destroyed, presumably by a mink, a common nest predator in that area. After my disappointment and sadness abated, I couldn't help but wonder if all the commotion I had witnessed might not have attracted unwelcome attention.

What does this story tell us about animal intelligence? To me, the most unintelligent aspect of the wagtail's behavior was his failure to recognize that the dipper chicks were not his, even when his own nest was only a yard away and visited regularly. (An analogous situation in humans would be this: Dad is on his way home with take-out food when he hears some kids in the house next door. He walks into the neighbors' house and says, 'Chinese food all right tonight, guys?' Meanwhile his wife is rummaging through the freezer wondering what to feed their kids now that Dad hasn't shown up. Dad does this five nights a week.) The wagtail's behavior seems unintelligent because it is inflexible, because it reflects the operation of a nestling-feeding mechanism that is highly determinate. I don't know for certain, but the wagtail's behavior is probably governed by some rule such as, 'Once you have a full beak, fly to your nest, and stuff the food in whatever open mouths you find, especially ones that are begging loudly.' My wayward wagtail just didn't get all the way to the right nest before executing the rest of the instructions. But so what? Over millions of years of evolution, the simple feeding rule, or some version of it, worked pretty well or, rather, it worked as well as other fancier, more flexible mechanisms that came with a bigger price tag. If we want to understand why some species are smarter than others, we have to become comfortable with the idea that smarter is not always better. We have to realize that while massive amounts of cognitive wherewithal was just what we needed in our niche, nobody else's niche is quite like ours.

Before leaving the wagtail story, I want to add a footnote that might spare a portion of the wagtail's reputation. When the female dipper (curiously, not the male) saw the wagtail approach her nest, she would usually give an alarm call and chase him off. This happened often enough that the wagtail learned to adjust his Good Samaritan deliveries in response. If he arrived with food but encountered the dipper parents, he would hop around on the bank until they had gone or, if the adult dippers lingered, he would relent and feed his own nestlings. I find this aspect of the story the most endearing and intriguing: the wagtail, while clueless as to how his behavior was jeopardizing his own biological fitness, was exquisitely sensitive to the social consequences of that same behavior.

The encounters between the female dipper and the male wagtail became less frequent because of the irony of negative feedback: the wagtail was doing such a marvelous job feeding the dipper chicks that the dipper parents downshifted their delivery rates in response. As the wagtail enjoyed less harassment from the dippers, he could indulge his bizarre calling more freely. The more the wagtail contributed, the less actively the chicks begged to their own parents, thus providing more feeding opportunities for the wagtail. And I speculate that at least the male dipper, with his other romantic commitments, probably welcomed the relief.

Clearing Our Vision

During the eighteen months I lived in Wales, I spent thousands of hours watching dippers. I didn't watch casually. I used binoculars to read the color-coded ankle bracelets that identified individual birds, and a spotting scope to see exactly what they were eating. I developed a coding system for their behavior and followed strict rules for how long to follow particular birds and what to do if they flew out of sight. During observations I spoke continuously into a tape recorder, then transcribed it all later, getting an accurate