The brain's versatile toolbox

Pinker, Steven. **Natural History** 106.8 (Sep 1997): 42-45.

The human brain is an extraordinary organ. It has allowed us to walk on the moon, to discover the nature of matter and life, and to play chess almost as well as a computer. But this virtuosity raises a puzzle. The brain of Homo sapiens achieved its modern form and size between 50,000 and 100,000 years ago, well before the invention of agriculture, civilizations, and writing in the last 10,000 years. Our foraging ancestors had no occasion to learn astrophysics or to play chess, and natural selection would not have rewarded them with more babies if they had. How, then, did our outsize brain evolve?

This puzzle led Alfred Russel Wallace, the codiscoverer of natural selection, to defect to creationism, and it has long frustrated our attempts to understand the mind as part of the natural world. But the puzzle can be solved with a key idea: the process of natural selection equipped our ancestors with a mental toolbox of intuitive theories about the world, which they used to master rocks, tools, plants, animals, and one another. We use the same toolbox today to master the intellectual challenges of modern societies, including the most abstruse concepts of modern science.

For more than 99 percent of our evolutionary history, we lived as foragers, and our recent ancestors must have lived much as foraging tribes do today, without any of the trappings of modern civilization. Observing their seemingly simple life, many people have wondered what nonliterate foragers do with their capacity for abstract intelligence. The foragers would have better grounds for asking that question about modern couch potatoes. A foraging life is a camping trip that never ends, but one without Swiss Army knives and freeze-dried pasta.

All foraging peoples use fire and shelters and manufacture many kinds of tools. Their engineering is often ingenious, involving poisons, smokeouts, glue traps, nets, baits, snares, corrals, concealed pits and clifftops, blowguns, and bows and arrows. Animal prey may thus be flushed out, cracked open, trapped, ambushed, or done in by weapons. Plants are cut down or unearthed, shelled and skinned, and detoxified by cooking, soaking, fermenting, and other tricks of the kitchen magician.

How do they accomplish these feats? With the help of language, foragers pool their knowledge and coordinate their actions. Their words offer a window to the kinds of knowledge they possess. All documented human cultures (and by extrapolation, ancestral foraging ones) have words for space, time, motion, number, mental states, tools, flora, fauna, and weather; they make logical distinctions between general and particular, apparent and real, possible and actual. People use these words and concepts to reason about invisible entities such as disease, meteorological forces, and absent animals. They also possess knowledge that is not easily expressed in words. Their mental maps may contain thousands of noteworthy sites, and their mental calendars record cycles of weather, animal migrations, and the life histories of plants.

So we humans evolved mental machinery that allowed us to cooperate and outsmart the local flora and fauna. Vital to that machinery is its ability to analyze and categorize experiences that reflect the world's causal structure, which lets us make good predictions about unseen events. The world is a heterogeneous place, with many kinds of entities-and laws that make them tick. The mental toolbox we inherited comes equipped with distinct kinds of intuitions-about space, number, objects, living things, tools, and minds. We can see these intuitions at work as children first try to make sense of their world.

The most fundamental mental tool is an intuitive physics: an understanding of how objects fall, roll, and bounce. Its foundation is an appreciation that the world contains objects that persist when out of sight and that obey laws; it is not a kaleidoscope of shimmering pixels or a magic show in which things disappear and reappear capriciously. In 1890, the philosopher and psychologist William James famously described the world of the infant as a "blooming, buzzing confusion," but recent experiments have shown that babies are not as confused as James thought. Infants as young as three months are apparently interpreting the blooms and buzzes as the outward signs of persisting, law-abiding objects; they are visibly surprised when an experimenter rigs up a display in which objects seem to vanish, pass through each other, fly apart, or move without having been pushed. As one psychologist summed up the results, "a blooming, buzzing confusion" describes the life of the parents, not of the infant.

But some objects do seem to defy physical laws. As the evolutionary biologist Richard Dawkins noted, if you throw a dead bird into the air, it will describe a graceful parabola and fall to the ground, exactly as physics books say it should, but if you throw a live bird in the air it may not touch land this side of the county boundary. These apparent scofflaws are living things, and we interpret them not as weird, springy objects or as law-defying miracles, but as obeying different kinds of laws, the laws of an intuitive biology. Living things are sensed to house an internal essence, which supplies a source of renewable energy, or oomph, that propels animals (usually in pursuit of a goal), gives them their form, and drives their growth and bodily functions.

This intuition guides the way people in all cultures treat the living world. Foragers are fine amateur biologists who classify local plants and animals into categories that often match the professional biologist's genus or species. They don't simply lump together animals that look alike; dissimilar-looking creatures such as caterpillars and butterflies or peacocks and peahens are classifled as the same animal. The intuition that organisms are driven by an internal constitution also allows foragers to predict movements and life cycles. Straight tracks tell of a beast aiming for a destination, at which it can perhaps be surprised; a flower in the spring may provide fruit or a nutritious underground tuber in the fall. The same intuition inspires foragers to prepare juices and powders from plants and animals and try them out as medicines, poisons, and food additives.

Children distinguish the living from the nonliving early in life. Infants expect objects to move only when launched by some external force, but they expect people to start and stop on their own. Preschoolers reason about animals by ignoring appearances and focusing on their innards. In one experiment, four-year-olds were shown pictures of an animal and asked what would happen if its outside or its insides were removed. When asked, for example, "What if you take out the

stuff inside the dog, you know, the blood and bones and things like that, and got rid of it and all you have left is the outside? Is it still a dog? Can it still bark and eat dog food?", the children answered "no." Alternatively, the children were asked to consider something that didn't look like a dog at all: "What if you take off the stuff outside of the dog, you know, the fur, and got rid of it and all you have left are the insides?" This time the children answered that it was still a dog and did doggy things.

A third way of knowing is intuitive engineering, the understanding of tools and other artifacts. Artifacts are defined not by their shape or constitution but by what they are intended to do. A store selling chairs might be stocked with anything from stools and dining room sets to beanbags, hammocks, and wooden cubes. A stump or elephant's foot becomes a chair if someone decides to use it as one. The only thing that chairs have in common is that someone intends them to hold up a human behind.

Tools appear in the fossil record millions of years before modern skulls do and must have been a major selection pressure for the expansion of the brains that make them. Today's one-year-old hominids tinker with sticks for pushing, strings for pulling, and supports for holding things up. Before they enter first grade, children have different intuitions about artifacts and living things. If you make a lion look like a tiger with a costume or a dye job and a shave, children say it is not a tiger but still a lion. But if, with some snipping and gluing, you make a coffeepot look like a birdfeeder, they say it just is a birdfeeder.

No law of intuitive physics, biology, or engineering, however, can explain the actions of human beings, who clearly don't behave like rocks, animals, or wind-up dolls. To predict the deeds of others, we need intuitive psychology-the conviction that people are driven by invisible, weightless mental states, such as beliefs and desires. We mortals can't literally read other people's minds, but we can make good guesses by listening carefully to what they say, watching their faces and eyes, and trying to make sense of their behavior. Like the other core intuitions, the rudiments of mind reading are first exercised in the crib. Infants make eye contact and track their parents' gaze, especially when they are uncertain why a parent is doing something. Three-year-olds show that they understand the nature of beliefs and desires and where they come from-for example, that a looker often wants what he is looking at, that you can't eat the memory of an apple, and that a person can tell what's in a box only by looking in it.

A child's precocious understanding of these domains-psychology, biology, physics, and engineering-suggests that the brain is prepared for them. Indeed, some patients with brain damage cannot name living things but can name artifacts, or vice versa, implying that artifacts and living things are stored in different ways in the brain. And some kinds of mental disorders seem to impair some domains and spare others. People with autism, for example, seem to lack an intuitive psychology, whereas those with Williams syndrome are competent intuitive psychologists but are spatially and mechanically challenged.

Our mental tools are sometimes most conspicuous when we apply them in ways they were not designed for. Slapstick humor comes from a sudden shift away from thinking of a person in the usual way, as a living locus of beliefs and desires, to seeing him as a material object ignominiously obeying the laws of physics (such as slipping on a banana peel). Religious beliefs

in souls, angels, and gods come from divorcing our intuitive psychology from our intuitive biology and physics so that we can think about minds that have no bodies. Animistic beliefs do the opposite-they marry intuitive psychology to intuitive biology, physics, or engineering and impute minds to trees, mountains, or idols.

And this brings us back to how our Stone Age minds grasp modern science. Formal sciences grew out of their intuitive counterparts. The conviction that living things have an essence, for example, is what impelled the first biologists to try to understand the nature of plants and animals by cutting them open and putting bits of them under a microscope. Anyone who announced he was trying to understand the nature of chairs by bringing them into a laboratory and putting bits of them under a microscope would be dismissed as mad, not given a grant.

But to advance from intuitive science to modern science, we often have to turn off parts of the intuitions out of which it grew. Newton's first law states that a moving object continues in a straight line unless acted on by a force. Ask college students what happens to a whirling tetherball that is cut loose, however, and a depressingly large minority, including many who have taken physics, say it would continue in a circular path. The students explain that the object acquires a "force," or "momentum," that powers it along the curve until the momentum gets "used up" and the path straightens out. Although erroneous, the students' beliefs are understandable because we evolved in a world with substantial friction, which makes moving objects slow down and stop, not in a lab with pucks gliding on air tables.

Modern science also pries our intuitive faculties loose from the objects they usually apply to and encourages us to aim them at seemingly inappropriate ones. To do mathematics, we primates-visual animals-invented graphs. These allow abstruse concepts to present themselves to our mind's eyes as reassuringly familiar shapes: "Y = mx + b" is a straight line; differentiable functions are smooth curves. They also allow mathematical operations to be performed by doodling in mental imagery: to add a constant, mentally shove the line upward; to multiply, rotate it; to integrate, color in the space beneath it. To do chemistry, we stretch our intuitive physics and treat the essence of a natural substance as a collection of tiny, bouncy, sticky objects. To do biology, we take our way of understanding artifacts and apply it to living things-organs as machines "engineered" by natural selection-and then to their essences, the molecules of life. To do psychology, we treat the mind as an organ of a living creature, as an artifact designed by natural selection, and as a collection of physical objects, neurons.

According to a saying that is well known among psychologists, if you give a boy a hammer, the whole world becomes a nail. The saying is usually aimed at overreaching theoreticians, but it seems to be appropriate to Homo sapiens in general. If you give a species an elementary grasp of psychology, biology, and mechanics, then for better and for worse, the whole world becomes a society, a zoo, and a machine.

References

Adapted from How the Mind Works (W.W. Norton and Company, October 1997).

Word count: **2268**

Copyright Natural History Magazine, Inc. Sep 1997