Animal intelligence and evolution of the human mind

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Subtle refinements in brain architecture, rather than large-scale alterations, make us smarter than other animals.

As far as we know, no dog can compose music, no dolphin can speak in rhymes, and no parrot can solve equations with two unknowns. Only humans can perform such intellectual feats, presumably because we are smarter than all other animal species-at least by our own definition of intelligence.

Of course, intelligence must emerge from the workings of the three-pound mass of wetware packed inside our skulls. Thus, researchers have tried to identify unique features of the human brain that could account for our superior intellectual abilities. But, anatomically, the human brain is very similar to that of other primates because humans and chimpanzees share an ancestor that walked the earth less than seven million years ago.

Accordingly, the human brain contains no highly conspicuous characteristics that might account for the species' cleverness. For instance, scientists have failed to find a correlation between absolute or relative brain size and acumen among humans and other animal species. Neither have they been able to discern a parallel between wits and the size or existence of specific regions of the brain, excepting perhaps Broca's area, which governs speech in people. The lack of an obvious structural correlate to human intellect jibes with the idea that our intelligence may not be wholly unique: studies are revealing that chimps, among various other species, possess a diversity of humanlike social and cognitive skills.

Nevertheless, researchers have found some microscopic clues to humanity's aptitude. We have more neurons in our brain's cerebral cortex (its outermost layer) than other mammals do. The insulation around nerves in the human brain is also thicker than that of other species, enabling the nerves to conduct signals more rapidly. Such biological subtleties, along with behavioral ones, suggest that human intelligence is best likened to an upgrade of the cognitive capacities of nonhuman primates rather than an exceptionally advanced form of cognition.

Smart Species

Because animals cannot read or speak, their aptitude is difficult to discern, much less measure. Thus, comparative psychologists have invented behavior-based tests to assess birds' and mammals' abilities to learn and remember, to comprehend numbers and to solve practical problems. Animals of various stripes-but especially nonhuman primates-often earn high marks on such action-oriented IQ tests. During World War I, German psychologist Wolfgang Köhler, for example, showed that chimpanzees, when confronted with fruit hanging from a high ceiling, devised an ingenious way to get it: they stacked boxes to stand on to reach the fruit. They also constructed long sticks to reach food outside their enclosure. Researchers now know that great apes have a sophisticated understanding of tool use and construction.

Psychologists have used such behavioral tests to illuminate similar cognitive feats in other mammals as well as in birds. Pigeons can discriminate between male and female faces and among paintings by different artists; they can also group pictures into categories such as trees, selecting those belonging to a category by pecking with their beaks, an action that often brings a food reward. Crows have intellectual capacities that are overturning conventional wisdom about the brain.

Behavioral ecologists, on the other hand, prefer to judge animals on their street smarts-that is, their ability to solve problems relevant to survival in their natural habitats-rather than on their test-taking talents. In this view, intelligence is a cluster of capabilities that evolved in response to particular environments. Some scientists have further proposed that mental or behavioral flexibility, the ability to come up with novel solutions to problems, is another good measure of animal intellect. Among birds, green herons occasionally throw an object in the water to lure curious fish-a trick that, ornithologists have observed, has been reinvented by groups of these animals living in distant locales. Even fish display remarkable practical intelligence, such as the use of tools, in the wild. Cichlid fish, for instance, use leaves as “ baby carriages” for their egg masses.

Animals also can display humanlike social intelligence. Monkeys engage in deception, for example; dolphins have been known to care for another injured pod member (displaying empathy), and a whale or porpoise may recognize itself in the mirror. Even some fish exhibit subtle kinds of social skills. Behavioral ecologist Redouan Bshary of the University of Neuchâtel in Switzerland and his colleagues described one such case in a 2006 paper. Bony fish such as the so-called cleaner wrasse (Labroides dimidiatus) cooperate and remove parasites from the skin of other fish or feed on their mucus. Bshary’s team found that bystander fish spent more time next to cleaners the bystanders had observed being cooperative than to other fish. Humans, the authors note, tend to notice altruistic behavior and are more willing to help do-gooders whom they have observed doing favors for others. Similarly, cleaner wrasses observe and evaluate the behavior of other finned ocean denizens and are more willing to help fish that they have seen assisting third parties.

From such studies, scientists have constructed evolutionary hierarchies of intelligence. Primates and cetaceans (whales, dolphins and porpoises) are considered the smartest mammals. Among primates, humans and apes are considered cleverer than monkeys, and monkeys more so than prosimians. Of the apes, chimpanzees and bonobos rank above gibbons, orangutans and gorillas. Dolphins and sperm whales are supposedly smarter than nonpredatory baleen whales such as blue whales. Among birds, scientists consider parrots, owls and corvids (crows and ravens) the brightest. Such a pecking order argues against the idea that intelligence evolved along a single path, culminating in human acumen. Instead intellect seems to have emerged independently in birds and mammals and also in cetaceans and primates.

Heavy Thoughts?

What about the brain might underlie these parallel paths to astuteness? One candidate is absolute brain size. Although many studies have linked brain mass with variations in human intelligence [see " High-Aptitude Minds," by Christian Hoppe and Jelena Stojanovic], size does not always correlate with smarts in different species. For example, clever small animals such as parrots, ravens, rats and relatively diminutive apes have brains of modest proportions, whereas some large animals such as horses and cows with large brains are comparatively dim-witted. Brain bulk cannot account for human intelligence either: At eight to nine kilograms, sperm and killer whale brains far outweigh the 1. 4 kilograms of neural tissue inside our heads. As heavy as five kilograms, elephant brains are also much chunkier than ours.

Relative brain size-the ratio of brain to body mass-does not provide a satisfying explanation for interspecies differences in smarts either. Humans do compare favorably with many medium and large species: our brain makes up approximately 2 percent of our body weight, whereas the blue whale's brain, for instance, is less than one 100th of a percent of its weight. But some tiny, not terribly bright animals such as shrews and squirrels win out in this measure. In general, small animals boast relatively large brains, and large animals harbor relatively small ones. Although absolute brain mass increases with body weight, brain mass as a proportion of body mass tends to decrease with rising body weight.

Another cerebral yardstick that scientists have tried to tie to intelligence is the degree of encephalization, measured by the encephalization quotient (EQ). The EQ expresses the extent to which a species' relative brain weight deviates from the average in its animal class, say, mammal, bird or amphibian. Here the human brain tops the list: it is seven to eight times larger than would be expected for a mammal of its weight. But EQ does not parallel intellect perfectly either: gibbons and some capuchin monkeys have higher EQs than the more intelligent chimpanzees do, and even a few pro-simians-the earliest evolved primates alive today-have higher EQs than gorillas do.

Or perhaps the size of the brain’s outermost layer, the cerebral cortex-the seat of many of our cognitive capacities-is the key. But it turns out that the dimensions of the cerebral cortex depend on those of the entire brain and that the size of the cortex constitutes no better arbiter of a superior mind. The same is true for the prefrontal cortex, the hub of reason and action planning. Although some brain researchers have claimed in the past that the human prefrontal cortex is exceptionally large, recent studies have shown that it is not. The size of this structure in humans is comparable to its size in other primates and may even be relatively small as compared with its counterpart in elephants and cetaceans.

The lack of a large-scale measure of the human brain that could explain our performance may reflect the idea that human intellect may not be totally inimitable. Apes, after all, understand cause and effect, make and use tools, produce and comprehend language, and lie to and imitate others. These primates may even possess a theory of mind-the ability to understand another animal’s mental state and use it to guide their own behavior. Whales, dolphins and even some birds boast some of these mental talents as well. Thus, adult humans may simply be more intuitive and facile with tools and language than other species are, as opposed to possessing unique cognitive skills.

Networking

Fittingly, researchers have found the best correlates for intelligence by looking at a much smaller scale. Brains consist of nerve cells, or neurons, and supporting cells called glia. The more neurons, the more extensive and more productive the neuronal networks can be-and those networks determine varied brain functions, including perception, memory, planning and thinking. Large brains do not automatically have more neurons; in fact, neuronal density generally decreases with increasing brain size because of the additional glial cells and blood vessels needed to support a big brain.

Humans have 11. 5 billion cortical neurons-more than any other mammal, because of the human brain’s high neuronal density. Humans have only about half a billion more cortical neurons than whales and elephants do, however-not enough to account for the significant cognitive differences between humans and these species. In addition, however, a brain’s information-processing capacity depends on how fast its nerves conduct electrical impulses. The most rapidly conducting nerves are swathed in sheaths of insulation called myelin. The thicker a nerve’s myelin sheath, the faster the neural impulses travel along that nerve. The myelinated nerves in the brains of whales and elephants are demonstrably thinner than they are in primates, suggesting that information travels faster in the human brain than it does in the brains of nonprimates.

What is more, neuronal messages must travel longer distances in the relatively large brains of elephants and whales than they do in the more compact human brain. The resulting boost in information-processing speed may at least partly explain the disparity in aptitude between humans and other big-brained creatures.

Among humans' cerebral advantages, language may be the most obvious. Various animals can convey complex messages to other members of their species; they can communicate about objects that are not in sight and relay information about individuals and events. Chimpanzees, gorillas, dolphins and parrots can even understand and use human speech, gestures or symbols in constructions of up to about three words. But even after years of training, none of these creatures develops verbal skills more advanced than those of a three-year-old child.

In humans, grammar and vocabulary all but explode at age three. This timing corresponds with the development of Broca's speech area in the left frontal lobe, which may be unique to humans. That is, scientists are unsure whether a direct precursor to this speech region exists in the nonhuman primate brain. The absence of an intricately wired language region in the brains of other species may explain why, of all animals, humans alone have a language that contains complex grammar. Researchers date the development of human grammar and syntax to between 80, 000 and 100, 000 years ago, which makes it a relatively recent evolutionary advance. It was also one that probably greatly enhanced human intellect.