WHY ARE SOME ANIMALS

THE UNUSUAL BEHAVIOR OF ORANGUTANS IN A SUMATRAN SWAMP

PERRY VAN DUIJNHOVEN FROM *AMONG ORANGUTANS: RED APES AND THE RISE OF HUMAN CULTURE*, BY CAREL VAN SCHAIK. THE BELKNAP PRESS OF HARVARD UNIVERSITY PRESS,

SO SMART?

SUGGESTS A SURPRISING ANSWER

ORANGUTAN mother and infant in Sumatra.

BY CAREL VAN SCHAIK

Even though we humans write the textbooks and may justifiably be suspected of bias, few doubt that we are the smartest creatures on the planet. Many animals have special cognitive abilities that allow them to excel in their particular habitats, but they do not often solve novel problems. Some of course do, and we call them intelligent, but none are as quick-witted as we are.

What favored the evolution of such distinctive brainpower in humans or, more precisely, in our hominid ancestors? One approach to answering this question is to examine the factors that might have shaped other creatures that show high intelligence and to see whether the same forces might have operated in our forebears. Several birds and nonhuman mammals, for instance, are much better problem solvers than others: elephants, dolphins, parrots, crows. But research into our close relatives, the great apes, is surely likely to be illuminating.

Scholars have proposed many explanations for the evolution of intelligence in primates, the lineage to which humans and apes belong (along with monkeys, lemurs and lorises). Over the past 13 years, though, my group's studies of orangutans have unexpectedly turned up a new explanation that we think goes quite far in answering the question.

Incomplete Theories

ONE INFLUENTIAL ATTEMPT at explaining primate intelligence credits the complexity of social life with spurring the development of strong cognitive abilities. This Machiavellian intelligence hypothesis suggests that success in social life relies on cultivating the most profitable relationships and on rapidly reading the social situation—for instance, when deciding whether to come to the aid of an ally attacked by another animal. Hence, the demands of society foster intelligence because the most intelligent beings would be most successful at making self-protective choices and thus would survive to pass their genes to the next generation. Machiavellian traits may not be equally beneficial to other lineages, however, or even to all primates, and so this notion alone is unsatisfying.

One can easily envisage many other forces that would promote the evolution of intelligence, such as the need to work hard for one's food. In that situation, the ability to figure out how to skillfully extract hidden nourishment or the capacity to remember the perennially shifting locations of critical food items would be advantageous, and so such cleverness would be rewarded by passing more genes to the next generation.

My own explanation, which is not incompatible with these other forces, puts the emphasis on social learning. In humans, intelligence develops over time. A child learns primarily from the guidance of patient adults. Without strong social—that is, cultural—inputs, even a potential wunderkind will end up a bungling bumpkin as an adult. We now have evidence that this process of social learning also applies to great apes, and I will argue that, by and large, the animals that are intelligent are the ones that are cultural: they learn from one another innovative solutions to ecological or social problems. In short, I suggest that culture promotes intelligence.

I came to this proposition circuitously, by way of the swamps on the western coast of the Indonesian island of Sumatra, where my colleagues and I were observing orangutans. The orangutan is Asia's only great ape, confined to the islands of Borneo and Sumatra and known to be something of a loner. Compared with its more familiar relative, Africa's chimpanzee, the red ape is serene rather than hyperactive and reserved socially rather than convivial. Yet we discovered in them the conditions that allow culture to flourish.

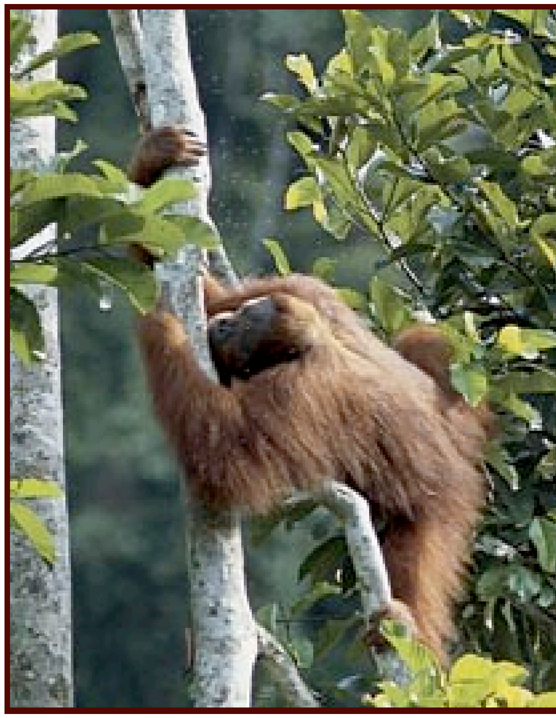
KLUET SWAMP provides an unusually lush habitat for orangutans. The author and his colleagues discovered that in such a productive setting, the apes, generally known to live solitary lives, are surprisingly sociable.

Technology in the Swamp

WE WERE INITIALLY attracted to the swamp because it sheltered disproportionately high numbers of orangutans—unlike the islands' dryland forests, the moist swamp habitat supplies abundant food for the apes year-round and can thus support a large population. We worked in an area near Suaq Balimbing in the Kluet swamp [*see map at left*], which may have been paradise for orangutans but, with its sticky mud, profusion of biting insects, and oppressive heat and humidity, was hell for researchers.

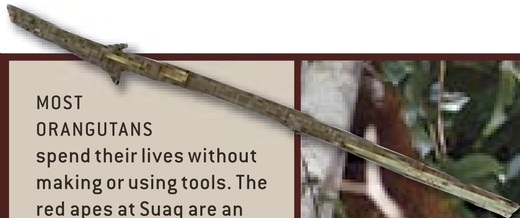
One of our first finds in this unlikely setting astonished us: the Suaq orangutans created and wielded a variety of tools. Although captive red apes are avid tool users, the most striking feature of tool use among the wild orangutans observed until then was its absence. The animals at Suaq ply their tools for two major purposes. First, they hunt for ants, termites and, especially, honey (mainly that of stingless bees)—more so than all their fellow orangutans elsewhere. They often cast discerning glances at tree trunks, looking for air traffic in and out of small holes. Once discovered, the holes become the focus of visual and then manual inspection by a poking and picking finger. Usually the finger is not long enough, and the orangutan prepares a stick tool. After carefully inserting the tool, the ape delicately moves it back and forth, and then withdraws it, licks it off and sticks it back in. Most of this "manipulation" is done with the tool clenched between the teeth; only the largest tools, used primarily to hammer chunks off termite nests, are handled.

The second context in which the Suaq apes employ tools involves the fruit of the *Neesia*. This tree produces woody, five-angled capsules up to 10 inches long and four inches wide. The capsules are filled with brown seeds the size of lima beans, which, because they contain nearly 50 percent fat, are highly nutritious—a rare and sought-after treat in a natural habitat without fast food. The tree protects its seeds by growing a very tough husk. When the seeds are ripe, however, the husk begins to split open; the cracks gradually widen, exposing neat rows of seeds, which have grown nice red attachments (arils) that contain some 80 percent fat. To discourage seed predators further, a mass of razor-sharp needles fills the husk. The orangutans at Suaq strip the bark off short, straight twigs, which they then hold in their mouths and insert into the cracks. By moving the tool up and down inside the crack, the animal detaches the seeds from their stalks. After this maneuver, it can drop the seeds



Overview/*The Orangutan Connection*

- The author has discovered extensive tool use among orangutans in a Sumatran swamp. No one has observed orangutans systematically using tools in the wild before.
- This unexpected finding suggests to the author a resolution to a long-standing puzzle: Why are some animals so smart?
- He proposes that culture is the key. Primatologists define culture as the ability to learn—by observation—skills invented by others. Culture can unleash ever increasing accomplishments and can bootstrap a species toward greater and greater intelligence.



MOST ORANGUTANS spend their lives without making or using tools. The red apes at Suaq are an exception; they create a variety of tools. One of the most common is a stick (*above right*) they prepare for gathering ants, termites and, especially, honey. Without the tool (*far left*), attempts to retrieve honey from a hole in a tree, by biting the hole, for example, often fail. The Suaq apes, in contrast, insert the tool into the hole and, holding it in their mouth (*arrow at right*), move it delicately back and forth. They then withdraw it to lick off the honey (*far right*).

straight into its mouth. Late in the season, the orangutans eat only the red arils, deploying the same technique to get at them without injury.

Both these methods of fashioning sticks for foraging are ubiquitous at Suaq. In general, "fishing" in tree holes is occasional and lasts only a few minutes, but when *Neesia* fruits ripen, the apes devote most of their waking hours to ferreting out the seeds or arils, and we see them grow fatter and sleeker day by day.

Why the Tool Use Is Cultural

WHAT EXPLAINS this curious concentration of tool use when wild orangutans elsewhere show so little propensity? We doubt that the animals at Suaq are intrinsically smarter: the observation that most captive members of this species can learn to use tools suggests that the basic brain capacity to do so is present.

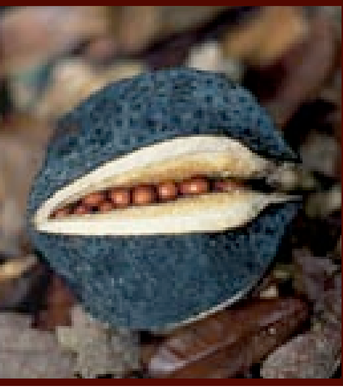
So we reasoned that their environment might hold the answer. The orangutans studied before mostly live in dry forest, and the swamp furnishes a uniquely lush habitat. More insects make their nests in the tree holes there than in forests on dry land, and *Neesia* grows only in wet places, usually near flowing water. Tempting as the environmental explanation sounds, however, it does not explain why orangutans in several populations outside Suaq ignore altogether these same rich food sources. Nor does it explain why some populations that do eat the seeds harvest them without tools (which results, of course, in their eating much less than the orangutans at Suaq do). The same holds for tree-hole tools. Occasionally, when the nearby hills—which have dryland forests—show massive fruiting, the Suaq orangutans go there to indulge, and while they are gathering fruit they use tools to exploit the contents of tree holes. The hill habitat is a dime a dozen throughout the orangutan's geographic range, so if tools can be used on the hillsides above Suaq, why not everywhere?

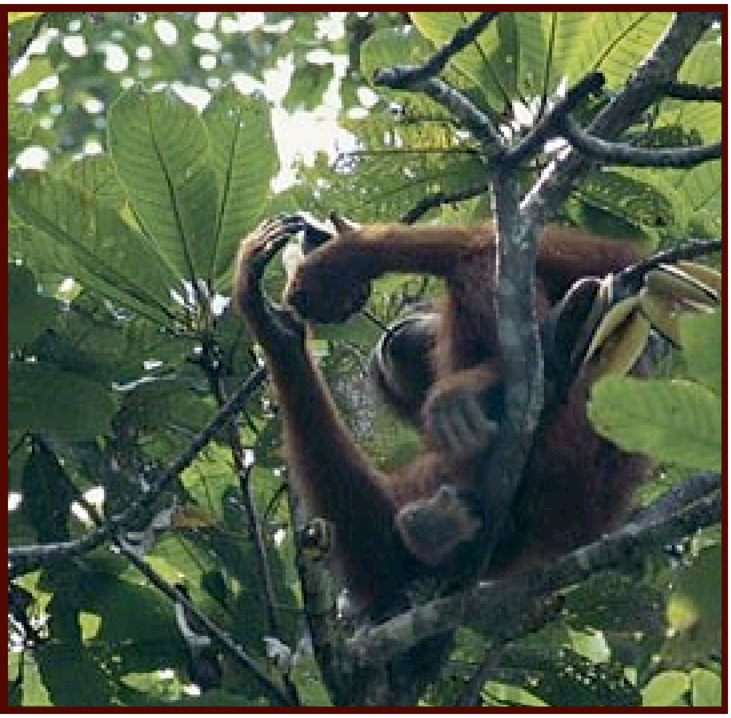
Another suggestion we considered, captured in the old adage that necessity is the mother of invention, is that the Suaq animals, living at such high density, have much more competition for provisions. Consequently, many would be left without food unless they could get at the hard-to-reach supplies—that is, they *need* tools in order to eat. The strongest argument against this possibility is that the sweet or fat foods that the tools make accessible sit very high on the orangutan preference list and should therefore be sought by these animals everywhere. For instance, red apes in all locations are willing to be stung many times by honeybees to get at their honey. So the necessity idea does not hold much water either.

A different possibility is that these behaviors are innovative techniques a couple of clever orangutans invented, which then spread and persisted in the population because other individuals learned by observing these experts. In other words, the tool use is cultural. A major obstacle to studying culture in nature is that, barring experimental introductions, we can never demonstrate convincingly that an animal we observe invents some new trick rather than simply applying a well-remembered but rarely practiced habit. Neither can we prove that one individual learned a new skill from another group member rather than figuring out what to do on its own. Although we can show that orangutans in the lab are capable of observing and learning socially, such studies tell us nothing about culture in nature—neither what it is generally about nor how much of it exists. So field-workers have had to develop a system of criteria to demonstrate that a certain behavior has a cultural basis.

First, the behavior must vary geographically, showing that it was invented somewhere, and it must be common where it is found, showing that it spread and persisted in a population. The tool uses at Suaq easily pass these first two tests. The second step is to eliminate simpler explanations that produce the same spatial pattern but without involv-

FRUIT OF THE *NEESIA* TREE (*below left*) has inspired another important tool in the repertoire of the orangutans at Suaq. The highly nutritious seeds are surrounded by razor-sharp needles that serve to keep out mammalian seed predators. To circumvent the painful needles, the Suaq apes strip the bark off short, straight twigs, which they then hold in their mouth and insert into cracks in the ripening fruit (*right*). By moving the tool up and down inside the crack, the ape detaches the seeds without getting injured. The photograph in the center shows a small fruit with the tool still sticking out.





ing social learning. We have already excluded an ecological explanation, in which individuals exposed to a particular habitat independently converge on the same skill. We can also eliminate genetics because of the fact that most captive orangutans can learn to use tools.

The third and most stringent test is that we must be able to find geographic distributions of behavior that can be explained by culture and are not easily explained any other way. One key pattern would be the presence of a behavior in one place and its absence beyond some natural barrier to dispersal. In the case of the tool users at Suaq, the geographic distribution of *Neesia* gave us decisive clues. *Neesia* trees (and orangutans) occur on both sides of the wide Alas River. In the Singkil swamp, however, just south of Suaq and on the same side of the Alas River [*see map on opposite page*], tools littered the floor, whereas in Batu-Batu swamp across the river they were conspicuously absent, despite our numerous visits in different years. In Batu-Batu, we did find that many of the fruits were ripped apart, showing that these orangutans ate *Neesia* seeds in the same way as their colleagues did at a site called Gunung Palung in distant Borneo but in a way completely different from their cousins right across the river in Singkil.

Batu-Batu is a small swamp area, and it does not contain much of the best swamp forest; thus, it supports a limited number of orangutans. We do not know whether tool use was never invented there or whether it could not be maintained in the smaller population, but we do know that migrants from across the river never brought it in because the Alas is so wide there that it is absolutely impassable for an orangutan. Where it is passable, farther upriver, *Neesia* occasionally grows, but the orangutans in that area ignore it altogether, apparently unaware of its rich offerings. A cultural interpretation, then, most parsimoniously explains the unexpected juxtaposition of knowledgeable tool users and brute-force foragers living practically next door to one another, as well as the presence of ignoramuses farther upriver.

Tolerant Proximity

WHY DO WE SEE these fancy forms of tool use at Suaq and not elsewhere? To look into this question, we first made detailed comparisons among all the sites at which orangutans have been studied. We found that even when we excluded tool use, Suaq had the largest number of innovations that had spread throughout the population. This finding is probably not an artifact of our own interest in unusual behaviors, because some other sites have seen far more work by researchers eager to discover socially learned behavioral innovations.

We guessed that populations in which individuals had more chances to observe others in action would show a greater diversity of learned skills than would populations offering fewer learning opportunities. And indeed, we were able to confirm that sites in which individuals spend more time with others have greater repertoires of learned innovations—a relation, by the way, that also holds among chimpanzees [*see illustration on page 70*]. This link was strongest for food-related behavior, which makes sense because acquiring feeding skills from somebody else

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requires more close-range observation than, say, picking up a conspicuous communication signal. Put another way, those animals exposed to the fewest educated individuals have the smallest collection of cultural variants, exactly like the proverbial country bumpkin.

When we looked closely at the contrasts among sites, we noticed something else. Infant orangutans everywhere spend over 20,000 daylight hours in close contact with their mothers, acting as enthusiastic apprentices. Only at Suaq, however, did we also see adults spending considerable time together while foraging. Unlike any other orangutan population studied so far, they even regularly fed on the same food item, usually termite-riddled branches, and shared food—the meat of a slow loris, for example. This unorthodox proximity and tolerance allowed less skilled adults to come close enough to observe foraging methods, which they did as eagerly as kids.

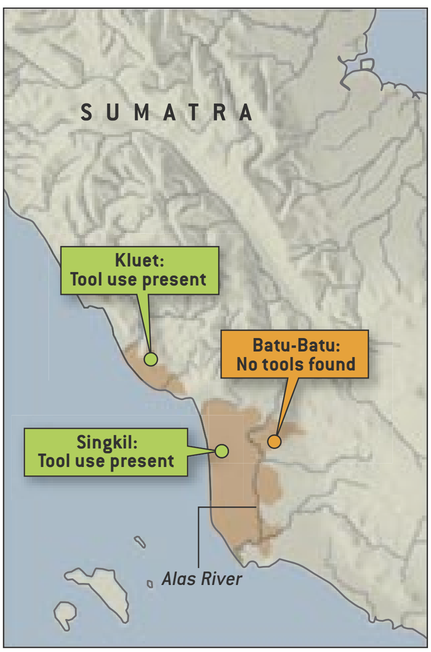
Acquisition of the most cognitively demanding inventions, such as the tool uses found only at Suaq, probably requires face time with proficient individuals, as well as several cycles of observation and practice. The surprising implication of this need is that even though infants learn virtually all their skills from their mothers, a population will be able to perpetuate particular innovations only if tolerant role models other than the mother are around; if mom is not particularly skillful, knowledgeable experts will be close at hand, and a youngster will still be able to learn the fancy techniques that apparently do not come automatically. Thus, the more connected a social network, the more likely it is that the group will retain any skill that is invented, so that in the end tolerant populations support a greater number of such behaviors.

Our work in the wild shows us that most learning in nature, aside from simple conditioning, may have a social component, at least in primates. In contrast, most laboratory experiments that investigate how animals learn are aimed at revealing the subject's ability for individual learning. Indeed, if the lab psychologist's puzzle were presented under natural conditions, where myriad stimuli compete for attention, the subject might never realize that a problem was waiting to be solved. In the wild, the actions of knowledgeable members of the community serve to focus the attention of the naive animal.

The Cultural Roots of Intelligence

OUR ANALYSES of orangutans suggest that not only does culture—social learning of special skills—promote intelligence, it favors the evolution of greater and greater intelligence in a population over time. Different species vary greatly in the mechanisms that enable them to learn from others, but formal experiments confirm the strong impression one gets from observing great apes in the wild: they are capable of learning by watching what others do. Thus, when a wild orangutan, or an African great ape for that matter, pulls off a cognitively complex behavior, it has acquired the ability through a mix of observational learning and individual practice, much as a human child has garnered his or her skills. And when an orangutan in Suaq has acquired more of these tricks than its less fortunate cousins elsewhere, it has done so because it had greater opportunities for social learning throughout its life. In brief, social learning may bootstrap an animal's intellectual performance onto a higher plane.

IMPASSABLE RIVERS may have halted the spread of tool use. *Neesia* trees and orangutans, for example, occur on both sides of the wide Alas River (*photograph*), but in the Singkil swamp (*map*), tools abound on the forest floor, whereas in Batu-Batu swamp across the river the resident orangutans use a simpler technique to detach *Neesia* seeds that does not involve tools. Migrants are not able to bring tool use to Batu-Batu, because the Alas is too wide there for an orangutan to cross.



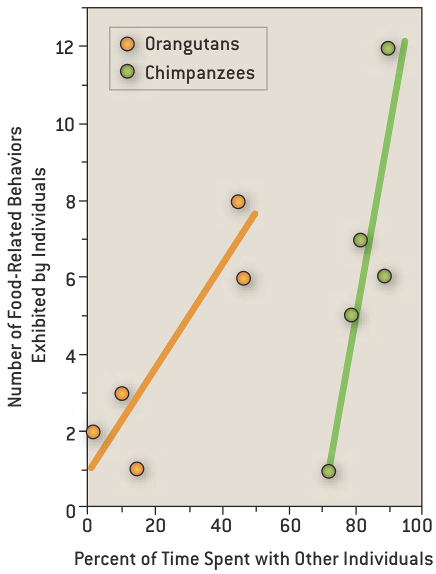
BASE MAP SOURCE: PERRY VAN DUIJNHOVEN; ADAPTED BY JEN CHRISTIANSEN; PERRY VAN DUIJNHOVEN (*photograph*)

To appreciate the importance of social inputs to the evolution of ever higher intelligence, let us do a thought experiment. Imagine an individual that grows up without any social inputs yet is provided with all the shelter and nutrition it needs. This situation is equivalent to that in which no contact exists between the generations or in which young fend for themselves after they emerge from the nest. Now imagine that some female in this species invents a useful skill—for instance, how to open a nut to extract its nutritious meat. She will do well and perhaps have more offspring than others in the population. Unless the skill gets transferred to the next generation, however, it will disappear when she dies.

Now imagine a situation in which the offspring accompany their mother for a while before they strike out on their own. Most youngsters will learn the new technique from their mother and thus transfer it—and its attendant benefits—to the next generation. This process would generally take place in species with slow development and long association between at least one parent and offspring, but it would get a strong boost if several individuals form socially tolerant groups.

We can go one step further. For slowly developing animals that live in socially tolerant societies, natural selection will tend to reward a slight improvement in the ability to learn through observation more strongly than a similar increase in the ability to innovate, because in such a society, an individual can stand on the shoulders of those in both present and past generations. We will then expect a feed-forward process in which animals can become more innovative and develop better techniques of social learning because both abilities rely on similar cognitive mechanisms. Hence, being cultural predisposes species with some innovative capacities to evolve toward higher intelligence. This, then, brings us to the new explanation for cognitive evolution.

This new hypothesis makes sense of an otherwise puzzling phenomenon. Many times during the past century people reared great ape infants as they would human children. These so-called enculturated apes acquired a surprising set of skills, effortlessly imitating complex behavior—understanding pointing, for example, and even some human language, becoming humorous pranksters and creating drawings. More recently, formal experiments such as those performed by E. Sue Savage-Rumbaugh of Georgia



POPULATIONS in which individuals have more chances to observe others in action show a greater diversity of learned skills than populations offering fewer learning opportunities. The relation holds for both chimpanzees and orangutans.

JEN CHRISTIANSEN; SOURCE: CAREL VAN SCHAIK

State University, involving the bonobo Kanzi, have revealed startling language abilities [see "The Emergence of Intelligence," by William H. Calvin; Scientific American, October 1994]. Though often dismissed as lacking in scientific rigor, these consistently replicated cases reveal the astonishing cognitive potential that lies dormant in great apes. We may not fully appreciate the complexity of life in the jungle, but I guess that these enculturated apes have truly become overqualified. In a process that encapsulates the story of human evolution, an ape growing up like a human can be bootstrapped to cognitive peaks higher than any of its wild counterparts.

The same line of thinking solves the long-standing puzzle of why many primates in captivity readily use—and sometimes even make—tools, when their counterparts in the wild seem to lack any such urges. The often-heard suggestion that they do not need tools is belied by observations of orangutans, chimpanzees and capuchin monkeys showing that some of this tool use makes available the richest food in the animals' natural habitats or tides the creatures over during lean periods. The conundrum is resolved if we realize that two individuals of the same species can differ dramatically in their intellectual performance, depending on the social environment in which they grew up.

Orangutans epitomize this phenomenon. They are known as the escape artists of the zoo world, cleverly unlocking the doors of their cages. But the available observations from the wild, despite decades of painstaking monitoring by dedicated field-workers, have uncovered precious few technological accomplishments outside Suaq. Wild-caught individuals generally never take to being locked up, always retaining their deeply ingrained shyness and suspicion of humans. But zoo-born apes happily consider their keepers valuable role models and pay attention to their activities and to the objects strewn around the enclosures, learning to learn and thus accumulating numerous skills.

The critical prediction of the intelligence-through-culture theory is that the most intelligent animals are also likely to live in populations in which the entire group routinely adopts innovations introduced by members. This prediction is not easily tested. Animals from different lineages vary so much in their senses and in their ways of life that a single yardstick for intellectual performance has traditionally been hard to find. For now, we can merely ask whether lineages that show incontrovertible signs of intelligence also have innovation-based cultures, and vice versa. Recognizing oneself in a mirror, for example, is a poorly understood but unmistakable sign of self-awareness, which is taken as a sign of high intelligence. So far, despite widespread attempts in numerous lineages, the only mammalian groups to pass this test are great apes and dolphins, the same animals that can learn to understand many arbitrary symbols and that show the best evidence for imitation, the basis for innovation-based culture. Flexible, innovation-based tool use, another expression of intelligence, has a broader distribution in mammals: monkeys and apes, cetaceans, and elephants—all lineages in which social learning is common. Although so far only these very crude tests can be done, they support the intelligence-through-culture hypothesis.

Another important prediction is that the propensities for innovation and social learning must have coevolved. Indeed, Simon Reader, now at Utrecht University in the Netherlands, and Kevin N. Laland, currently at the University of St. Andrews in Scotland, found that primate species that show more evidence of innovation are also those that show the most evidence for social learning. Still more indirect tests rely on correlations among species between the relative size of the brain (after statistically correcting for body size) and social and developmental variables. The well-established correlations between gregariousness and relative brain size in various mammalian groups are also consistent with the idea.

Although this new hypothesis is not enough to explain why our ancestors, alone among great apes, evolved such extreme intelligence, the remarkable bootstrapping ability of the great apes in rich cultural settings makes the gap seem less formidable. The explanation for the historical trajectory of change involves many details that must be painstakingly pieced together from a sparse and confusing fossil and archaeological record. Many researchers suspect that a key change was the invasion of the savanna by tool-wielding, striding early *Homo*. To dig up tubers and deflesh and defend carcasses of large mammals, they had to work collectively and create tools and strategies. These demands fostered ever more innovation and more interdependence, and intelligence snowballed.

Once we were human, cultural history began to interact with innate ability to improve performance. Nearly 150,000 years after the origin of our own species, sophisticated expressions of human symbolism, such as finely worked nonfunctional artifacts (art, musical instruments and burial gifts), were widespread [see "The Morning of the Modern Mind," by Kate Wong; SCIENTIFIC AMERICAN, June 2005]. The explosion of technology in the past 10,000 years shows that cultural inputs can unleash limitless accomplishments, all with Stone Age brains. Culture can indeed build a new mind from an old brain. SA

ORANGUTANS near Sumatra's western coast are much more gregarious than red apes living elsewhere. Juveniles seek one another's company at every possible opportunity.

MORE TO EXPLORE

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