THE "IT"

SKULL OF A HUMAN faces off with a chimpanzee skull (*at right*). Despite divergent brain sizes, chimps have many of the same cognitive abilities as humans, with a few key exceptions.

FACTOR

The capacity to engage in shared tasks such as hunting large game and building cities may be what separated modern humans from our primate cousins

By Gary Stix

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AT A PSYCHOLOGY LABORATORY IN LEIPZIG, GERMANY, TWO TODDLERS eye gummy bears that lie on a board beyond their reach. To get the treats, both tots must pull in tandem on either end of a rope. If only one child pulls, the rope detaches, and they wind up with nothing.

A few miles away, in a plexiglass enclosure at Pongoland, the ape facility at the Leipzig Zoo, researchers repeat the identical experiment, but this time with two chimpanzees. If the primates pass the rope-and-board test, each one gets a fruit treat.

By testing children and chimps in this way, investigators hope to solve a vexing puzzle: Why are humans so successful as a species? *Homo sapiens* and *Pan troglodytes* share almost 99 percent of their genetic material. Why, then, did humans come to populate virtually every corner of the planet—building the Eiffel Tower, Boeing 747s and H-bombs along the way? And why are chimps still foraging for their supper in the dense forests of equatorial Africa, just as their ancestors did seven or so million years ago, when archaic humans and the great apes separated into different species?

As with any event that occurred on the time scale of evolution—hundreds of thousands or millions of years in the making—scientists may never reach a consensus on what really happened. For years the prevailing view was that only humans make and use tools and are capable of reasoning using numbers and other symbols. But that idea fell by the wayside as we learned more about what other primates are capable of. A chimp, with the right coach, can add numbers, operate a computer and light up a cigarette.

At present, the question of why human behavior differs from that of the great apes, and how much, is still a matter of debate. Yet experiments such as the one in Leipzig, under the auspices of the Max Planck Institute for Evolutionary Anthropology, have revealed a compelling possibility, identifying what may be a unique, but easy to overlook, facet of the human cognitive apparatus. From before their first birthday—a milestone some psychologists term "the nine-month revolution"—children begin to show an acute awareness of what goes on inside their mother's and father's heads. They evince this new ability by following their parents' gaze or looking where they point. Chimps can also figure out what is going on in a companion's mind to some degree, but humans take it one step further: infant and elder also have the ability to put their heads together to focus on what must be done to carry out a shared task. The simple act of adult and infant rolling a ball back and forth is enabled by this subtle cognitive advantage.

Some psychologists and anthropologists think that this melding of minds may have been a pivotal event that occurred hundreds of thousands of years ago and that shaped later human evolution. The ability of small bands of hunter-gatherers to work together in harmony ultimately set off a cascade of cognitive changes that led to the development of language and the spread of diverse human cultures across the globe.

This account of human psychological evolution, synthesized from bits and pieces of research on children and chimps, is speculative, and it has its doubters. But it provides perhaps the most impressively broad-ranging picture of the origins of cognitive abilities that make humans special.

THE RATCHET EFFECT

THE MAX PLANCK INSTITUTE maintains the world's largest research facility devoted to examining the differences in behavior between humans and the great apes. Dozens of studies may be running at any one time. Researchers can draw subjects from a database of more than 20,000 children and recruit chimpan-

IN BRIEF

Humans—it was once thought—differed from other animals by their use of tools and their overall superiority in a range of cognitive abilities. Close observation of the behaviors of chimpanzees and other great apes has proved these ideas to be wrong.

Chimpanzees score as highly as young children on tests of general reasoning abilities but lack many of the social skills that come naturally to their human cousins. Unlike humans, chimps do not collaborate in the large groups needed to build complex societies.

Comparison of human and chimp psychology reveals that an essential source of the differences in humans may be the evolution of the ability to intuit what another person is thinking so that both can work toward a shared goal.

PRECEDING PAGES: INGO ARNDT *Getty Images*

EYES ON THE PRIZE: Both children and chimpanzees sometimes undergo the same tests to compare how closely members of each species work with one another. The two partners must cooperate by pulling each rope in unison to get a treat—either gummy bears in a child laboratory at the Max Planck Institute or bananas or other fruit at the nearby zoo. If one team member pulls and the other does not, the rope comes free, and the pair go hungry.

Photographs by Daniel Rosenthal

zees or members of any of the other great ape species—orangutans, bonobos and gorillas—from the Wolfgang Köhler Primate Research Center at the Leipzig Zoo a few miles away.

The institute began 17 years ago, seven years after the reunification of Germany. Founding the institute required coming to grips with the tarnished legacy of German anthropology—and its association with Nazi racial theories and, in particular, the grisly human experiments performed in Auschwitz by Josef Mengele, who was a physician with a doctorate in anthropology. The institute's organizers went out of their way to recruit group leaders for genetics, primatology, linguistics and other disciplines who were not native Germans.

One of them was Michael Tomasello, a tall, bearded psychologist and primatologist. Now 64, he grew up in a small citrus-growing city at the epicenter of the Florida peninsula. He began his academic career at the University of Georgia with a dissertation on the way toddlers acquire language. While he was doing his doctorate in the 1970s, linguists and psychologists often cited language as exhibit number one for human exceptionalism in the animal world.

Tomasello's doctoral thesis chronicled how his almost two-year-old daughter learned her first verbs. The emergence of proto words—"play play" or "ni ni"—revealed a natural inclination of the young child to engage in trial-and-error testing of language elements, an exercise that gradually took on the more conventional structuring of grammar and syntax. This learning process stood in contrast to the ideas of Noam Chomsky and other linguists who contended that grammar is somehow genetically hardwired in our brains—an explanation that struck Tomasello as reductionist. "Language is such a complicated thing that it couldn't have evolved like the opposable thumb," he says.

His work on language broadened his thinking about the relation between culture and human evolution. Tomasello realized that selective forces alone, acting on physical traits, could not explain the emergence of complex tools, language, mathematics and elaborate social institutions in the comparatively brief interval on the evolutionary time line since humans and chimps parted ways. Some innate mental capacity displayed by hominins (modern humans and our extinct relatives) but absent in nonhuman primates must have enabled our forebears to behave in ways that vastly hastened the ability to feed and clothe themselves and to flourish in any environment, no matter how forbidding.

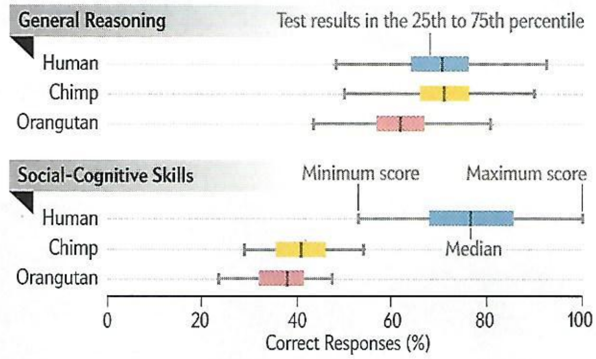
When Tomasello moved to a professorship at Emory University during the 1980s, he availed himself of the university's Yerkes primate research center to look for clues to this capacity in studies comparing the behaviors of children with those of chimps. The move set in motion a multidecade quest that he has continued at Max Planck since 1998.

In his studies of chimp learning, Tomasello noticed that apes do not ape each other the way humans imitate one another. One chimp might emulate another chimp using a stick to fetch ants out of a nest. Then others in the group might do the same. As Tomasello looked more closely, he surmised that chimps were able to understand that a stick could be used for "ant dipping," but they were unconcerned with mimicking one technique or another that might be used in hunting for the insects. More important, there was no attempt to go beyond the basics and then do some tinkering to make a new and improved ant catcher.

CROSS-SPECIES IQ TESTING

Smart as a Chimp?

One widely held hypothesis suggests that, overall, humans are more intelligent than other primates. A study by the Leipzig researchers showed that chimps and young children (though not orangutans) perform equally on tests of capacities measured by conventional IQ tests (*top*), such as spatial and quantitative abilities. But children do better on cognitive tests related to social skills, such as learning from others (*bottom*).



SOURCE: "HUMANS HAVE EVOLVED SPECIALIZED SKILLS OF SOCIAL COGNITION: THE CULTURAL INTELLIGENCE HYPOTHESIS," BY ESTHER HERRMANN ET AL., IN *SCIENCE*, VOL. 317; SEPTEMBER 7, 2007

In human societies, in contrast, this type of innovation is a distinguishing characteristic that Tomasello calls a "ratchet effect." Humans modify their tools to make them better and then pass this knowledge along to their descendants, who make their own tweaks—and the improvements ratchet up. What starts as a lobbed stone projectile invented to kill a mammoth evolves over the millennia into a slingshot and then a catapult, a bullet, and finally an intercontinental ballistic missile.

This cultural ratchet provides a rough explanation for humans' success as a species but leads to another question: What specific mental processes were involved in transmitting such knowledge to others? The answer has to begin with speculations about changes in hominin physiology and behavior that may have taken place hundreds of thousands of years ago. One idea—the social brain hypothesis, put forward by anthropologist Robin Dunbar of the University of Oxford—holds that group size, and hence cultural complexity, scales up as brains get bigger. And scientists know that by 400,000 years ago, *Homo heidelbergensis,* probably our direct ancestor, had a brain almost as large as ours.

Tomasello postulates that, equipped with a bigger brain and confronted with the need to feed a growing population, early hominins began careful strategizing to track and outwit game. The circumstances exerted strong selection pressures for cooperation: any member of a hunting party who was not a team player—taking on a carefully defined role when tracking and cornering an animal—would have been excluded from future outings and so might face an unremittingly bleak future. If one hunter was a bad partner, Tomasello notes, the rest of the group would then decide: "We won't do this again." In his view, what separated modern humans from the hominin pack was an evolutionary adaptation for hypersociality.

The paleoarchaeological record of bones and artifacts is too scant to provide support for Tomasello's hypothesis. He draws his evidence from a comparison of child and chimp—matching our closest primate relative with a toddler who has yet to master a language or be exposed to formal schooling. The untutored child allows researchers to assess cognitive skills that have yet to be fully shaped by cultural influences and so can be considered to be innate.

Studies in Leipzig during the past decade or so have uncovered more similarities than differences between humans and chimps, but they also highlight what Tomasello calls "a small difference that made a big difference." One immense research undertaking, led by Esther Herrmann of the developmental and comparative psychology department at the Max Planck Institute under Tomasello's tutelage, ran from 2003 until its publication in *Science* in 2007. It entailed administering multiple cognitive tests to 106 chimpanzees at two African wildlife sanctuaries, 32 orangutans in Indonesia and 105 toddlers, aged two and a half years, in Leipzig.

The investigators set out to determine whether humans' bigger brain meant the children were smarter than great apes and, if so, what being smarter meant, exactly. The three species were tested on spatial reasoning (such as looking for a hidden reward), an ability to discriminate whether quantities were large or small, and an understanding of cause-and-effect relationships. It turned out that the toddlers and the chimpanzees scored almost identically on these tests (orangutans did not perform quite as well).

When it came to social skills, though, there was no contest. Toddlers bested both chimps and orangutans on tests (adapted for nonverbal apes) that examined the ability to communicate, learn from others, and evaluate another being's perceptions and wishes. The researchers interpreted the results as showing that human children are not born with a higher IQ (general reasoning capacities) but rather come equipped with a special set of abilities—"cultural intelligence," as the *Science* study put it—that prepares them for learning later from parents, teachers and playmates. "It was really the first time that it was shown that social-cognitive abilities are the key skills that make us special in comparison to other animals," Herrmann says.

Digging deeper required probing for the specific psychological processes that underlie humans' ultrasocial tendencies. Tomasello's research showed that at about nine months of age, parent and child engage in a figurative form of mind reading. Each has what psychologists call a "theory of mind." Each is aware of what the other one knows when they look together at a ball or block and play a little game with it. Each carries a mental image of these items in the same way a group of *H. heidelbergensis* would have all visualized a deer intended as dinner. This capacity to engage with another person to play a game or achieve a common goal is what Tomasello calls shared intentionality (a term he borrowed from philosophy). In Tomasello's view, shared intentionality is an evolutionary adaptation unique to humans—a minute difference with momentous consequences, rooted in an inherited predisposition for a degree of cooperative social interactions that is absent in chimps or any other species.

Humans have a special capacity for engaging in figurative "mind reading" of another person's thoughts. They use these deductions to make plans for achieving a joint goal—whether it be carrying a log or building a skyscraper.

THE BENEFITS OF MIND READING

THE INSTITUTE RESEARCHERS NOTED that chimps, too, can read one another's minds to some degree. But their natural inclination is to use whatever they learn in that way to outcompete one another in the quest for food or mates. The chimp mind, it appears, is involved in a kind of Machiavellian mental scheming—"If I do this, will he do that?"—as Tomasello explains it. "It is inconceivable," he said in an October 2010 talk at the University of Virginia, "that you would ever see two chimpanzees carrying a log together."

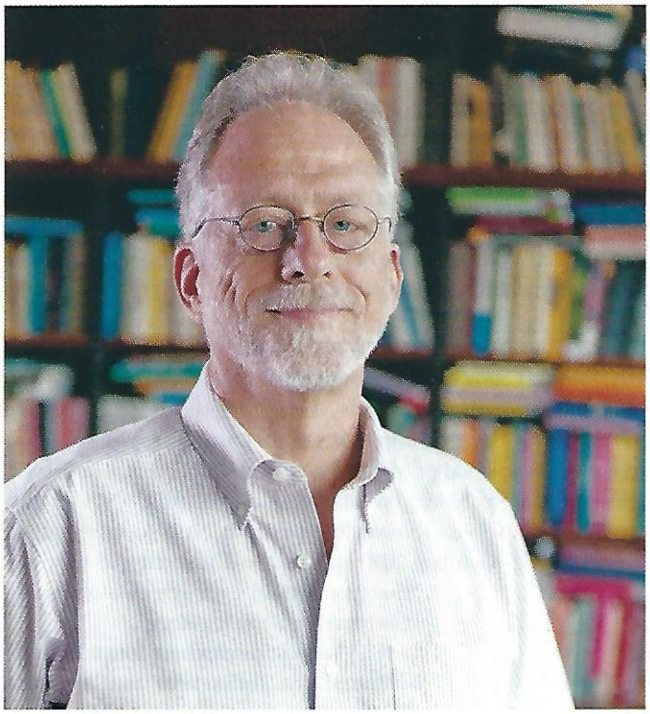
The Leipzig researchers formally demonstrated the differences that separate the two species in the rope-and-board experiment, in which two chimpanzees at the Leipzig Zoo could get a snack of fruit only if they both pulled a rope attached to a board. If food was placed at both ends of the board, the apes took the fruit closest to them. If the treats were placed in the middle, however, the more dominant ape would grab the food, and after a few trials, the subordinate simply stopped playing. In the institute's child lab, the children worked together, whether the gummy bears were placed in the middle or at the ends of the board. When the treat was in the middle, the three-year-olds negotiated so that each would get an equal share.

Ancestral humans' mutual understanding of what was needed to get the job done laid the basis for the beginnings of social interactions and a culture based on cooperation, Tomasello argues. This "common ground," as he calls it, in which members of a group know much of what others know, may have opened the way for development of new forms of communication.

An ability to devise and perceive shared goals—and to intuit immediately what a hunting partner was thinking—apparently allowed our hominin ancestors to make cognitive strides in other ways, such as developing more sophistication in communicative uses of gesturing than our ape relatives possess.

The basic gestural repertoire of our hominin kin may have once been similar to that of the great apes. Archaic humans may have pointed, as chimpanzees do today, to convey commands—"Give me this" or "Do that"—a form of communication centered on an individual's needs. Chimps, perhaps reminiscent of humans in a primeval past, still make no attempt to use these gestures for teaching or passing along information.

For humans, gesturing took on new meaning as their mental-processing abilities got better. A hunter would point to a glade in the forest to indicate where a deer was grazing, an ac-



MICHAEL TOMASELLO has pioneered studies comparing "a few small differences that make a large difference" in the cognitive abilities of humans relative to those of chimpanzees.

tion immediately understood by a nearby companion. The way such pointing can take on new meanings is evident in modern life. "If I point to indicate 'Let's go have a cup of coffee over there,' it's not in the language," Tomasello says. "The meaning of 'that café' is in the finger, not in the language."

Young children understand this type of pointing, but chimps do not. This difference became evident in one study in which the experimenter repeatedly put blocks on a plate that the child needed for building a tower, which the child then used. At a certain juncture, there were no objects left when needed, and so the infant started pointing to the now empty plate, indicating that she wanted one of the blocks that were no longer there. The child knew that the adult would make the correct inference—the ability to refer to an absent entity is, in fact, a defining characteristic of human language. At the zoo, chimps put through a similar exercise—with food substituted for blocks—did not lift a finger when facing a vacant plate.

Only slightly older children start to understand gestures that pantomime an action—moving a hand to one's mouth to represent hunger or thirst. Chimps seeing these gestures during a study remain clueless. An ape will understand what is happening when a human applies a hammer to a nut to get the meat but is befuddled when that same person makes a pounding motion on the hand to convey the idea of carrying out the same action.

This type of gesturing—an extension of humans' cognitive capacity for shared intentionality—may have been the basis for communicating abstract ideas needed to establish more elaborate social groups, whether they be a tribe or a nation. Pantomiming would have enabled people to create story lines, such as conveying "the antelope grazes on the other side of the hill" by holding both hands in a V pattern on the top of one's head to signify the animal and then raising and lowering the hands to depict the hill. These scenarios derive from comparative experiments demonstrating that toddlers have an intuitive understanding of iconic gestures for many familiar activities but that chimpanzees do not.

Some of this gesturing occurred perhaps not just through moving the hands but also through vocalizations intended to represent specific objects or actions. These guttural noises may have evolved into speech, further enhancing the ability to manage complex social relationships as populations continued to grow—and rivalries arose among tribal groups. A group adept at working together would outcompete those that bickered among themselves.

Humans' expanding cognitive powers may have promoted specific practices for hunting, fishing, plant gathering or marriage that turned into cultural conventions—the way "we" do things—that the group as a whole was expected to adopt. A collection of social norms required each individual to gain awareness of the values shared by the group—a "group-mindedness" in which every member conformed to an expected role. Social norms produced a set of moral principles that eventually laid a foundation for an institutional framework—governments, armies, legal and religious systems—to enforce the rules by which people live. The millennial journey that began with a particular mind-set needed by bands of hunters now scaled up to entire societies.

Chimps and other great apes never got started down this path. When chimps hunt together to prey on colobus monkeys in Ivory Coast, this activity, as Tomasello interprets it, entails every chimp trying to run down the monkey first to get the most meat, whereas human hunter-gatherers, even in contemporary settings, cooperate closely as they track game and later share the spoils equitably. Tomasello concludes that ape societies and those of other foragers such as lions may appear to cooperate, but the dynamics at play within the group are still fundamentally competitive in nature.

THE GREAT DEBATE

TOMASELLO'S VERSION of an evolutionary history is not universally accepted, even within the institution. One floor up from his office, in the department of primatology, Catherine Crockford talks me though a video her graduate student Liran Samuni made in March. It shows a young chimpanzee in the Taï National Park in Ivory Coast near the Liberian border.

The chimp the researchers call Shogun has just caught a large, black-and-white colobus monkey. Shogun is having trouble eating his still alive and squirming catch and issues a series of sharp "recruitment screams" to summon help from two elder hunters lodged in the tree canopy. Kuba, one of the two, arrives on the scene shortly, and Shogun calms down a bit and takes his first real bite. But then Shogun continues to scream until the other hunter, Ibrahim, shows up. The younger ape puts his finger in Ibrahim's mouth as a "reassurance gesture," a mannerism that ensures that all is well. Ibrahim gives the sought-for emotional support by not biting Shogun's finger. The three then share the meal. "It's interesting that he's recruiting these two dominant males that could take this whole monkey from him," Crockford says. "But as you can see, they're not taking it from him. He's still allowed to eat it."

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SCIENTIFIC AMERICAN ONLINE Watch an interview with Michael Tomasello at ScientificAmerican.com/sep2014/stix-origins

Crockford argues that it is still too early to draw conclusions about the extent to which chimps cooperate. "I don't think we know the limits of what chimps are doing," she says. "I think [Tomasello's] arguments are brilliant and really clear in terms of our current knowledge, but I think that with new tools that we're taking to the field, we'll find out whether the current limits are the limits of what chimps can do or not." Crockford is working with several other researchers to develop tests that would identify the social-bonding hormone oxytocin in chimpanzee urine. Some studies have shown that the hormone rises when chimps share food, a sign that the animals may cooperate when feeding.

Crockford did her doctoral studies at the institute in Leipzig, with both Tomasello and Christophe Boesch, head of the Max Planck Institute's department of primatology. Boesch has argued against Tomasello's conclusions by highlighting his own extensive research in the Taï National Park showing that chimps have a highly collaborative social structure—one chimp steers the monkey prey in the desired direction; others block its path along the way or take on yet additional roles. Boesch's views on chimp cooperation are similar to those of Frans de Waal of the Yerkes National Primate Research Center at Emory [see "One for All," on page 68]. Still others criticize Tomasello from a diametrically opposing viewpoint. Daniel Povinelli of the University of Louisiana at Lafayette contends that Tomasello overstates chimps' cognitive capacities in suggesting that they have some ability to understand the psychological state of others in the group.

For his part, Tomasello seems to enjoy being in the midst of this academic jousting, saying: "In my mind, Boesch and de Waal are anthropomorphizing apes, and Povinelli is treating them like rats, and they're neither." He adds, jokingly, "We're in the middle. Since we're getting attacked equally from both sides, we must be right."

Condemnation from some quarters is tempered by a deep respect from others. "I used to think that humans were very similar to chimps," says Jonathan Haidt, a leading social scientist at the New York University Stern School of Business. "Over the years, thanks in large part to Tomasello's work, I've come to believe that the small difference he has studied and publicized—the uniquely human ability to do shared intentionality—took us over the river to a new shore, where social life is radically different."

Resolving these debates will require more research from zoo, lab and field station—perhaps through new studies on the extent to which chimps have a theory of mind about others. Still other research already under way by Tomasello's group is intended to determine whether the conclusions about human behavior, drawn from tests on German children, carry over if similar tests are performed on children in Africa or Asia. One study asks whether German preschoolers share their collective sense of what is right or wrong with the Samburu, a seminomadic people in northern Kenya.

There may also be room to look more deeply at human-ape differences. One of Tomasello's close longtime colleagues, Josep Call, who heads the Wolfgang Köhler Center, thinks that shared intentionality alone may not suffice to explain what makes humans special. Other cognitive capacities, he says, may also differentiate humans from other primates—one example may be "mental time travel"—our ability to imagine what may happen in the future.

Advancing an interspecies research agenda beyond comparisons of human and ape psychology may involve looking at differences in genetic makeup among chimps, humans—and even our closest evolutionary kin, the Neandertals.

More perspective on the overlap between humans and chimps may come from looking inside the human brain—an endeavor that is ongoing on yet another floor at Max Planck. Svante Pääbo, who led a team that finished an initial sequencing of the Neandertal genome in 2010, conjectures in a recent book that Tomasello's ideas about the uniqueness of human thinking may ultimately be tested through genetic analyses.

When those studies begin, a logical place to start would be to fuse research on chimp and human behaviors with the quixotic journey to understand the interactions among the hundreds of genes involved in autism. Children with the disorder, not unlike chimps, have difficulty understanding social cues. Comparing the genes in children with autism with those in unaffected children—and then with the DNA of chimps and perhaps even Neandertals, our closest evolutionary cousins—may yield a better understanding of a genetic basis for human sociality.

These investigations may also help explain why, over millennia, we progressed from bands of foragers to societies that not only provide food and shelter more efficiently than chimps do but also offer unceasing opportunities for social dealings—chances to move to any corner of the planet within a day's time or to convey messages to Tucson or Timbuktu as fast as a thought comes to mind. SA

MORE TO EXPLORE

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