Chapter 2: So What Really Makes Us Human?

Elephants have trunks; giraffes have necks; anteaters have tongues. What do we humans have that makes us unique? If you've read the first chapter of this book, you're probably ready to answer: our pfc. Right, but other mammals also have pfcs, and advanced primates such as chimpanzees and bonobos[1]* have pfcs almost the same size as ours. So what specifically was the change that led humans to populate the world with seven billion of us, building cities, surfing the internet, and sending rockets into space, while chimps and bonobos still live in the jungle and face the threat of extinction?

There are in fact a whole mess of things that are biologically different about humans when compared with other primates. There's very little difference in size between males and females (known as "reduced sexual dimorphism.") We walk upright on two legs ("bipedality"). We're capable of fine manipulation with our hands and can throw projectiles accurately and powerfully. We have much smaller upper canine teeth. We have larger brains, factoring in the size of our bodies (known as "encephalization quotient.") Our infants are helpless for years, relying entirely on adult support. Females don't show any signs when they're ovulating (known as "concealed ovulation") and experience menopause. And we're virtually hairless, except for our heads and genitals.[2] Now, this seems like a highly varied set of differences. Which of these were the major drivers on the road to worldwide domination?

A basic timeframe may help to crystallize this question. It's now generally agreed, as a result of genetic sequencing, that we humans shared our last common ancestor with chimpanzees and bonobos a little more than six million years ago. By way of perspective, that's about the same time frame that horses and zebras, lions and tigers, and rats and mice also shared their common ancestors. If you just look at a physical comparison between humans and chimpanzees, that doesn't seem too unreasonable. But it you look at the massive differences in what we've accomplished, there's clearly something else going on. Michael Tomasello, a leading figure in the field of evolutionary anthropology, makes the point that "if we are searching for the origins of uniquely human cognition, therefore, our search must be for some small difference that made a big difference, some adaptation, or small set of adaptations, that changed the process of primate cognitive evolution in fundamental ways."[3] But where does the search begin?

A plausible story of our ancestors

In 2009, a major worldwide event occurred in the usually quiet and dusty corridors of evolutionary archaeology. In what was billed as the "breakthrough of the year,"[4] *Science* magazine published a slew of articles on a newly discovered human ancestor which lived 4.4 million years ago in Ethiopia, known as *Ardipithecus ramidus*, or more affectionately, Ardi. What made the find so noteworthy was that enough remains had been found to reconstruct Ardi's whole skeleton, which a large team had painstakingly done over fifteen years of intense excavation and analysis. Ardi's reconstructed skeleton surprised conventional wisdom because, even though she was fairly close in time to our last

[1] Bonobos, previously known as "pygmy chimpanzees" are one of the two species comprising the genus *Pan*, along with the "common chimpanzee."
[2] For a useful table listing characteristically human attributes, see Flinn, M. V., Geary, D. C., and Ward, C. V. (2005). "Ecological dominance, social competition, and coalitionary arms races: Why humans evolved extraordinary intelligence." *Evolution and Human Behavior*, 26(1), 10-46.
[3] Tomasello, M. (1999). "The Human Adaptation for Culture." *Annual Review of Anthropology*(28), 509-29.
[4] Gibbons, A. (2009). "Breakthrough of the Year: *Ardipithecus Ramidus*." *Science*, 326, 598-599.

common ancestor, she was already walking upright, as opposed to the knuckle-walking or swinging from tree branches that modern chimpanzees do.[5]

In that issue of *Science*, team leader C. Owen Lovejoy used his findings to suggest a plausible story for a set of new behaviors that launched our ancestors on the road to *homo sapiens*, which he called "an early hominid adaptive suite."[6] In an analysis that rivals the best detective stories, he focused on three key characteristics differentiating Ardi and other later hominids from chimpanzees: bipedality; the loss of the big upper canine teeth that other primates have; and female concealed ovulation. What on earth could these three apparently unrelated developments have in common?

Lovejoy's story begins with the thinning out of dense tropical vegetation due to changing climate. Ardi is thought to have lived in woodlands with small patches of forest. In order to get enough to eat, Ardi's species were becoming omnivores, increasingly leaving the cover of the woodlands to venture out onto the plains, most likely scavenging for carrion that other predators had left behind. But the plains were a dangerous place for hominids that were used to living in the forest. Most predators could easily outrun them and cut them down. So, it made more sense for groups of males to cooperate closely with each other, going out together on multi-day foraging missions in the savanna. On successful missions, the males could bring meat back to their families, which would become an increasingly important source of fuel. Bringing back provisions was a lot easier if you could walk upright, using your arms for carrying, and this may have accelerated the evolution of bipedality. Gradually, the females began to choose males who were good providers for them and their infants, instead of the traditional choice of the most aggressive male. As cooperation between males became more important than aggressive competition, those large upper canines, used mostly for fighting rivals, became less important. In fact, females may have started to select mates with smaller upper canines, preferring a mate that would focus more on bringing back the bacon.

But there was still one problem with this otherwise happy scenario. No male in his right mind is going to go foraging with his buddies for days at a time if he sees his partner is in heat when he's leaving. He'd be spending his whole time worrying about who's getting into bed with her while he's gone. This is where the development of concealed ovulation becomes so important. When ovulation is no longer advertised with a clarion call, the risk of cuckoldry decreases and becomes more manageable.

These are the set of behaviors that Lovejoy calls an early hominid adaptive suite, which he defines as a set of interrelated characteristics which, together, form a pattern that optimizes a species for enhanced evolutionary success. While some of Lovejoy's arguments remain controversial, perhaps the most important part of the story, which has major ramifications for our own species, is the shift away from individual competitiveness to increased cooperation within a group. This cooperation was the launching pad for *homo sapiens*, as we will soon see.

Mimetic culture

Between the time of Ardi, 4.4 million years ago, and the emergence of our species, *homo sapiens*, about two hundred thousand years ago, there was a long and crucial period of hominid development that has been called the "mimetic phase" by the influential cognitive neuroscientist Merlin Donald. Here's how he describes it:

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[5] White, T. D., Asfaw, B., Beyene, Y., Haile-Selassie, Y., Lovejoy, C. O., Suwa, G., and WoldeGabriel, G. (2009). "Ardipithecus ramidus and the Paleobiology of Early Hominids." *Science*, 326, 64-86.

[6] Lovejoy, C. O. (2009). "Reexamining Human Origins in Light of *Ardipithecus ramidus*." *Science*, 326(2 October 2009), 74e1-74e8.

> a layer of cultural interaction that is based entirely on a collective web of conventional, expressive nonverbal actions. Mimetic culture is the murky realm of eye contact, facial expressions, poses, attitude, body language, self-decoration, gesticulation, and tones of voice.[7]

Mimetic behavior includes such uniquely human traits as "mime, imitation, skill and gesture."[8] What's fascinating about the mimetic phase is that we modern humans never left it behind. We've added language on top of it, but our mimetic communication is still, in Donald's words, "the primary dimension that defines our personal identity."[9] You can get a feeling for the power of mimetic expression when you think of communications we make that are non-verbal: prayer rituals, chanting and cheering in a sports stadium, expressions of contempt or praise, intimacy or hostility. "The mimetic level of representation," Donald notes, is so all-encompassing that it "underlies all modern cultures and forms the most basic medium of human communication."[10]

In his book, *The Singing Neanderthals*, archaeologist Steve Mithen gives an evocative account of what the mimetic phase of hominid evolution may have felt like. He describes a scene he recreates imaginatively from the remains found in an archaeological dig in East Africa which was occupied 1.6 million years ago, "located next to a watercourse, close to groves of shady trees and clumps of fruiting bushes, with access to stones for flaking":

> Emanating from the site would have been a variety of calls, reflecting the diversity of activities … and the varying emotional states of individuals and the group as a whole. One might have heard predator alarm calls; calls relating to food availability and requests for help with butchery; mother-infant communications; the sounds of pairs and small groups maintaining their social bonds by communicating with melodic calls; and the vocalizations of individuals expressing particular emotions and seeking to induce them in others. Finally, at dusk, one should perhaps imagine synchronized vocalizations – a communal song – that induced calm emotions in all individuals and faded away into silence as night fell and the hominids went to sleep in the trees.[11]*

The importance of this last episode of mimesis in the day – the communal song – cannot be overstated. Mimetic communication became the social glue that bonded hominid communities together and at the same time induced further evolutionary changes that formed modern humans. "Mimetic skill," in Donald's view, "represented a new level of cultural development, because it led to a variety of important new social structures, including a collectively held model of the society itself. It provided a new vehicle for social control and coordination, as well as the cognitive underpinnings of pedagogical skill and cultural innovation."[12]

Historian William McNeill, who's written a book on the effects of mimesis through history[13], describes the evolutionary impact of the greater cooperation that arose among early humans as a result of their mimetic synchrony:

> rhythmic voicing and dance had the effect of dissipating personal rivalries and enhancing a warm feeling of togetherness among participants, as community song and dance and other rhythmic exercises—aerobics, marching in step, grandstand cheering, and the like—still do. As a result, large bands, sustained by the

[7] Donald, M. (2001). A Mind So Rare: The Evolution of Human Consciousness, New York: Norton, 265.
[8] Ibid. p. 263.
[9] Ibid. p. 265.
[10] Ibid. p. 88.
[11] Mithen, S. (2006). *The Singing Neanderthals: The Origins of Music, Language, Mind, and Body*, Cambridge, Mass.: Harvard University Press. With disarming honesty, Mithen relates how he was initially "entirely unconvinced" by Donald's theory of mimetic culture when it first came out in 1991, and gradually over fifteen years came to appreciate "the seminal contribution that Donald made when he proposed mimesis as a key means of Early Human communication."
[12] Donald, M. (1991). Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition, Cambridge, Mass.: Harvard University Press, 199-200.
[13] McNeill, W. H. (1995). *Keeping Together In Time: Dance and Drill in Human History*. Cambridge: Harvard University Press.

> emotional side effects of voicing and dance, were capable of cooperating more effectually. Indeed, those who engaged in such exercises had such great advantages that only bands that learned to dance and make sounds together were able to survive. Rhythmically voiced sound and dance thus became a distinguishing human trait since the members of no other species ever spontaneously invented this way to express themselves and strengthen social bonds in doing so.[14]

In the early 1990s, a team of neuroscientists in Italy researching the brains of macaque monkeys stumbled upon a class of neurons that may be responsible for the underlying brain activity that leads to mimetic behavior. They were studying certain neurons in the monkeys' motor cortex that fired when the monkeys performed a certain action, such as reaching for a piece of food. Then, they noticed something very strange. When one of the researchers in the lab reached for a piece of food, the same neurons fired in the monkey's brain, even though the monkey wasn't doing anything. They began to realize that what they were watching in the monkey's brain was a representation of the act of reaching, regardless of who was doing it. Before too long, they decided to call these "mirror neurons," because they precisely mirrored somebody else's actions.[15] Since then, studies on humans have demonstrated that we also have mirror neurons, which light up whether we perform a task ourselves or see someone else performing it.[16]

This fascinating discovery of mirror neurons offers an important clue for how certain elements of mimetic behavior, such as mimicking, could have arisen. But since these mirror neurons exist in other primates, it still doesn't explain the cognitive breakout achieved by humans. After all, chimpanzees don't chant, cheer, or sing and dance in rhythm together. In their mimetic phase of development, our early ancestors achieved what Donald calls "a very remarkable human adaptation" which is "one of the most complex capacities of the human brain," one which he localizes in the "hominid 'executive' brain."[17]

This radical breakthrough in the human brain entailed the ability for a hominid to look at others and realize that they had a mind that functioned somewhat like his own; to realize that when they did something, they were most likely being motivated by the same sort of things that motivated him. This ability presumably began with the mirror neurons and then applied a new conceptual layer to mirror not only the other person's actions, but also their thoughts and emotions.[18] This conceptual breakthrough has been called "theory of mind," and in the past thirty years, has come to be recognized as fundamental to human development and uniqueness.

Theory of mind.

In 1978, primate researchers Premack and Woodruff published what was to become a seminal paper entitled "Does the chimpanzee have a theory of mind?".[19] This was the first time that the phrase "theory of mind" had been used in the scientific literature, which they described as an ability to represent and infer the mental states of others. It "may properly be viewed as a theory," they stated, "because such states are not directly observable, and the system can be used to make predictions about the behaviors of others."[20]

[14] McNeill, W. H. (2000). "A Short History of Humanity." *The New York Review of Books*, 47(11).
[15] Rizzolatti, G., Fogassi, L., and Gallese, V. (2006). "Mirrors in the Mind." *Scientific American*, 54-61.
[16] Keysers, C., and Gazzola, V. (2010). "Social Neuroscience: Mirror Neurons Recorded in Humans." *Current Biology*, 20(8), R353-R354.
[17] Quoted in Winkelman, M. (2002). "Shamanism and Cognitive Evolution." *Cambridge Archaeological Journal*, 12(1), 71-101.
[18] For the linkage of mirror neurons to theory of mind, see Gallese, V., and Goldman, A. (1998). "Mirror neurons and the simulation theory of mind-reading." *Trends in Cognitive Sciences*, 2(12), 493-501.
[19] Premack, D., & Woodruff, G. (1978). "Does the chimpanzee have a theory of mind?" *Behavioral and Brain Sciences*, 4, 515–526.
[20] Cited in Povinelli, D. J., and Preuss, T. M. (1995). "Theory of mind: evolutionary history of a cognitive specialization." *Trends in Neurosciences*, 18(9:November 9, 1995), 418-424.

More recently, Tomasello has conducted extensive research into how theory of mind differentiates us from other primates. He gives a list of social actions that we take for granted but which nonhuman primates simply don't do:

> In their natural habitats, nonhuman primates:
> Do not point or gesture to outside objects for others;
> Do not hold objects up to show them to others;
> Do not try to bring others to locations so that they can observe things there;
> Do not actively offer objects to other individuals by holding them out;
> Do not intentionally teach other individuals new behaviors.[21]

He believes that they don't do these things because they "do not understand others as intentional agents in the process of pursuing goals or mental agents in the process of thinking about the world." In his view, the biological makeup of chimpanzees' and humans' brains would be very similar except for the one major difference that we humans "identify" with others of our species "more deeply than do other primates." It's from this "one uniquely human, biologically inherited, cognitive capacity," he believes, that all the other uniquely human traits emerged.[22]

It's important to understand that, although they're similar, theory of mind is not the same thing as empathy. As neuroscientist Tania Singer points out, empathy is all about sharing the feelings and emotions of another person. Imagine you're a volunteer helping out in a foreign country that's just suffered a natural disaster. You might be sitting with a woman who's just lost her children, putting your arm around her while she's sobbing in grief. Perhaps she speaks no English, and you know nothing about her life other than her grief. You would probably feel intense empathy for her, even if you had no idea what thoughts, intentions or beliefs are going through her mind. On the other hand, you can apply your theory of mind on people for whom you have no empathic feelings whatsoever, such as a rival you're competing against in your profession.

One reason this distinction is important is that empathy and theory of mind are believed to arise from different neural pathways in the brain. Singer, who has reviewed multiple brain imaging studies on the subject, explains that empathy activates the same emotional circuits in our brains and bodies that come alive when we have our own feelings.[23] Here, we can see how those mirror neurons are most likely springing into gear, mirroring not just the actions but the feelings of those we care about. On the other hand, theory of mind activates a different set of brain areas, most notably the pfc.

In fact, it's a specific area within the pfc called the medial prefrontal cortex that gets activated when we exercise our theory of mind. This is especially interesting because it's exactly the same part of the pfc that gets activated when we exercise our self-awareness and think about ourselves. In the words of one study, "data indicate that the ability to reflect on one's own mental states, as well as those of others, might be the result of evolutionary changes in the prefrontal cortex."[24] In another study, subjects were asked to think about themselves in a wide variety of different states, including pain, tickling, actions and looking at pictures. In all this variety, the one part of the brain that was consistently activated whenever the subjects were thinking about themselves was the medial prefrontal cortex.[25]

The fact that the medial prefrontal cortex is activated when thinking both about yourself and others suggests a fundamental linkage between the evolution of theory of mind and that other uniquely human trait, self-awareness. This linkage can be seen, not just in the actions of our pfc, but also in the

[21] Tomasello, M. (2000). *The Cultural Origins of Human Cognition*, Cambridge, Mass.: Harvard University Press, 21.
[22] Ibid.
[23] Singer, T. (2006). "The neuronal basis and ontogeny of empathy and mind reading: Review of literature and implications for future research." *Neuroscience and Biobehavioral Reviews*(30 (2006)), 855-863.
[24] Povinelli and Preuss, op. cit.
[25] Frith, C. D., and Frith, U. (1999). "Interacting Minds - A Biological Basis." *Science*, 286, 1692-1695.

developing mind of an infant. A child doesn't develop a fully fledged theory of mind until she's reached around 3-5 years of age. But even in the first few months of an infant's life, Tomasello describes how, in their attempts to understand other people around them, infants "apply what they already experience of themselves," making the judgment that "others are 'like me' and so they should work like me as well." Tomasello then traces what he calls a "social-cognitive revolution" that occurs in infants at around nine months. Around that age, an infant begins to follow someone else's gaze and direct other people's attention to something she cares about. At some point, the infant realizes that the other person's attention is directed at her! "She now knows she is interacting with an intentional agent who perceives her and intends things toward her." Before too long, the infant realizes that her actions affect other people's emotional states. "This new understanding of how others *feel* about me opens up the possibility for the development of shyness, self-consciousness, and a sense of self-esteem." The infant has begun to participate in the social universe. Tomasello notes as evidence of this that, around the first birthday, an infant begins to show the "first signs of shyness and coyness in front of other persons and mirrors."[26]

The key point in this infant's drama is that it takes an understanding of other people as intentional agents to begin to arrive at an awareness of yourself. And it takes both of these steps together to develop a sense of yourself as a social agent, someone interacting in society. It's when the hominid brain began to use its theory of mind and self-awareness for social purposes that the evolution towards modern *homo sapiens* really got going. In fact, over the past thirty years, a powerful theory called the Social Brain Hypothesis has gained increasing acceptance as an explanation for the full development of our unique human cognition.

The Social Brain Hypothesis

Around the same time that Premack and Woodruff were coining the phrase "theory of mind," a series of ground-breaking studies were forming the idea that primate intelligence "evolved not to solve physical problems, but to process and use social information, such as who is allied with whom and who is related to whom, and to use this information for deception."[27] In the context of what we learned about Ardi's circumstances 4.4. million years ago, this certainly makes sense. Venturing out on the savannah, hominids couldn't defend themselves alone against hungry carnivores and banded together for safety. As they did so, they faced ever-increasing cognitive demands from being in bigger social groups. And it wasn't just the size of the group, but the complexity of the lifestyle that increased. If you went out with your buddies on a foraging group, how could you make sure that no-one who remained behind would make a pass at your partner?

Decades of research on this subject have, in fact, shown that species of monkeys and apes that typically live in larger groups also have a larger neocortex (the more recently evolved part of the brain that houses the pfc).[28] Even outside of primates, this correlation seems to exist. A recent study of hyenas, for example, shows that the spotted hyena, which lives in more complex societies, has "far and away the largest frontal cortex" of all the different hyena species.[29] For this reason, experts in the field are comfortable stating that "the balance of evidence now clearly favors the suggestion that it was the computational demands of living in large, complex societies that selected for large brains."[30]

In the early days of the social brain hypothesis, the emphasis was on the competitive aspect of living in complex societies. Researchers would talk about "primate politics" and the name of one book on

[26] Tomasello, op. cit., 89-90.
[27] Emery, N. J., and Clayton, N. S. (2004). "The Mentality of Crows: Convergent Evolution of Intelligence in Corvids and Apes." *Science*, 306, 1903-1907.
[28] Dunbar, R. I. M., and Shultz, S. (2007). "Evolution in the Social Brain." *Science*, 317(7 September 2007).
[29] Zimmer, C. (2008). "Sociable, and Smart" *The New York Times*, (March 4, 2008).
[30] Dunbar and Shultz, op. cit.

the subject was *Machiavellian Intelligence: Social Evolution in Monkeys, Apes and Humans*.[31] In the view of an influential thinker on the subject, Richard Alexander, as hominids became more dominant in their ecology, they no longer needed to evolve better capabilities to deal with the natural environment. Instead, they began to evolve new cognitive skills in order to outcompete each other. In this way, we became (in his words) our own "hostile force of nature," entering into a "social arms race" with each other.[32] Alexander saw our ancestors as playing a "mental chess game" with the other members of their group, "predicting future moves of a social competitor… and appropriate countermoves":

> In this situation, the stage is set for a form of runaway selection, whereby the more cognitively, socially, and behaviorally sophisticated individuals are able to out maneuver and manipulate other individuals to gain control of resources in the local ecology and to gain control of the behavior of other people…[33]

Outmaneuvering, manipulation and control… are these then the defining characteristics of our human uniqueness? If it sounds bleak, it falls well within a tradition that has interpreted Darwin's original theory of evolution from the same chilling perspective. As described by some supporters of Alexander's theory:

> The conceptualization of natural selection as a 'struggle for existence' of Darwin and Wallace becomes, in addition, a special kind of struggle with other human beings for control of the resources that support life and allow one to reproduce.[34]

While Alexander was honing his theory of the "social arms race," another biologist, Robert Trivers, was explaining how, from an evolutionary perspective, altruism was really just a sophisticated form of selfishness. In a much cited paper, he described what he called "reciprocal altruism" as an ancient evolutionary strategy that could be seen in the behavior of fish and birds, and he interpreted human altruism in the same way. "Under certain circumstances," he wrote, "natural selection favors these altruistic behaviors because in the long run they benefit the organism performing them."[35]

This approach is fully consistent with what's become generally known as the "selfish gene" interpretation of evolution, as popularized by biologist Richard Dawkins. In this view (which is extensively critiqued later in this book) all evolution can be explained by the "selfish" drive of our genes to replicate themselves. And those special human characteristics that we value so highly are no exception. "Let us try to teach generosity and altruism," Dawkins suggests, "because we are born selfish." Alexander himself comes to a similar conclusion, proposing that "ethics, morality, human conduct, and the human psyche are to be understood only if societies are seen as collections of individuals seeking their own self-interest."[36]

However, in recent years, there's been an important shift in our understanding of these social dynamics. What has come to seem more remarkable to researchers is not how our bigger brains made us socially competitive, but how they made us more cooperative with each other. In fact, Tomasello sees this as the key differentiating factor between the social intelligence of humans and that of other primates. According to him, it's the chimpanzees, not the humans, who are obsessed with competing against each other. "Among primates," he writes, "humans are by far the most cooperative species, in just about any way this appellation is used."[37] For this reason, Tomasello argues, the "social competition" view may

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[31] Cited by Moll, H., and Tomasello, M. (2007). "Cooperation and human cognition: the Vygotskian intelligence hypothesis." *Phil. Trans. R. Soc. Lond. B*, 362(1480), 639-648.
[32] Cited by Flinn et al., op. cit.
[33] Ibid.
[34] Ibid.
[35] Trivers, R. L. (1971). "The Evolution of Reciprocal Altruism." *The Quarterly Review of Biology*, 46(1), 35-57.
[36] Quoted in Gintis, H., Bowles, S., Boyd, R., and Fehr, E. (2003). "Explaining altruistic behavior in humans." *Evolution and Human Behavior*, 24(3), 153-172.
[37] Moll and Tomasello, op. cit.

have driven the evolution of primate intelligence, but the cognitive skills that have enabled humans alone to develop language, culture and civilization have been "driven by, or even constituted by, social cooperation."

Tomasello and his colleague, Henrike Moll, focus on a uniquely human dynamic that they call "shared intentionality," which is our ability to realize that another person is seeing the same thing we're seeing, but that they're also seeing it from a different perspective. "The notion of perspective – we are experiencing the same thing, but potentially differently — is," Moll and Tomasello believe, "unique to humans and of fundamental cognitive importance." In their view, it was the special cooperation arising from shared intentionality that "transformed human cognition from a mainly individual enterprise into a mainly collective cultural enterprise involving shared beliefs and practices."[38]

The idea that we humans evolved a sense of true altruism, where we're driven to cooperate with our social group by a natural disposition that transcends our selfish needs, may be attractive to some, but it has been shown to have one fundamental flaw: the free-rider problem. Let's go back to the Ardi example of the band of males venturing out on a multi-day mission into the savannah looking for meat. If one of those males secretly sneaks back to camp and makes out with the females still there, then his genes will be the ones that survive. Evolutionary researchers have, in fact, modeled this problem using game theory and tested real examples in the lab using the famous "prisoner's dilemma" game[39]*, and have confirmed that only "a few selfish players suffice to undermine the cooperation" of those who trusted each other.[40]

Does this mean that Alexander and company were right, and in fact human social intelligence must be explained by selfish competition? Not so fast. Those same researchers have spent years modeling more realistic versions of what life may have been like for early hominids evolving their social skills, and have arrived at a more sophisticated view of innate human cooperation that they have called "altruistic punishment."

Altruistic punishment

Imagine you're sitting alone in a room. In the next room is someone else, whom you don't know. You're never going to meet each other. A researcher walks in holding a hundred dollars and tells you that this sum will be split between you and the stranger in the other room. And the good news is, you're allowed to decide exactly how you want to split it. But there's a catch. You can only propose one split. The person in the other room will be told the split and can either accept it or reject it. If he accepts it, the money is shared accordingly. If he rejects it, you'll both get nothing.

Welcome to the ultimatum game. If you're like most people, you'll decide to split the hundred dollars down the middle, so you get $50, the other person will clearly accept his $50, and you'll both be ahead. Researchers view the ultimatum game as convincing evidence that refutes the earlier view of humans as fundamentally self-interested. If that were the case, then you ("the proposer") would be more likely to keep $90 and offer $10 to the other stranger ("the responder"). The responder would be likely to accept $10 because, being self-interested, he would be happier with $10 than nothing. But that's not what people do. Responders in fact frequently reject offers below $30, and the most popular amount offered by proposers is $50.[41]

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[38] Ibid.

[39] The prisoner's dilemma game is a fundamental problem in game theory, where if two people cooperate they both gain a high payoff; but if one player betrays the other who is still cooperating, the betrayer wins everything and the cooperator nothing; if both betray each other, they both get a low payoff.

[40] Fehr, E., and Fischbacher, U. (2003). "The nature of human altruism." *Nature*, 425, 785-791.

[41] Gintis et al., op. cit.

It seems that we humans have a powerfully evolved sense of fairness. So powerful, in fact, that we would rather walk away with nothing than permit someone else to take extreme advantage of us. Researchers call this "altruistic punishment." But even altruistic punishment is not powerful enough by itself to overcome the free rider problem in human groups. Think back to the Ardi situation. Suppose that sneaky free rider has skulked back to camp and is coming on strongly to one of the females whose partner is out hunting. But there's another male who had stayed home and sees what's going on. What does he do? Does he confront the free rider, possibly risking his own life? Or does he turn away and do nothing? This has been called by researchers the problem of the "non-punisher." In a way, if someone lets a free rider get away with things without punishing him, they're really a free-rider too and deserve to be punished. When modeling these situations, the researchers have indeed found that cooperation can be maintained in sizable groups indefinitely, but only in situations where both free riders and "non-punishers" are punished. These groups would tend to be more effective than groups of self-interested individuals, and their members would be more likely to pass their genes on to later generations.[42]

Thus, the possibility exists that, over thousands of generations, our social intelligence was molded by cooperative group dynamics to evolve an innate sense of fairness, and a drive to punish those who flagrantly break the rules, even if it's at our own expense. Some researchers have gone so far as to argue that this evolved sense of fairness has led to "the evolutionary success of our species and the moral sentiments that have led people to value freedom, equality, and representative government."[43]

From social intelligence to cognitive fluidity

Whether our social intelligence has caused us to be fundamentally cooperative, competitive, or both, there's one aspect of it that most researchers can agree on: it's driven by the actions of the pfc. And increasingly, it's believed that most of the special capabilities of the pfc emerged from its evolution as a tool of social intelligence. Tomasello, among others, speculates that "the evolutionary adaptations aimed at the ability of human beings to coordinate their social behavior with one another" is what underlies "the ability of human beings to reflect on their own behavior and so to create systematic structures of explicit knowledge."[44] Another researcher notes that "the neuropsychological functions that create the capacity for culture are very much akin to those capacities attributed to executive functioning—inhibition, self-awareness, self-regulation, imitation and vicarious learning."[45]

In this view, many of our unique abilities that are mediated by the pfc – abstract thinking, rule-making, mental time travel into the past and the future – arose not because they were in themselves vital for human adaptation but as an accidental by-product of our social cognitive skills. Surprisingly, this phenomenon has been found to be fairly common in evolution, and has been given the name "exaptation," meaning a characteristic that evolved for other usages and later got co-opted for its current role. A classic example of exaptation is bird feathers, which are thought to have originally evolved for regulation of body heat and only later became used as a means of flying.[46]

What is it, then, about the pfc that could take a set of social cognitive skills and transform them into an array of such varied and astonishing capabilities? One answer to this question might be that the pfc is connected to virtually all other parts of the brain, and this gives it the unique capability to merge different inputs, such as vision and hearing, instinctual urges, emotions and memories, into one integrated story. This has led one research team to speculate that the "outstanding intelligence of

[42] Fehr and Fischbacher, op. cit.
[43] Gintis et al., op. cit.
[44] Tomasello, op. cit. p. 197.
[45] Barkley, R. A. (2001). "The Executive Functions and Self-Regulation: An Evolutionary Neuropsychological Perspective." *Neuropsychology Review*, 11(1), 1-29.
[46] Gould, S. J., and Vrba, E. S. (1982). "Exaptation - A Missing Term in the Science of Form." *Paleobiology*, 8(1: Winter 1982), 4-15.

humans" may result not from "qualitative differences" compared with other primates, but from the pfc's combination of the same functions which may have developed separately in other species.[47] In fact, the human pfc's connectivity is dramatically greater than that of other primates. The celebrated neuroscientist, Jean-Pierre Changeux, notes that "from chimpanzee to man one observes an increase of at least 70 percent in the possible connections among prefrontal workspace neurons – undeniably a change of the highest importance."[48]

Archaeologist Steve Mithen has proposed an influential theory of human evolution on this basis.[49] Mithen begins with the premise that early hominids may have developed specialized, or "domain-specific" skills. For example, they may have developed social intelligence (as discussed above), technical intelligence for tool-making, or increasing knowledge about the natural world, but they were unable to connect these intelligences together. It's helpful to imagine these domain-specific intelligences like the blades and tools in a Swiss army knife. You can use each of them, but you'd be hard pressed to use them all together at the same time.[50] But, Mithen suggests, at some time in the development of the modern human mind, we developed what he calls "cognitive fluidity," whereby we started combining these domain-specific intelligences into an integrated meta-intelligence. He gives an example of Neanderthals who may have been socially intelligent and technically able to make clothes and jewellery, but only modern humans, in his view, made the evolutionary jump to combine these skills and make their artefacts in a particular way to "mediate those social relationships."[51]*

Another research team, Coolidge and Wynn, have focused their attention on a particular pfc capability, known as "working memory," which may have been the linchpin to permit this kind of cognitive fluidity in humans.[52] Working memory is the ability to consciously "hold something in your mind" for a short time. For example, if someone tells you a phone number and you have to go across the room to write it down, you'll use your working memory to hold it in your mind until it's down on paper, at which point it's freed up for something else. But working memory is far more than just "short-term memory." Comparable to the random access memory ("RAM") of a computer, it's the process used by the mind to keep enough discrete items up and running so they can be joined together to arrive at a new understanding or a new plan. It's been referred as a "global workspace… onto which can be written those facts that are needed in a current mental program,"[53] or perhaps more concisely, "the blackboard of the mind."[54] Changeux notes that there is "a very clear difference between … higher primates and man with regard to the quantity of knowledge that they are capable of holding on working memory for purposes of evaluation and planning,"[55] and Coolidge and Wynn have gone on to argue that it's the enhanced working memory of humans that's the crucial differentiating factor for our uniqueness.

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[47] Roth, G., and Dicke, U. (2005). "Evolution of the brain and intelligence." *Trends in Cognitive Sciences*, 9(5: May 2005), 250-253.
[48] Changeux, J.-P. (2002). *The Physiology of Truth: Neuroscience and Human Knowledge*, M. B. DeBevoise, translator, Cambridge, Mass.: Harvard University Press, 108-9.
[49] Mithen, S. (1996). *The Prehistory of the Mind*, London: Thames & Hudson.
[50] The Swiss army knife metaphor is attributed to Leda Cosmides & John Tooby in Mithen, op. cit. 42.
[51] It should be noted that, although Mithen contrasts modern humans with Neanderthals, the cognitive difference between the two is a matter of great controversy. See Zilhao, J. (2010). "Symbolic use of marine shells and mineral pigments by Iberian Neandertals." *PNAS*, 107(3), 1023-1028, for an argument that the difference between the two was demographic/social rather than genetic/cognitive. However, the Neanderthal issue is not crucial to Mithen's underlying thesis.
[52] Coolidge, F. L., and Wynn, T. (2001). "Executive Functions of the Frontal Lobes and the Evolutionary Ascendancy of *Homo Sapiens*." *Cambridge Archaeological Journal*, 11(2:2001), 255-60. See also: Coolidge, F. L., and Wynn, T. (2005). "Working Memory, its Executive Functions, and the Emergence of Modern Thinking." *Cambridge Archaeological Journal*, 15(1), 5-26.
[53] Duncan, J. (2001). "An Adaptive Coding Model of Neural Function in Prefrontal Cortex." *Nature Reviews: Neuroscience*, 2, 820-829.
[54] Patricia Goldman-Rakic quoted by Balter, M. (2010). "Did Working Memory Spark Creative Culture?" *Science*, 328, 160-163
[55] Changeux, op. cit.

What the pfc did for early humans

Mithen's "cognitive fluidity" and Coolidge and Wynn's "enhanced working memory" are really two different ways of describing the same basic dynamic of the pfc connecting up diverse aspects of the mind's intelligence to create coherent meaning that wasn't there before. But what specifically did this enhanced capability do for our early human ancestors?

To begin with, it enabled us to make tools. It used to be conventional wisdom that humans are the only tool-makers, so much so that the earliest known genus of the species *homo*, which lived around two million years ago, is named *homo habilis*, or "handy man." Then, in the 1960s, Jane Goodall discovered that chimpanzees also used primitive tools, such as placing stalks of grass into termite holes. When Goodall's boss, Louis Leakey, heard this, he famously replied "Now we must now redefine 'tool', redefine 'man', or accept chimpanzees as humans!"[56] Well, as we've seen in the preceding pages, there's been plenty of work done in redefining "man" since then, but none of this takes away from the fact that humans clearly use tools vastly more effectively than chimpanzees or any other mammals.

To be fair to our old "handy man" *homo habilis*, even the primitive stone tools they left behind, called Oldowan artifacts after the Olduvai Gorge in East Africa where they were first found, represented a major advance in working memory over our chimpanzee cousins. Steve Mithen has pointed out that some Oldowan tools were clearly manufactured to make other tools, such as "the production of a stone flake to sharpen a stick."[57] Making a tool to make another tool is unknown in chimpanzees, and requires determined planning, holding the idea of the second tool in your working memory while you're preparing your first tool. Oldowan artifacts remained the same for a million years, so even though they were an advance over chimp technology, there was none of the innovation that we associate with our modern pfc functioning. The next generation of tools, called the Acheulian industry, required more skillful stone knapping, and show attractive bilateral symmetry, but they also remained the same for another million years or so.[58] It was around three hundred thousand years ago, shortly before anatomically modern humans emerged, that stone knapping really took off, with stone-tipped spears and scrapers with handles representing "an order-of-magnitude increase in technological complexity."[59]

None of these tools – even the more primitive Oldowan and Acheulian – can be made by chimpanzees, and they could never have existed without the power of abstraction provided by the pfc.[60]* Planning for this kind of tool-making required a concept of the future, when the hard work put into making the tool would turn out to be worthwhile. As psychologists Liberman and Trope have pointed out, transcending the present to mentally traverse distances in time and in space "is made possible by the human capacity for abstract processing of information." Making function-specific tools, they note, "required constructing hypothetical alternative scenarios of future events," which could only be done through activating a "brain network involving the prefrontal cortex."[61]

Another fundamental human characteristic arising from this abstraction of past and future is the power of self-control. As one psychologist observes, "self-control is nearly impossible if there is not some

[56] Cited in McGrew, W. C. (2010). "Chimpanzee Technology." *Science*, 328, 579-580.
[57] Mithen 1996, op. cit., 96.
[58] Proctor, R. N. (2003). "The Roots of Human Recency: Molecular Anthropology, the Refigured Acheulean, and the UNESCO Response to Auschwitz." *Current Anthropology*, 44(2: April 2003), 213-239.
[59] Ambrose, S. H. (2001). "Paleolithic Technology and Human Evolution." *Science*, 291(2 March 2001), 1748-1753.
[60] Mithen 1996, op. cit., p. 97 relates a failed attempt to get a famous bonobo named Kanzi, who was very advanced in linguistic skills, to make Oldowan-style stone tools.
[61] Liberman, N., and Trope, Y. (2008). "The Psychology of Transcending the Here and Now." *Science*, 322(21 November 2008), 1201-1205.

means by which the individual is capable of perceiving and valuing future over immediate outcomes."[62] Anyone who has watched children grow up and gradually become more adept at valuing delayed rewards over immediate gratification will not be surprised at the fact that the pfc doesn't fully develop in a modern human until her early twenties.

This abstraction of the future gave humans not only the power to control themselves but also to control things around them. A crucial pfc-derived human characteristic is the notion of *will*, the conscious intention to perform a series of activities, sometimes over a number of years, to achieve a goal. Given the fundamental nature of this capability, it's not surprising that, as Tomasello points out, in many languages the word that denotes the future is also the word "for such things as volition or movement to a goal." In English, for example, the original notion of "I will it to happen" is embedded in the future tense in the form "It will happen."[63]

This is already an impressive range of powerful competencies made available to early humans by the pfc. But of all the powers granted to humans by the awesome connective faculties of the pfc, there seems little doubt that the most spectacular is the power to understand and communicate sets of meaningful symbols, known as symbolization.

The symbolic net of human experience

A full generation before Louis Leakey realized it was time to "redefine man," a German philosopher named Ernst Cassirer who had fled the Nazis was already doing so, writing in 1944 that "instead of defining man as an *animal rationale* we should define him as an *animal symbolicum."*[64] He wasn't alone in this view. A leading American anthropologist, Leslie White, also believed that the "capacity to use symbols is a defining quality of humankind."[65] Because of our use of symbols, Cassirer wrote, "compared with the other animals man lives not merely in a broader reality; he lives, so to speak, in a new *dimension* of reality."[66]

Why would the use of symbols take us to a different dimension of reality? First, it's important to understand what exactly is meant by the word "symbol." In the terminology adopted by cognitive anthropologists, we need to differentiate between an *icon*, an *index*, and a *symbol*. A simple example may help us to understand the differences. Suppose it's time for you to feed your pet dog. You open your pantry and look at the cans of pet food available. Each can has a picture on it of the food that's inside. That picture is known as an *icon*, meaning it's a "representative depiction" of the real thing. Now, you open the can and your dog comes running, because he smells the food. The smell is an *index* of the food, meaning it's "causally linked" to what it signifies. But now suppose that instead of giving your hungry dog the food, you wrote on a piece of paper "FOOD IN TEN MINUTES" and put it in your dog's bowl. That writing is a *symbol*, meaning that it has a purely arbitrary relationship to what it signifies, that can only be understood by someone who shares the same code. Clearly, your dog doesn't understand symbols, and now he's pawing at the pantry door trying to get to his food.[67]*

To understand how symbols arose, and why they are so important, it helps to begin with the notion of working memory discussed earlier. Terrence Deacon has suggested that symbolic thought is "a

[62] Barkley, op. cit.
[63] Tomasello, op. cit., p. 43.
[64] Cassirer, E. (1944). *An Essay on Man*, New Haven: Yale University Press, 26.
[65] Cited by Renfrew, C. (2007). *Prehistory: The Making of the Human Mind*, New York: Modern Library: Random House, 91.
[66] Cassirer, op. cit.
[67] The distinction, originally made by American philosopher Charles Sanders Peirce, is described in detail in Deacon, T. W. (1997). *The Symbolic Species: The Co-evolution of Language and the Brain*, New York: Norton; and is also referred to by Noble, W., and Davidson, I. (1996). *Human Evolution, Language and Mind: A psychological and archaeological inquiry*, New York: Cambridge University Press. I am grateful to Noble & Davidson for the powerful image of writing words to substitute for food in the dog's bowl as an example of a symbol.

way of offloading redundant details from working memory, by recognizing a higher-order regularity in the mess of associations, a trick that can accomplish the same task without having to hold all the details in mind."[68] Remember the image of working memory as a blackboard? Now imagine a teacher asking twenty-five children to come up and write on the blackboard what they had to eat that morning before they came to school. The blackboard would quickly fill up with words like cereals and eggs, pancakes and waffles. Now, suppose that, once the blackboard's filled up, the teacher erases it all and just writes on the blackboard the word "BREAKFAST". That one word, by common consent, symbolizes everything that had previously been written on the blackboard. And now it's freed up the rest of the blackboard for anything else.

That's the powerful effect that the use of symbols has on human cognition. But there's another equally powerful aspect of writing that one word "BREAKFAST" on the blackboard. Every schoolchild has her own experience of what she ate that morning, but by sharing in the symbol "BREAKFAST," she can rise above the specifics of her own particular meal and understand that there's something more abstract that is being communicated, referring to the meal all the kids had before they came to school regardless of what it was. For this reason, symbols are an astonishingly powerful means of communicating, allowing people to transcend their individual experiences and share them with others. Symbolic communication can therefore be seen as naturally emerging from human minds evolving on the basis of social intelligence. This has led one research team to define modern human behavior as "behavior that is mediated by socially constructed patterns of symbolic thinking, actions, and communication."[69]

Once it got going, symbolic thought became so powerful that it pervaded every aspect of how we think about the world. In Cassirer's words:

> Man cannot escape from his own achievement… No longer in a merely physical universe, man lives in a symbolic universe. Language, myth, art, and religion are parts of this universe. They are the varied threads which weave the symbolic net, the tangled web of human experience. All human progress in thought and experience refines upon and strengthens this net.[70]

Because of our symbolic capabilities, Deacon adds, "we humans have access to a novel higher-order representation system that… provides a means of representing features of a world that no other creature experiences, the world of the abstract." We live our lives not just in the physical world, "but also in a world of rules of conduct, beliefs about our histories, and hopes and fears about imagined futures." [71]

For all the power of symbolic thought, there was one crucial ingredient it needed before it could so dramatically take over human cognition. It needed a means by which each individual could agree on the code to be used in referencing what they meant. It had to be a code which everyone could learn and that could be communicated very easily, taking into account the vast array of different things that could carry symbolic meaning. In short, it needed language – that all-encompassing network of symbols that we'll explore in the next chapter.

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[68] Deacon, op. cit., p. 89.
[69] Henshilwood, C. S., and Marean, C. W. (2003). "The Origin of Modern Human Behavior: Critique of the Models and Their Test Implications"*Current Anthropology*. City, pp. 627-651.
[70] Cassirer, op. cit.
[71] Deacon, op. cit., p. 423.