More praise for *The Secret of Our Success*

"*The Secret of Our Success* provides a valuable new perspective on major issues in human evolution and behavior. Bringing together topics from such diverse areas as economics, psychology, neuroscience, and archaeology, this book will provoke vigorous debates and will be widely read."

—Alex Mesoudi, author of *Cultural Evolution*

"Is the ability to acquire highly evolved culture systems like languages and technologies the secret of humans' success as a species? This book convinces us that the answer is emphatically 'yes.' Moving beyond the sterile nature-nurture debates of the past, Joseph Henrich demonstrates that culture—as much a part of our biology as our legs—is an evolutionary system that works by tinkering with our innate capacities over time."

—Peter J. Richerson, University of California, Davis

"In the last decade, in the interstices between biology, anthropology, economics, and psychology, a remarkable new approach to explaining the development of human societies has emerged. It's the most important intellectual innovation on this topic since Douglass North's work on institutions in the 1970s and it will fundamentally shape research in social science in the next generation. This extraordinary book is the first comprehensive statement of this paradigm. You'll be overwhelmed by the breadth of evidence and the creativity of ideas. I was."

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"With compelling chapter and verse and a very readable style, Joseph Henrich's book makes a powerful argument—in the course of the gene-culture coevolution that has made us different from other primates, culture, far from being the junior partner, has been the driving force. A terrific book that shifts the terms of the debate."

—Stephen Shennan, University College London

"A delightful and engaging expedition into and all around the many different processes of genetic and cultural evolution that have made humans such 'a puzzling primate.'"

—Michael Tomasello, codirector of the Max Planck Institute for Evolutionary Anthropology

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THE SECRET OF OUR SUCCESS

How Culture Is Driving Human Evolution, Domesticating Our Species, and Making Us Smarter

JOSEPH HENRICH

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PREFACE

We humans are not like other animals. Sure, we are obviously similar to monkeys and other apes in many ways, but we also variously play chess, read books, build missiles, enjoy spicy dishes, donate blood, cook food, obey taboos, pray to gods, and make fun of people who dress or speak differently. And though all societies make fancy technologies, follow rules, cooperate on large scales, and communicate in complex languages, different societies do all this in very different ways and to significantly different degrees. How could evolution have produced such a creature, and how does answering this question help us understand human psychology and behavior? How can we explain both cultural diversity and human nature?

My journey to addressing these questions, and writing this book, began in 1993 when I quit my engineering position at Martin Marietta, near Washington DC, and drove to California, where I enrolled as a graduate student in UCLA's Department of Anthropology. I had two interests at the time, which I'd developed while pursuing undergraduate degrees in both anthropology and aerospace engineering at the University of Notre Dame. One interest focused on understanding economic behavior and decision-making in the developing world, with the idea that new insights might help improve people's lives around the globe. In part, I was attracted to anthropology because the research involved in-depth and long-term fieldwork, which I felt had to be crucial to understanding people's decisions and behavior, and the challenges they faced. This was my "applied" focus. Intellectually, I was also keenly interested in the evolution of human societies, particularly in the basic question of how humans went from living in relatively small-scale societies to complex nation-states over the last ten millennia.

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The plan was to study with two well-known anthropologists, one a sociocultural anthropologist and ethnographer named Allen Johnson, and the other an archaeologist named Tim Earle.

After a summer of research in Peru, traveling by dugout canoe among indigenous Matsigenka communities in Amazonia, I wrote my master's thesis on the effects of market integration on farming decisions and deforestation. Things were going fine, my advisors were happy (though Tim had departed for another university), and my thesis was accepted.

Nevertheless, I was dissatisfied with what anthropology had to offer for explaining why the Matsigenka were doing what they were doing. For starters, why were Matsigenka communities so different from the nearby indigenous Piro communities, and why did they seem to have subtly adaptive practices that they themselves couldn't explain?

I considered bailing out of anthropology at this point and heading back to my old engineering job, which I had quite liked. However, during the previous few years I'd gotten excited about human evolution. I had also enjoyed studying human evolution at Notre Dame, but I hadn't seen how it could help me with explaining either economic decision-making or the evolution of complex societies, so I'd thought of it more as a hobby. At the beginning of graduate school, to narrowly focus my energies on my main interests, I tried to get out of taking the required graduate course on human evolution. To do this, I had to appeal to the instructor of the graduate course in biological anthropology, Robert Boyd, and argue to him that my undergraduate work met the course requirements. I'd already successfully done this for the required sociocultural course. Rob was very friendly, looked carefully over the classes I had taken, and then denied the request. If Rob hadn't denied my request, I suspect I'd be back doing engineering right now.

It turned out that the field of human evolution and biological anthropology was full of ideas one could use to explain important aspects of human behavior and decision-making. Moreover, I learned that Rob and his long-time collaborator, the ecologist Pete Richerson, had been working on ways to model culture using mathematical tools from population genetics. Their approach also allowed one to think systematically about how natural selection might have shaped human learning abilities and psychology. I didn't know any population genetics, but because I knew about state variables, differential equations, and stable equilibria (I was an aerospace engineer), I could more or less read and understand their papers. By the end of my first year, working on a side project under Rob's guidance, I'd written a MATLAB program to study

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the evolution of conformist transmission (you'll hear more about this in chapter 4).

Entering my third year, with a master's under my belt, I decided to go back to the drawing board—to start over, in a sense. I consciously took a "reading year," though I knew it would extend my time to the PhD by one year. You could probably get away with this only in a department of anthropology. I had no classes to take, no advisors to work for, and no one really seemed to care what I was doing. I started by going to the library to take out a stack of books. I read books on cognitive psychology, decision-making, experimental economics, biology, and evolutionary psychology. Then I moved to journal articles. I read every article ever written on an economics experiment called the Ultimatum Game, which I'd used during my second and third summers with the Matsigenka. I also read a lot by the psychologists Daniel Kahneman and Amos Tversky, as well as by a political scientist named Elinor Ostrom. Kahneman and Ostrom would, years later, both receive Nobel Prizes in economics. Of course, along the way, I never stopped reading anthropological ethnographies (this was my "fun" reading). In many ways, that year was the first year of research on this book, and by the end of it, I had developed a murky vision for what I wanted to do. The goal was to integrate insights from across the social and biological sciences to build an evolutionary approach to studying human psychology and behavior that takes seriously the cultural nature of our species. We needed to harness the full arsenal of available methods, including experiments, interviews, systematic observation, historical data, physiological measures, and rich ethnography. We had to study people, not in university laboratories, but in their communities and over their life course (from babies to the elderly). From this vantage point, disciplines like anthropology, and especially subdisciplines like economic anthropology, began to look small and insular.

Of course, Boyd and Richerson, building on work by Marc Feldman and Luca Cavalli-Sforza, had already laid down some of the key theoretical foundations in their 1985 book, *Culture and the Evolutionary Process*. However, in the mid-1990s there was still essentially no program of empirical research, no toolbox of methods, and no established ways of testing the theories generated by the evolutionary models. Moreover, the existing ideas about psychological processes hadn't been developed very far or in ways that easily connected with the rising intellectual tides in cultural or evolutionary psychology, neuroscience, or even with the scientific wings of cultural anthropology.

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During this time, two new graduate students had arrived to work with Rob Boyd: Francisco Gil-White and Richard McElreath (now a director at the Max Planck Institute for Evolutionary Anthropology). A little later, Natalie Smith (now Natalie Henrich) moved over from archeology to work with Rob on cooperation. Suddenly, I was no longer alone; I had like-minded friends and collaborators with shared interests. This was an exciting and fast moving time, as new ideas and fresh intellectual avenues seemed to be bubbling up all over the place. It felt like someone had suddenly taken the brakes off and removed the stops. Rob and I were assembling a team of field ethnographers and economists to conduct behavioral experiments around the globe and study human sociality. This was virtually unheard of, since ethnographers do not work in teams and they certainly don't (or, didn't) use economic games. Based on my first experiments in Peru, I sent off a paper entitled "Does Culture Matter in Economic Behavior?" to a journal I'd found in the library called the *American Economic Review*. As an anthropology graduate student, I had no idea this was the top journal in economics, or how skeptical economists were at that time about culture. Meanwhile, Francisco was importing methods from developmental psychology to test his ideas about folk sociology and ethnicity (see chapter 11) among herders in Mongolia. Natalie and I invented the Common Pool Resources (CPR) Game to study conservation behavior in Peru. (To our dismay, we later learned that it had already been invented.) Richard was writing computer programs to create and study "cultural phylogenies," something no one had done, and was discussing with a Caltech economist named Colin Camerer how to use computer-based experimental techniques to test theories of social learning. Francisco and I came up with a new theory of human status over coffee one morning (see chapter 8). And, inspired by reading the diffusion of innovations literature in sociology, I started wondering if it was possible to detect a "signature" of cultural learning from data on the diffusion of new ideas and technologies over time. Several of these early efforts later became substantial research endeavors in various disciplines.

It has now been twenty years since this began for me in 1995, so I'm laying down this book as a waymark, a work in progress. I'm more convinced than ever that to understand our species and to build a science of human behavior and psychology, we need to begin with an evolutionary theory of human nature. Getting this at least partially right is paramount to taking the next step. Recently, I've been particularly encouraged by this year's World Development Report 2015, which is entitled *Mind,*

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chin, Carel van Schaik, Felix Warneken, Janet Werker, Annie Wertz, Polly Wiessner, David Sloan Wilson, Harvey Whitehouse, Andy Whiten, and Richard Wrangham (as well as many others, including those already mentioned above).

Over the years in planning and writing this book, I had conversations with an immense number of friends, coauthors, and colleagues who have shaped my thinking. This is my collective brain (see chapter 12).

Joe Henrich
22 January 2015
Vancouver, Canada

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THE SECRET OF OUR SUCCESS

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CHAPTER 1

A PUZZLING PRIMATE

You and I are members of a rather peculiar species, a puzzling primate.

Long before the origins of agriculture, the first cities, or industrial technologies, our ancestors spread across the globe, from the arid deserts of Australia to the cold steppe of Siberia, and came to inhabit most of the world's major land-based ecosystems—more environments than any other terrestrial mammal. Yet, puzzlingly, our kind are physically weak, slow, and not particularly good at climbing trees. Any adult chimp can readily overpower us, and any big cat can easily run us down, though we are oddly good at long-distance running and fast, accurate throwing. Our guts are particularly poor at detoxifying poisonous plants, yet most of us cannot readily distinguish the poisonous ones from the edible ones. We are dependent on eating cooked food, though we don't innately know how to make fire or cook. Compared to other mammals of our size and diet, our colons are too short, stomachs too small, and teeth too petite. Our infants are born fat and dangerously premature, with skulls that have not yet fused. Unlike other apes, females of our kind remain continuously sexually receptive throughout their monthly cycle and cease reproduction (menopause) long before they die. Perhaps most surprising of all is that despite our oversized brains, our kind are not that bright, at least not innately smart enough to explain the immense success of our species.

Perhaps you are skeptical about this last point?

Suppose we took you and forty-nine of your coworkers and pitted you in a game of Survivor against a troop of fifty capuchin monkeys

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ter 4, our capacities for learning from others are themselves finely honed products of natural selection. We are adaptive learners who, even as infants, carefully select when, what, and from whom to learn. Young learners all the way up to adults (even MBA students) automatically and unconsciously attend to and preferentially learn from others based on cues of prestige, success, skill, sex, and ethnicity. From other people we readily acquire tastes, motivations, beliefs, strategies, and our standards for reward and punishment. Culture evolves, often invisibly, as these selective attention and learning biases shape what each person attends to, remembers, and passes on. Nevertheless, these cultural learning abilities gave rise to an interaction between an accumulating body of cultural information and genetic evolution that has shaped, and continues to shape, our anatomy, physiology, and psychology.

Anatomically and physiologically, the escalating need to acquire this adaptive cultural information drove the rapid expansion of our brains, giving us the space to store and organize all this information, while creating the extended childhoods and long postmenopausal lives that give us the time to acquire all this know-how and the chance to pass it on. Along the way, we'll see that culture has left its marks all over our bodies, shaping the genetic evolution of our feet, legs, calves, hips, stomachs, ribs, fingers, ligaments, jaws, throats, teeth, eyes, tongues, and much more. It has also made us powerful throwers and long-distance runners who are otherwise physically weak and fat.

Psychologically, we have come to rely so heavily on the elaborate and complicated products of cultural evolution for our survival that we now often put greater faith in what we learn from our communities than in our own personal experiences or innate intuitions. Once we understand our reliance on cultural learning, and how cultural evolution's subtle selective processes can produce "solutions" that are smarter than we are, otherwise puzzling phenomena can be explained. Chapter 6 illustrates this point by tackling questions such as, Why do people in hot climates tend to use more spices and find them tastier? Why did aboriginal Americans commonly put burnt seashells or wood ash into their cornmeal? How could ancient divination rituals effectively implement game theoretic strategies to improve hunting returns?

The growing body of adaptive information available in the minds of other people also drove genetic evolution to create a second form of human status, called prestige, which now operates alongside the dominance status we inherited from our ape ancestors. Once we understand prestige, it will become clear why people unconsciously mimic more

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successful individuals in conversations; why star basketball players like LeBron James can sell car insurance; how someone can be famous for being famous (the Paris Hilton Effect); and, why the most prestigious participants should donate first at charity events but speak last in decision-making bodies, like the Supreme Court. The evolution of prestige came with new emotions, motivations, and bodily displays that are distinct from those associated with dominance.

Beyond status, culture transformed the environments faced by our genes by generating social norms. Norms influence a vast range of human action, including ancient and fundamentally important domains such as kin relations, mating, food sharing, parenting, and reciprocity. Over our evolutionary history, norm violations such as ignoring a food taboo, botching a ritual, or failing to give one's in-laws their due from one's hunting successes meant reputational damage, gossip, and a consequent loss of marriage opportunities and allies. Repeated norm violations sometimes provoked ostracism or even execution at the hands of one's community. Thus, cultural evolution initiated a process of *self-domestication*, driving genetic evolution to make us prosocial, docile, rule followers who expect a world governed by social norms monitored and enforced by communities.

Understanding the process of self-domestication will allow us to address many key questions. In chapters 9 to 11, we'll explore questions such as, How did rituals become so psychologically potent, capable of solidifying social bonds and fostering harmony in communities? How do marriage norms make better fathers and expand our family networks? Why is our automatic and intuitive response to stick to a social norm, even if that means paying a personal cost? Similarly, when and why does careful reflection cause greater selfishness? Why do people who wait for the "walk signal" at traffic lights also tend to be good cooperators? What was the psychological effect of World War II on America's Greatest Generation? Why do we prefer to interact with, and learn from, those who speak the same dialect as we do? How did our species become the most social of primates, capable of living in populations of millions, and at the same time, become the most nepotistic and warlike?

The secret of our species' success resides not in the power of our individual minds, but in the *collective brains* of our communities. Our collective brains arise from the synthesis of our cultural and social natures—from the fact that we readily learn from others (are *cultural*) and can, with the right norms, live in large and widely interconnected groups (are *social*). The striking technologies that characterize our species, from

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the kayaks and compound bows used by hunter-gatherers to the antibiotics and airplanes of the modern world, emerge not from singular geniuses but from the flow and recombination of ideas, practices, lucky errors, and chance insights among interconnected minds and across generations. Chapter 12 shows how it's the centrality of our collective brains that explains why larger and more interconnected societies produce fancier technologies, larger toolkits, and more know-how, and why when small communities suddenly become isolated, their technological sophistication and cultural know-how begins to gradually ebb away. As you'll see, innovation in our species depends more on our sociality than on our intellect, and the challenge has always been how to prevent communities from fragmenting and social networks from dissolving.

Like our fancy technologies and complex sets of social norms, much of the power and elegance of our languages come from cultural evolution, and the emergence of these communication systems drove much of our genetic evolution. Cultural evolution assembles and adapts our communicative repertoires in ways similar to how it constructs and adapts other aspects of culture, such as the making of a complicated tool or the performance of an intricate ritual. Once we understand that languages are products of cultural evolution, we'll be able to ask a variety of new questions such as, Why are languages from people in warmer climates more sonorous? Why do languages with larger communities of speakers have more words, more sounds (phonemes), and more grammatical tools? Why is there such a difference between the languages of small-scale societies and those that now dominate the modern world? In the longer run, the presence of such culturally evolved communicative repertoires created the genetic selective pressures that drove our larynx (the voice box) down, whitened our eyes, and endowed us with a birdlike propensity for vocal mimicry.

Of course, all these products of cultural evolution, from words to tools, do indeed make us individually smarter, or at least mentally better equipped to thrive in our current environments (so, "smarter"). You, for example, probably received a massive cultural download while growing up that included a convenient base-10 counting system, handy Arabic numerals for easy representation, a vocabulary of at least 60,000 words (if you are a native English speaker), and working examples of the concepts surrounding pulleys, springs, screws, bows, wheels, levers, and adhesives. Culture also provides heuristics, sophisticated cognitive skills

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like reading, and mental prostheses like the abacus that have evolved culturally to both fit, and to some degree, modify our brains and biology. However, as you'll see, we don't have these tools, concepts, skills, and heuristics because our species is smart; we are smart because we have culturally evolved a vast repertoire of tools, concepts, skills, and heuristics. Culture makes us smart.

Besides driving much of our species genetic evolution and making us (somewhat) "self-programmable," culture has woven itself into our biology and psychology in other ways. By gradually selecting institutions, values, reputational systems, and technologies over the eons, cultural evolution has influenced the development of our brains, hormonal responses, and immune reactions, as well as calibrating our attention, perceptions, motivations, and reasoning processes to better fit the diverse culturally constructed worlds in which we grow up. As we'll see in chapter 14, culturally acquired beliefs alone can change pain into pleasure, make wine more (or less) enjoyable, and, in the case of Chinese astrology, alter the length of believers' lives. Social norms, including those contained in languages, effectively supply training regimes that shape our brains in various ways, ranging from expanding our hippocampus to thickening our corpus callosum (the information highway that connects the two halves of our brains). Even without influencing genes, cultural evolution creates both psychological and biological differences between populations. You, for example, have been altered biologically by the aforementioned cultural download of skills and heuristics.

In the chapter 17, I'll explore how this view of our species changes how we think about several key questions:

1. What makes humans unique?
2. Why are humans so cooperative compared to other mammals?
3. Why do societies vary so much in their cooperativeness?
4. Why do we seem so smart compared to other animals?
5. What makes societies innovative, and how will the Internet influence this?
6. Is culture still driving genetic evolution?

The answers to these questions alter how we think about the interface of culture, genes, biology, institutions, and history and how we approach human behavior and psychology. This approach also has important practical implications for how we build institutions, design policies, address social problems, and understand human diversity.

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CHAPTER 2

IT'S NOT OUR INTELLIGENCE

Humans have altered more than one-third of the earths' land surface. We cycle more nitrogen than all other terrestrial life forms combined and have now altered the flow of two-thirds of the earth's rivers. Our species uses 100 times more biomass than any large species that has ever lived. If you include our vast herds of domesticated animals, we account for more than 98% of terrestrial vertebrate biomass.[1]

Such facts leave little doubt that we are the ecologically dominant species on the planet.[2] Yet, they open the question of *why us?* What explains our species' ecological dominance? What is the secret of our success?

To pursue these questions let's begin by putting aside the hydroelectric dams, mechanized agriculture, and aircraft carriers of the modern world, along with the steel plows, massive tombs, irrigation works, and grand canals of the ancient world. We need to go back long before industrial technology, cities, and farming to understand how a particular tropical primate managed to spread across the globe.

Not only did ancient hunter-gatherers expand into most of the earth's terrestrial ecosystems, we probably also contributed to the extinction of much of its megafauna—that is, to the extinction of large vertebrates like mammoths, mastodons, giant deer, woolly rhinos, immense ground sloths, and giant armadillos, as well as some species of elephants, hippos, and lions. While climatic shifts were also likely contributors to these extinctions, the disappearance of many megafaunal species eerily coincides with the arrival of humans on different continents and large is-

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While broadly on target, these observations succeed only in pushing the question back to how and why humans are capable of creating the necessary tools, techniques, and organizational forms to adapt to, and thrive in, such a diversity of environments. Why can't other animals achieve this?

The most common answer is that we are simply more intelligent. We have big brains with ample cognitive processing power and other souped-up mental abilities (e.g., greater working memory) that allow us to figure out how to solve problems creatively. The world's leading evolutionary psychologists, for example, have argued that humans evolved "improvisational intelligence," which allows us to formulate causal models of how the world works. These models then permit us to devise useful tools, tactics, and stratagems "on the fly." In this view, an individual faced with an environmental challenge, say hunting birds, throws his big primate brain into overdrive, figures out that wood can store elastic energy (a causal model), and then goes on to craft bows, arrows, and spring traps to get those birds.[8]

An alternative, though perhaps complementary, view is that our big brains are full of genetically endowed cognitive abilities that have emerged via natural selection to solve the most important and recurrent problems faced by our hunter-gatherer ancestors. These problems are often thought of as relating to specific domains, such as finding food, water, mates, and friends, as well as avoiding incest, snakes, and disease. When cued by environmental circumstances, these cognitive mechanisms take in problem-specific information and deliver solutions. The psychologist Steve Pinker, for example, has long argued that we are smarter and more flexible "not because we have fewer instincts than other animals; it is because we have more."[9] This view suggests that since our species has long relied on tracking and hunting, we might have evolved psychological specializations that fire up and endow us with tracking or hunting abilities (as cats have) when we are placed in the right circumstances.

A third common approach to explaining our species' ecological dominance focuses on our prosociality, our abilities to cooperate intensively across many different domains and extensively in large groups. Here the idea is that natural selection made us highly social and cooperative, and then by working together we conquered the globe.[10]

Thus, the three common explanations for our species' ecological success are (1) generalized intelligence or mental processing power, (2) specialized mental abilities evolved for survival in the hunter-gatherer envi-

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ronments of our evolutionary past, and/or (3) cooperative instincts or social intelligence that permit high levels of cooperation. All of these explanatory efforts are elements in building a more complete understanding of human nature. However, as I'll show, none of these approaches can explain our ecological dominance or our species' uniqueness without first recognizing the intense reliance we have on a large body of locally adaptive, culturally transmitted information that no single individual, or even group, is smart enough to figure out in a lifetime. To understand both human nature and our ecological dominance, we first need to explore how cultural evolution gives rise to complex repertoires of adaptive practices, beliefs, and motivations.

In chapter 3, lost European explorers will teach us about the nature of our vaulted intelligence, cooperative motivations, and specialized mental abilities. However, before setting sail with the explorers, I want to warm up by shaking your confidence on just how smart our species really is relative to other primates. Yes, we are intelligent, as earth creatures go; nevertheless, we are not nearly smart enough to account for our immense ecological success. Moreover, while we humans are good at certain cognitive feats, we are not so good at others. Many of both our mental skills and deficiencies can be predicted by recognizing that our brains evolved and expanded in a world in which the crucial selection pressure was our ability to acquire, store, organize, and retransmit an ever-growing body of cultural information. Like natural selection, our cultural learning abilities give rise to "dumb" processes that can, operating over generations, produce practices that are smarter than any individual or even group. Much of our seeming intelligence actually comes not from raw brainpower or a plethora of instincts, but rather from the accumulated repertoire of mental tools (e.g., integers), skills (differentiating right from left), concepts (fly wheels), and categories (basic color terms) that we inherit culturally from earlier generations.[11]

One quick terminological note before we face off against the apes. Throughout this book, *social learning* refers to any time an individual's learning is influenced by others, and it includes many different kinds of psychological processes. *Individual learning* refers to situations in which individuals learn by observing or interacting directly with their environment and can range from calculating the best time to hunt by observing when certain prey emerge, to engaging in trial-and-error learning with different digging tools. So, individual learning too captures many different psychological processes. Thus, the least sophisticated forms of social learning occur simply as a by-product of being around others and en-

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gaging in individual learning. For example, if I hang around you and you use rocks to crack open nuts, then I'm more likely to figure out *on my own* that rocks can be used to crack open nuts because I'll tend to be around rocks and nuts more frequently and can thus more easily make the relevant connections myself. *Cultural learning* refers to a more sophisticated subclass of social learning abilities in which individuals seek to acquire information from others, often by making inferences about their preferences, goals, beliefs, or strategies and/or by copying their actions or motor patterns. When discussing humans, I'll generally refer to *cultural learning*, but with nonhumans and our ancient ancestors, I'll call it *social learning*, since we often aren't sure if their social learning includes any actual cultural learning.

Showdown: Apes versus Humans

Let's begin by comparing the mental abilities of humans with two other closely related large-brained apes: chimpanzees and orangutans. As just mentioned, we "get smart" in part by acquiring a vast array of cognitive abilities via cultural learning. Cultural evolution has constructed a developmental world full of tools, experiences, and structured learning opportunities that harness, hone, and extend our mental abilities. This often occurs without anyone's conscious awareness. Consequently, to get a proper comparison with nonhumans, it might be misleading to compare apes to fully culturally equipped adults, who, for example, know fractions. Since its probably impossible, and certainly unethical, to raise children without access to these culturally evolved mental tools, researchers often compare toddlers to nonhuman apes (hereafter just "apes"). Admittedly, toddlers are already highly cultural beings, but they have had much less time to acquire additional cognitive endowments (e.g., knowing right vs. left, subtraction, etc.) and have had no formal education.

In a landmark study, Esther Herrmann, Mike Tomasello, and their colleagues at the Institute for Evolutionary Anthropology in Leipzig, Germany, put 106 chimpanzees, 105 German children, and 32 orangutans through a battery of 38 cognitive tests.[12] Their test battery can be broken down into subtests that capture abilities related to space, quantities, causality, and social learning. The space subtest includes tasks related to spatial memory and rotation in which participants have to recall the location of an object or track an object through a rotational movement. The quantities subtest measures participants' ability to assess

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relative amounts, or to account for additions and subtractions. The causality subtest assesses participants' abilities to use cues related to shape and sound to locate desirable things, as well as their ability to select a tool with the right properties to solve a problem (i.e., build a causal model). In the social learning subtest, participants are given opportunities to observe a demonstrator use a hard-to-discover technique to obtain a desirable object, such as extracting some food out of a narrow tube. Participants are then given the same task they just observed and can use what they just saw demonstrated to help them obtain the desired object.

Figure 2.2 is striking. On all the subtests of mental abilities, except social learning, there's essentially no difference between chimpanzees and two-and-a-half-year-old humans, despite the fact that the two-and-a-half-year-olds have much larger brains. Orangutans, who have slightly smaller brains than chimpanzees, do a bit worse, but not much worse. Even on the subtest that focused specifically on assessing the causal efficacy of tool properties (causal modeling), the toddlers got 71% correct, the chimps 61%, and the orangutans 63%. Meanwhile the chimps trounced the toddlers on tool use 74% to 23%.

By contrast, for the social learning subtest, the averages shown in figure 2.2 actually conceal the fact that most of the two-and-a-half-year-olds scored 100% on the test, whereas most of the apes scored 0%. Overall, these findings suggest that the only exceptional cognitive abilities possessed by young children in comparison to two other great apes relate to social learning, and not to space, quantities, or causality.

Crucially, if we gave this same battery to adult humans, they would blow the roof off the tests, performing at or near the ceiling (100% correct). This might lead you to think that the whole setup is unfair to the humans, because Esther, Mike, and their colleagues are comparing toddlers to older apes, who varied in ages from 3 to 21 years. Interestingly, however, older apes do not generally do better on these tests than younger apes—quite unlike humans. By age three, the cognitive performances of chimpanzees and orangutans—at least in these tasks—are about as good as they get.[13] Meanwhile, the young children will experience continuous, and eventually massive, improvements in their cognitive scores over at least the coming two decades of their lives. Just how good they will get will depend heavily on where, and with whom, they grow up.[14]

It's important to realize that chimpanzees and orangutans do have some social learning abilities, especially when compared to other animals, but when you have to design a test that is applicable to both apes

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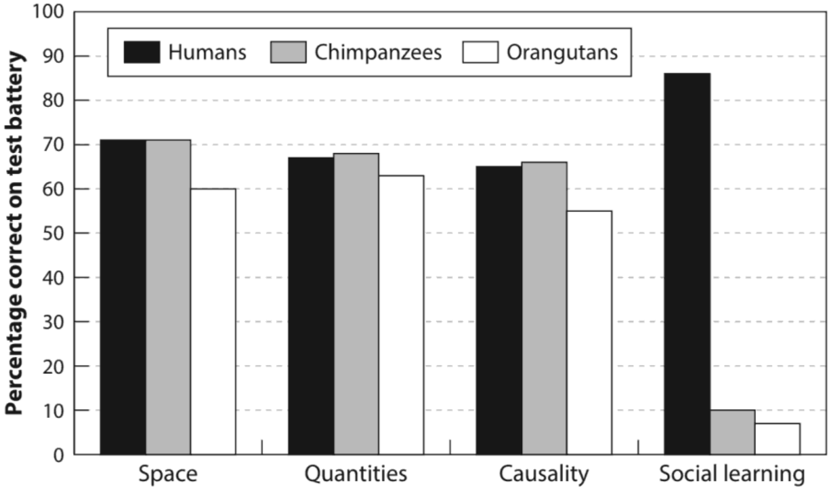

Figure 2.2. Average performance on four sets of cognitive tests with chimpanzees, orangutans, and toddlers.

and humans, the apes inevitably end up near the floor and the humans near the ceiling. In fact, we'll see later that when compared to other apes, humans are prolific, spontaneous, and automatic imitators, even willing to copy seemingly unnecessary or purely stylistic steps. When demonstrations include "extra" or "wasteful" steps, chimpanzee social learning emerges as superior to that of humans because we end up acquiring wasteful or inefficient elements whereas chimps filter these out.

Memory in Chimpanzees and Undergraduates

Despite the fact that our cognitive abilities improve as we grow up, especially in enriched cultural environments, we still do not end up with uniformly superior mental abilities compared to other apes. Let's consider first the available data comparing humans and chimpanzees in (1) working memory and information processing speed, and then in (2) games of strategic conflict. Both sets of findings bring into question the notion that our success as a species results from sheer brainpower or better mental processors. The second set of findings questions the notion that our minds are specialized for social maneuvering or strategizing in a Machiavellian world.

If you take an intelligence test, you may hear a list of numbers and then be asked to recall those numbers in reverse order. This measures

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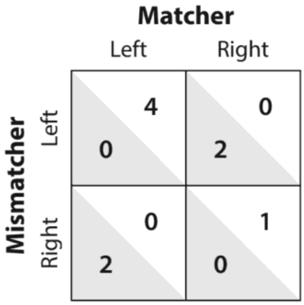

Figure 2.4. The payoffs for the Matcher and Mismatcher in an Asymmetric Matching Pennies Game. Each player has to pick Left or Right. The Mismatcher's payoffs appear in the gray-shaded region of each cell while Matcher's payoffs appear in the white regions. The Matcher gets a higher payoff when he matches on Left than when he matches on Right (4 vs. 1). Meanwhile, the Mismatcher gets the same payoff regardless of how he mismatches.

human brains and created our fancy mental abilities is called the *Machiavellian intelligence hypothesis*. This view emphasizes that our brains and intelligence are specialized for dealing with other people and argues that our brain size and intelligence arose from an "arms race" in which individuals competed in an ever-escalating battle of wits to strategically manipulate, trick, exploit, and deceive each other. If this is so, we should be particularly good in games of strategic conflict compared to chimpanzees.[19]

Matching Pennies is a classic game of strategic conflict that has been played with both chimpanzees and humans. In the game, individuals are paired with another of their species for several rounds of interaction. Each player is placed into the role of either the Matcher or the Mismatcher. In each round, participants must select either Left or Right. The Matcher gets a reward only when his choice (Left or Right) *matches* the choice of his opponent. By contrast, the Mismatcher gets a reward only when his choice mismatches his opponent. The rewards, however, need not be symmetric, as illustrated in figure 2.4. In this asymmetric version, the Matcher gets 4 apple cubes (or cash for humans) when she successfully matches on Left, but only gets 1 cube when she matches on Right. Meanwhile, the Mismatcher gets only two cubes for any successful mismatches, no matter how they arise.

This kind of interaction can be analyzed using game theory. To win, the first thing to realize is that both players should be as unpredictable as possible. Nothing about your prior choices should allow your oppo-

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nent to anticipate your next play—you have to randomize. To see this, put yourself into the shoes of the Matcher. Your opponent gets two cubes whether he plays Left (L) or Right (R), so you should essentially flip a coin with heads for R and tails for L. This means you'll play R and L each 50% of the time, and your opponent won't be able to predict your choices. If you deviate from 50%, your opponent will be able to exploit you more frequently. Now consider matters from the position of the Mismatcher: if you now similarly flip a coin, the Matcher will shift to play mostly L, since that gives him four instead of one. To compensate, as a Mismatcher you need to play R 80% of the time. Thus, the predicted winning strategy in a contest of intelligent rational actors is that Matchers should randomize their responses, playing L 50% of the time, while Mismatchers should randomize by playing L only 20% of the time. This outcome is called the Nash equilibrium. The fraction of the time that one should play L can be moved around by simply changing the payoffs for matching or mismatching on L or R.

A research team from Caltech and Kyoto University tested six chimpanzees and two groups of human adults: Japanese undergraduates and Africans from Bossou, in the Republic of Guinea. When chimpanzees played this asymmetric variant of Matching Pennies (figure 2.4), they zoomed right in on the predicted result, the Nash equilibrium. Humans, however, systematically and consistently missed the rational predictions, with Mismatchers performing particularly poorly. This deviation from "rationality," though it was in line with many prior tests of human rationality, was nearly seven times greater than the chimpanzees' deviation. Moreover, detailed analyses of the patterns of responses over many rounds of play show that the chimps responded more quickly to both their opponents' recent moves and to changes in their payoffs (i.e., when they switched from playing the Matcher to the Mismatcher). Chimpanzees seem to be better at individual learning and strategic anticipation, at least in this game.[20]

The performance of the apes in this setup was no fluke. The Caltech-Kyoto team also ran two other versions of the game, each with different payoffs. In both versions, the chimps zeroed in on the Nash equilibrium as it moved around from game to game. This means that chimps can develop what game theorists call a *mixed strategy*, which requires them to randomize their behavior around a certain probability. Humans, however, often struggle with this.

A final insight into the humans' poor performance comes from an analysis of participants' response times, which measures the time from

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the start of a round until the player selects his move. For both species, Mismatchers took longer than Matchers. However, the humans took *much longer* than the chimps. It's as if the humans were struggling to inhibit or suppress an automatic reaction.

This pattern may reflect a broader bug in human cognition: our automatic and unconscious tendency to imitate (to match). In Matching Pennies and other games like Rock-Paper-Scissors, one player sometimes accidentally reveals his or her choice a split-second before the other player. This flash look at an opponents' move could result in more victories for those who delay. And in Matching Pennies, experiments show that it does for Matchers, for whom copying leads to victories. For Mismatchers, however, it leads to more losses, because they sometimes fail to inhibit imitation. In Rock-Paper-Scissors, it results in more ties (e.g., rock-rock), because the slower player sometimes unconsciously imitates the choice of his or her opponent.[21] The reason is that we humans are rather inclined to copy—spontaneously, automatically, and often unconsciously. Chimpanzees don't appear to suffer from this cognitive "bug," at least not nearly to the same degree.

This is really just the beginning. So far, I have highlighted comparisons between human and ape cognition to suggest that although we are an intelligent species, we are not nearly smart enough to account for our species' ecological success. I could have also tapped the vast literature in psychology and economics, which tests the judgment and decision-making of undergraduates against benchmarks from statistics, probability, logic, and rationality. In many contexts, but not all, we humans make systemic logical errors, see illusory correlations, misattribute causal forces to random processes, and give equal weight to small and large samples. Not only do humans often fall systematically short of these standard benchmarks, we actually often don't do appreciably better than other species—like birds, bees, and rodents—on these tests. Sometimes, we do worse.[22] We, for example, suffer from the Gambler's fallacy, Concorde (or sunk cost) fallacy and Hot-hand fallacy, among others. Gamblers believe they are "due" at the craps tables (they're not), movie goers continue watching painfully bad movies even if they know they'd have more fun doing something else (e.g., sleeping), and basketball betters see certain players get the "hot-hand," even when they are actually seeing lucky streaks that are consistent with the player's typical scoring percentage. Meanwhile, rats, pigeons and other species don't suffer from such reasoning fallacies, and consequently often make the more profitable choices in analogous situations.

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If our species is such a bunch of dimwits, how can we explain our species' success? And why do we seem so smart? I'll answer these questions in the next fifteen chapters. But before we get to all that, let's put my claims to the test. Stripped of our cultural know-how, can we humans fire-up our big brains and stoke up our fancy intellects enough to survive as hunter-gatherers?

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CHAPTER 3

LOST EUROPEAN EXPLORERS

In June 1845 the HMS *Erebus* and the HMS *Terror*, both under the command of Sir John Franklin, sailed away from the British Isles in search of the fabled Northwest Passage, a sea channel that could energize trade by connecting western Europe to East Asia. This was the Apollo mission of the mid-nineteenth century, as the British raced the Russians for control of the Canadian Arctic and to complete a global map of terrestrial magnetism. The British admiralty outfitted Franklin, an experienced naval officer who had faced Arctic challenges before, with two field-tested, reinforced ice-breaking ships equipped with state-of-the-art steam engines, retractable screw propellers, and detachable rudders. With cork insulation, coal-fired internal heating, desalinators, five years of provisions, including tens of thousands of cans of food (canning was a new technology), and a twelve-hundred-volume library, these ships were carefully prepared to explore the icy north and endure long Arctic winters.[1]

As expected, the expedition's first season of exploration ended when the sea ice inevitably locked them in for the winter around Devon and Beechney Islands, 600 miles north of the Arctic Circle. After a successful ten-month stay, the seas opened and the expedition moved south to explore the seaways near King William Island, where in September they again found themselves locked in by ice. This time, however, as the next summer approached, it soon became clear that the ice was not retreating and that they'd remain imprisoned for another year. Franklin promptly died, leaving his crew to face the coming year in the pack ice with

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polar bear bone (yes, you also need to know how to kill polar bears; best to catch them napping in their dens). Once you've plunged your harpoon's head into the seal, you're then in a wrestling match as you reel him in, onto the ice, where you can finish him off with the aforementioned bear-bone spike.[4]

Now you have a seal, but you have to cook it. However, there are no trees at this latitude for wood, and driftwood is too sparse and valuable to use routinely for fires. To have a reliable fire, you'll need to carve a lamp from soapstone (you know what soapstone looks like, right?), render some oil for the lamp from blubber, and make a wick out of a particular species of moss. You will also need water. The pack ice is frozen salt water, so using it for drinking will just make you dehydrate faster. However, old sea ice has lost most of its salt, so it can be melted to make potable water. Of course, you need to be able to locate and identify old sea ice by color and texture. To melt it, make sure you have enough oil for your soapstone lamp.

These few examples are just the tip of an iceberg of cultural know-how that's required to live in the Arctic. I have not even alluded to the know-how for making baskets, fishing weirs, sledges, snow goggles, medicines, or leisters (figure 3.1), not to mention all the knowledge of weather, snow, and ice conditions required for safe travel using a sledge.

Nevertheless, while the Inuit are impressive, perhaps I am asking too much, and no one could have survived getting stuck in the ice for two years in the Artic. After all, we are a tropical primate, and the average temperatures during the winters on King William Island range between –25°C (–13°F) and –35°C (–31°F), and were even lower in the mid-nineteenth century. It happens, however, that two other expeditions have found themselves also stranded on King William Island, both before and after Franklin's expedition. Despite being much smaller and less well-equipped than Franklin's men, both crews not only survived but went on to future explorations. What was the secret of their success?[5]

Fifteen years before the Franklin Expedition, John Ross and a crew of twenty-two had to abandon the *Victory* off the coast of King William Island. During three years on the island, Ross not only survived but also managed to explore the region, including locating the magnetic pole. The secret of Ross's success is not surprising; it was the Inuit. Although not known as a "people person," he managed to befriend the locals, establish trading relations, and even fashion a wooden leg for lame Inuit man. Ross marveled at Inuit snow houses, multiuse tools, and amazing

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cold-weather attire; he enthusiastically learned about Inuit hunting, sealing, dogs, and traveling by dog sledge. In return, the Inuit learned from Ross's crew the proper use of a knife and fork while formally dining. Ross is credited with gathering a great deal of ethnological information, though in part this was driven by his practical need to obtain survival-crucial information and to maintain good relations. During their stay, Ross worried in his journals when the Inuit disappeared for long stretches and looked forward to the bounty they would return with—including packages such as 180 pounds of fish, fifty sealskins, bears, musk ox, venison, and fresh water. He also marveled at the health and vigor of the Inuit. Ross's sledge expeditions during this time always included parties of Inuit, who acted as guides, hunters, and shelter builders. After four years, during which time he was presumed dead by the British Admiralty, Ross managed to return to England with nineteen of his twenty-two men. Years later, in 1848, Ross would again deploy lightweight sledges, based on Inuit designs, in an overland search for Franklin's lost expedition. These sledge designs were adopted by many future British expeditions.

A little over a half century later, Roald Amundsen spent two winters on King William Island and three in the Arctic. In his refurbished fishing sloop, he went on to be the first European to successfully traverse the Northwest Passage. With knowledge of both Ross and Franklin, Amundsen immediately sought out the Inuit and learned from them how to make skin clothing, hunt seals, and manage dog sleds. Later, he would put these Inuit skills and technologies—clothing, sledges, and houses—to good use in beating Robert Scott to the South Pole. In praising the effectiveness of Inuit clothing at –63°F (–53°C), the Norwegian Amundsen wrote, "Eskimo dress in winter in these regions is far superior to our European clothes. But one must either wear it all or not at all; any mixture is bad. . . . You feel warm and comfortable the moment you put it on [in contrast with wool]." Amundsen made similar comments about Inuit snow houses (more on those in chapter 7). After finally deciding to replace the metal runners on his sledge with wooden ones, he noted, "One can't do better in these matters than copy the Eskimo, and let the runners get a fine covering of ice; then they slide like butter."[6]

The Franklin Expedition is our first example from the Lost European Explorer Files.[7] The typical case goes like this: Some hapless group of European or American explorers find themselves lost, cut off, or otherwise stuck in some remote and seemingly inhospitable place. They eventually run out of provisions and increasingly struggle to find food and

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sometimes water. Their clothing gradually falls apart, and their shelters are typically insufficient. Disease often follows, as their ability to travel deteriorates. Cannibalism frequently occurs, as things get desperate. The most instructive cases are those in which fate permits the explorers to gain exposure and experience in the "hostile" environment they will have to (try to) survive in before their supplies totally run out. Sadly, these explorers generally die. When some do survive, it's because they fall in with a local indigenous population, who provides them with food, shelter, clothing, medicine, and information. These indigenous populations have typically been surviving, and often thriving, in such "hostile" environments for centuries or millennia.

What these cases teach us is that humans survive neither by our instinctual abilities to find food and shelter, nor by our individual capacities to improvise solutions "on the fly" to local environmental challenges. We can survive because, across generations, the selective processes of cultural evolution have assembled packages of cultural adaptations—including tools, practices, and techniques—that cannot be devised in a few years, even by a group of highly motivated and cooperative individuals. Moreover, the bearers of these cultural adaptations themselves often don't understand much of how or why they work, beyond the understanding necessary for effectively using them. Chapter 4 will lay out the foundations of the processes that build cultural adaptations over generations.

Before moving on, however, let's again dip into the Lost European Explorer Files just to make sure the Arctic isn't a special case of an excessively challenging environment.

The Burke and Wills Expedition

In 1860, while returning from the first European trip across the interior of Australia, from Melbourne north to the Gulf of Carpentaria, four explorers found that they had nearly used up three months' worth of provisions and were increasingly forced to live off the land. The expedition leader, Robert Burke (a former police inspector) and his second-in-command, William Wills (a surveyor), along with Charles Gray (a 52-year-old sailor) and John King (a 21-year-old soldier), soon had to begin eating their pack animals, which included six camels that had been imported especially for this desert trip. The horse and camel meat extended their provisions but also meant they had to abandon their equipment as they traveled. Gray got increasingly weak, stole food, and

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soon died of dysentery. The remaining trio eventually made it back to their rendezvous point, an expedition depot at Coopers Creek, where they expected the rest of their large expedition party to be waiting with fresh supplies and provisions. However, this waiting party, who were also sick, injured, and running short on food, had departed earlier the same day. Burke, Wills, and King had just missed them, but the trio did manage to access some buried provisions. Still weak and exhausted, Burke decided not to try to catch the rest of their party, by heading south, but instead to follow Coopers Creek west toward Mount Hopeless (yes, really, Mount Hopeless), about 150 miles away, where there was a ranch and police outpost. While traveling along Coopers Creek, not long after departing the rendezvous depot, both of their two remaining camels died. This left them stuck along Coopers Creek because without either the camels to carry water or some knowledge of how to find water in the outback, the trio could not traverse the last open stretch of desert between the creek and the outpost at Mount Hopeless.[8]

Stranded, and now with their recent infusion of provisions running low, the explorers managed to make peaceful contact with a local aboriginal group, the Yandruwandrha. These aboriginal hunter-gatherers gave them gifts of fish, beans, and some cakes, which the men learned were made from a "seed" called nardoo (technically, it's a sporocarp, not a seed). Our trio clearly paid some attention when they were with the Yandruwandrha, but this didn't improve their success in fishing or trapping. However, impressed by the cakes, they did start searching for the source of the nardoo seeds, which they believed to be from a tree. After much searching, and running on empty, the trio finally wandered across a flat covered with nardoo—which turned out to be a cloverlike, semiaquatic fern, not a tree. Initially, the men just boiled the sporocarp, but later they found (not made) some grinding stones and copied the Yandruwandrha women whom they had observed preparing the cakes. They pounded the seeds, made flour, and baked nardoo bread.

This was an apparent boon in the men's plight, because it finally seemed they had a reliable source of calories. For more than a month, the men collected and consumed nardoo, as they all became increasingly fatigued and suffered from massive and painful bowel movements. Despite consuming what should have been sufficient calories (4–5 lbs. per day, according to Wills's journal), Burke, Wills, and King merely got weaker (see figure 3.2). Wills writes about what was happening to them by first describing the bowel movements caused by the nardoo:

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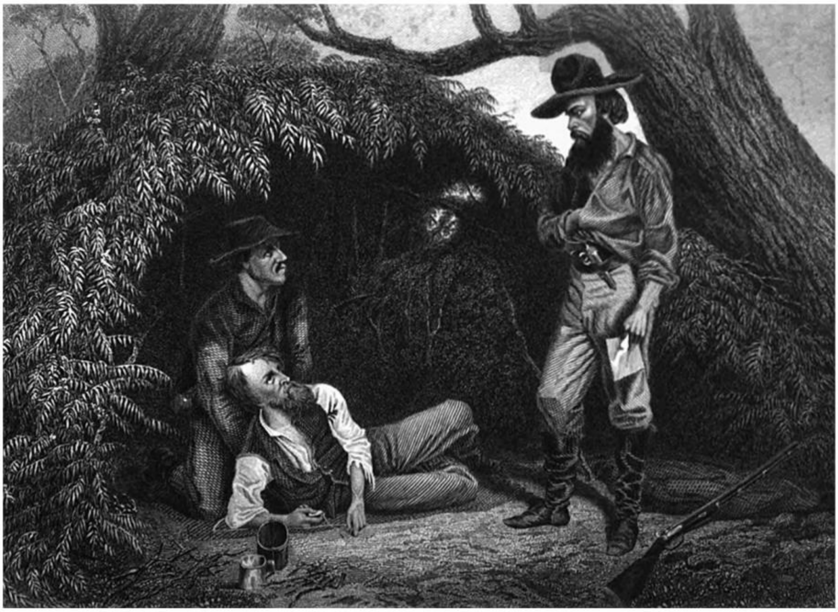

Figure 3.2. Painting of Burke, Wills, and King as they struggled to survive along Coopers Creek. Painted by Scott Melbourne and published in Wills's diary (Wills, Wills, and Farmer 1863).

> I cannot understand this nardoo at all; it certainly will not agree with me in any form. We are now reduced to it alone, and we manage to get from four to five pounds per day between us. The stools it causes are enormous, and seem greatly to exceed the quantity of bread consumed, and is very slightly altered in appearance from what it was when eaten. . . . Starvation on nardoo is by no means unpleasant, but for the weakness one feels and the utter inability to move oneself, for as far as appetite is concerned, it gives me the greatest satisfaction.[9]

Burke and Wills died within a week of this journal entry. Alone, King managed to continue by appealing to the Yandruwandrha, who took him in, fed him, and taught him to construct a proper shelter. Three months later King was found by a relief expedition and returned to Melbourne.

Why did Burke and Wills die?

Like many plants used by hunter-gatherers, nardoo is indigestible and at least mildly toxic unless properly processed. Unprocessed nardoo

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gling in novel environments, with another account, that of a lone young woman who found herself stranded for eighteen years in the place she grew up. Seventy miles off the coast of Los Angeles, and thirty miles from the nearest land, foggy, barren, and windswept San Nicolas Island was once inhabited by a thriving aboriginal society linked by trade to the other Channel Islands and the coast. However, by 1830 the island's population was dwindling, in part due to a massacre by Kodiak hunter-gatherers from the then Russian-controlled Aleutian Islands who had set up camp on San Nicolas to hunt otters. In 1835 Spanish missionaries from Santa Barbara sent a ship to transport the remaining island inhabitants to the mainland missions. During a rushed evacuation, one young native woman in her mid-twenties dashed off to search for her missing child. To evade a looming storm, the ship ended up leaving her behind on the island, and due to some unlucky quirks of fate, she was largely (but not entirely) forgotten.

Surviving for eighteen years, this lone castaway ate seals, shellfish, sea birds, fish, and various roots. She deposited dried meats on different parts of the island for times of sickness or other emergencies. She fashioned bone knives, needles, bone awls, shell fishhooks, and sinew fishing lines. She lived in whalebone houses and weathered storms in a cave. For transporting water, she wove a version of the amazing watertight baskets that were common among the California Indians. For clothing, she fashioned waterproof tunics by sewing together seagull skins with the feathers still on and wore sandals woven from grasses. When finally found, she was described as being in "fine physical condition" and attractive, with an "unwrinkled face." After overcoming an initial scare at being suddenly found, the lone woman promptly offered the search party dinner, which she was cooking at the time they arrived.[12]

The contrast with our lost European explorers could hardly be starker. One lone woman equipped with only the cumulative know-how of her ancestors survived for eighteen years whereas fully provisioned and well-financed teams of experienced explorers struggled in Australia, Texas, and the Arctic. These diverse cases testify to the nature of our species' adaptation. During eons of relying on large bodies of cumulative cultural knowledge, our species became addicted to this cultural input; without culturally transmitted knowledge about how to locate and process plants, fashion tools from available materials, and avoid dangers, we don't last long as hunter-gatherers. Despite the intelligence we acquire from having such big brains, we can't survive in the kinds of environments so commonly inhabited by our hunter-gatherer ancestors over

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our evolutionary history. While our attention, cooperative tendencies, and cognitive abilities have likely been shaped by natural selection to life in our ancestral environments, these genetically evolved psychological adaptations are entirely insufficient for our species. Neither our intelligence nor domain-specific psychological abilities fire up to distinguish edible from toxic plants or to construct watercraft, bone awls, snow houses, canoes, fishhooks, or wooden sledges. Despite the critical importance of hunting, clothing, and fire in our species' evolutionary history, no innate mental machinery delivered to our explorers information on locating snow-covered seal holes, making projectiles, or starting fires.

Our species' uniqueness, and thus our ecological dominance, arises from the manner in which cultural evolution, often operating over centuries or millennia, can assemble cultural adaptations. In the cases above, I've emphasized those cultural adaptations that involve tools and know-how about finding and processing food, locating water, cooking, and traveling. But as we go along, it will become clear that cultural adaptations also involve how we think and what we like, as well as what we can make.

In chapter 4, I will show how evolutionary theory can be successfully applied to build an understanding of culture. Once we understand how natural selection has shaped our genes and our minds to build and hone our abilities to learn from others, we will see how complex cultural adaptations—including tools, weapons, and food-processing techniques, as well as norms, institutions and languages—can emerge gradually without anyone fully apprehending how or why they work. In chapter 5, we will examine how the emergence of cultural adaptations began driving our genetic evolution, leading to an enduring culture-gene coevolutionary duet that took us down a novel pathway, eventually making us a truly cultural species.

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CHAPTER 4

HOW TO MAKE A CULTURAL SPECIES

To understand why European explorers couldn't survive as hunter-gatherers while locals—even when stranded alone—could, we need to understand how populations generate cultural adaptations—the suites or packages of skills, beliefs, practices, motivations, and organizational forms that permit people to survive, and often thrive, in diverse and challenging environments. The process is—in some crucial sense—smarter than we are. Over generations, often outside of conscious awareness, individuals' choices, learned preferences, lucky mistakes, and occasional insights aggregate to produce cultural adaptations. These often-complex packages contain subtle and implicit insights that impress modern engineers and scientists (see chapter 7). We have glimpsed some of these cultural adaptations, from Inuit clothing to nardoo detoxification, and will study other such adaptations, ranging from food taboos that protect pregnant women from marine toxins to religious rituals that galvanize greater prosociality. Before getting to these, however, we need to build an understanding of cultural evolution, from the ground up, that can explain how it is that human populations end up with complexes of tools, tastes, and techniques that are honed to local environmental challenges.

This brings us to a central insight. Rather than opposing "cultural" with "evolutionary" or "biological" explanations, researchers have now developed a rich body of work showing how natural selection, acting on

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genes, has shaped our psychology in a manner that generates *nongenetic evolutionary processes* capable of producing complex cultural adaptations. Culture, and cultural evolution, are then a consequence of genetically evolved psychological adaptations for learning from other people. That is, natural selection favored genes for building brains with abilities to learn from others. These learning abilities, when operating in populations and over time, can give rise to subtly adaptive behavioral repertoires, including those related to fancy tools and large bodies of knowledge about plants and animals. These emergent products arose initially as unintended consequences of the interaction of learning minds in populations, over time. With this intellectual move, "cultural explanations" become but one type of "evolutionary explanation," among a potential host of other noncultural explanations.

In their now classic treatise, *Culture and the Evolutionary Process*, Rob Boyd and Pete Richerson laid the foundations of this approach by developing a body of mathematical models that explore our capacities for cultural learning as genetically evolved psychological adaptations. Once cultural learning is approached as a psychological adaptation or as a suite of adaptations, we can then ask how natural selection has shaped our psychology and motivations so as to allow us to most effectively acquire useful practices, beliefs, ideas, and preferences from others.[1] These are questions about *who* we should learn from, and *what* we should attend to and infer, as well as *when* input from cultural learning should overrule our own direct experience or instincts.

Evidence from diverse scientific fields is now revealing how finely tuned our psychological adaptations for cultural learning are. Natural selection has equipped our species with a wide range of mental abilities that allow us to effectively and efficiently acquire information from the minds and behaviors of other people. These learning instincts emerge early, in infants and young children, and generally operate unconsciously and automatically. In many circumstances, as we saw in the Matching Pennies Game and Rock-Paper-Scissors, we find it difficult to inhibit our automatic imitative instincts. As we'll see below, even when getting "right answers" is important, our cultural learning mechanisms fire up, to influence our practices, strategies, beliefs, and motivations. In fact, sometimes the more important getting the right answer is, the more we rely on cultural learning.

As a point of departure, it is worth considering how pervasive the effects of cultural learning are on our behavior and psychology. Box 4.1 lists just some of the domains where the influence of cultural learning

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has been studied.[2] The list includes domains of distinct evolutionary importance, such as food preferences, mate choice, technological adoptions, and suicide, as well as social motivations related to altruism and fairness. As we'll see in later chapters, cultural learning reaches directly into our brains and changes the *neurological values* we place on things and people, and in doing so, it also sets the standards by which we judge ourselves. One classic set of experiments shows that children acquire the performance standards by which they are willing or unwilling to reward themselves.[3] Children saw a demonstrator rewarding himself or herself with M&Ms only after exceeding either a relatively higher score in a bowling game or a relatively lower score. The children copied the rewarding standards of the demonstrator such that the kids exposed to the "high standards" model tended not to eat the M&Ms unless their score exceeded the higher threshold. As will become clear, culturally acquired standards or values guide our efforts and persistence at individual learning, training, and trial-and-error learning.

Box 4.1: Domains of Cultural Learning

- Food preferences and quantity eaten
- Mate choices (individuals and their traits)
- Economic strategies (investments)
- Artifact (tool) functions and use
- Suicide (decision and method)
- Technological adoptions
- Word meanings and dialect
- Categories ("dangerous animals")
- Beliefs (e.g., about gods, germs, etc.)
- Social norms (taboos, rituals, tipping)
- Standards of reward and punishment
- Social motivations (altruism and fairness)
- Self-regulation
- Judgment heuristics

Let's begin by exploring how thinking of our cultural learning abilities as genetically evolved psychological adaptations deepens our understanding of both how we adapt to our worlds as individuals and how populations adapt to their environments over generations. Our first

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To see the power and pervasiveness of the use of success cues in cultural learning, consider the following experiment. MBA students participated in two different versions of an investment game. In the game, they had to allocate their money across three different investment options, labeled A, B, and C. They were told each investment's average monetary returns and its variation (sometimes you get more than average, other times, less). They were also told the relationships or correlations among the investments; for example, if investment A's value goes up, then B's value tends to go down. Participants could borrow money to invest. During each round of the game, each player would make his or her allocations and receive the returns. After each round, players could alter their investment allocations for the next round, and this went on for sixteen rounds. At the end of the game, each player's portfolio performance ranking relative to the other players heavily influenced their grade in the course, moving it up or down. If you know any MBAs, you'll know this is a serious incentive, and these players were thus strongly motivated to make the most money in the game.

The experimenters randomly assigned players to one of two different versions, or treatments. In one version, the MBAs made their decisions in isolation, receiving only the individual experience derived from their own choices over the sixteen rounds. The other version was identical except that the allocations chosen and performance rankings of all participants were posted between each round, using anonymous labels.

The difference in the results from each version surprised the economists who designed the experiment (though, admittedly, many economists are pretty easily surprised by human behavior[6]). Three patterns are striking. First, the MBAs didn't use the additional information available in the second treatment (with posted performances) in the complex and sophisticated way economic theory assumes. Instead, careful analysis shows that many participants were merely copying ("mimicking") the investment allocations made by the top performers in the previous round. Second, the environment of this experiment is simple enough that one can actually calculate the profit-maximizing investment allocations. This optimal allocation can be compared with where participants actually ended up in round 16 for each of the two versions. Left only to their own individual experience, the MBAs ended up very far away from the optimal allocation—thus, poor overall performance. However, in the second treatment, when they mimicked each other's investments, the group zeroed in on the optimal allocation by the end of the game. Here, the whole group made more money, which is interesting since

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there were no incentives for group performance, as grade assignments were all based on relative rankings. Finally, while opportunities to imitate each other had a dramatic effect on improving the overall group performance, it also led to some individual catastrophes. Sometimes top performers had taken large risks, which paid off in the short run—they got lucky. But their risky allocations, which often included massive borrowing, were copied by others. Since you can't copy the luck along with the allocation choices, an inflated number of bankruptcies resulted as a side effect.[7]

The central finding of this experiment, that people are inclined to copy more successful others, has been repeatedly observed in an immense variety of domains, both in controlled laboratory conditions and in real-world patterns.[8] In experiments, undergraduates rely on *success-biased* learning when real money is on the line—when they are paid for correct answers or superior performance. In fact, the more challenging the problem or the greater the uncertainty, the more inclined people are to rely on cultural learning, as predicted by evolutionary models. This tells us something about *when* individuals will rely on cultural learning over their own direct experience or intuitions.[9]

Interestingly, if you are a real stock market investor, this is now a formal strategy: you can purchase exchange-traded funds (ETFs) that match the picks of the market gurus (GURU), billionaire investors (iBillionaire), or the top money managers (ALFA).[10] But remember, you can't copy their luck.

Experimentally, economists have also shown that people rely on this skill- or success-biased cultural learning to (1) infer and copy others' beliefs about the state of the world, even when others have identical information, and (2) adapt to competitive situations, where copying others is far from the optimal strategy. In the real world, farmers from around the globe adopt new technologies, practices, and crops from their more successful neighbors.[11]

Running in parallel with the work in economics, decades of work by psychologists has also shown the importance of success and skill biases. This work underlines the point that these learning mechanisms operate outside conscious awareness and with or without incentives for correct answers.[12] One set of recent experiments by Alex Mesoudi and his collaborators are particularly relevant for our focus here on complex technologies.[13] In his arrowhead design task, participants engaged in repeated rounds of trial-and-error learning using different arrowhead designs to engage in virtual hunting on a computer. When-

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ever the opportunities were made available, students readily used success-biased cultural learning to help design their arrowheads. When cultural information was available, it rapidly led the group to the optimal arrowhead design and was most effective in more complex, more realistic environments.

In the last fifteen years, an important complementary line of evidence has become available as developmental psychologists have returned to focusing on cultural learning in children and infants. With new evolutionary thinking in the air, they have zoomed in on testing specific ideas about the *who*, *when*, and *what* of cultural learning. It's now clear that infants and young children use cues of competence and reliability, along with familiarity, to figure out from whom to learn. In fact, by age one, infants use their own early cultural knowledge to figure out who tends to know things, and then use this performance information to focus their learning, attention, and memory.

Infants are well known to engage in what developmental psychologists call "social referencing." When an infant, or young child, encounters something novel, say when crawling up to a chainsaw, they will often look at their mom, or some other adult in the room, to check for an emotional reaction. If the attending adult shows positive affect, they often proceed to investigate the novel object. If the adult shows fear or concern, they back off. This occurs even if the attending adult is a stranger. In one experiment, mothers brought one-year-olds to the laboratory at Seoul National University. The infants were allowed to play and get comfortable in the new environment, while mom received training for her role in the experiment. The researchers had selected three categories of toys, those to which infants typically react (1) positively, (2) negatively, and (3) with uncertain curiosity (an ambiguous toy). These different kinds of toys were each placed in front of the infants, one at a time, and the infant's reactions were recorded. Mom and a female stranger sat on either side of the baby and were instructed to react either with smiling and excitement or with fear.

The results of this study are strikingly parallel to studies of cultural learning among both young children and university students. First, the babies engaged in social referencing, looking at one of the adults, four times more often, and more quickly, when an ambiguous toy was placed in front of them. That is, under uncertainty, they used cultural learning. This is precisely what an evolutionary approach predicts for *when* individuals should use cultural learning (see note 9). Second, when faced with an ambiguous toy, babies altered their behavior based on the

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adults' emotional reactions: when they saw fear, they backed off, but when they saw happiness, they approached the toy and changed to regard it more positively. Third, infants tended to reference the stranger more than their moms, probably because mom herself was new to this environment and was thus judged less competent by her baby.[14]

By 14 months, infants are already well beyond social referencing and already showing signs of using skill or competence cues to select models. After observing an adult model acting confused by shoes, placing them on his hands, German infants tended not to copy his unusual way of turning on a novel lighting device: using his head. However, if the model acted competently, confidently putting shoes on his feet, babies tended to copy the model and used their heads to activate the novel lighting device.[15]

Later, by age three, a substantial amount of work shows that children not only track and use competence in their immediate cultural learning but retain this information to selectively target their future learning in multiple domains. For example, young children will note who knows the correct linguistic labels for common objects (like "ducks"), use this information for targeting their learning about both novel tools or words, and then remember this competence information for a week, using it to preferentially learn new things from the previously more competent model.[16]

Prestige

By observing whom others watch, listen to, defer to, hang-around, and imitate, learners can more effectively figure out from whom to learn. Using these "prestige cues" allows learners to take advantage of the fact that other people also are seeking, and have obtained, insights about who in the local community is likely to possess useful, adaptive information. Once people have identified a person as worthy of learning from, perhaps because they've learned about their success, they necessarily need to be around them, watching, listening, and eliciting information through interaction. Since they are trying to obtain information, learners defer to their chosen models in conversation, often giving them "the floor." And, of course, learners automatically and unconsciously imitate their chosen models, including by matching their speech patterns (see chapter 8). Thus, we humans are sensitive to a set of ethological patterns (bodily postures or displays), including visual attention, "holding the floor," deference in conversation, and vocal mimicry, as well as

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others. We use these prestige cues to help us rapidly zero in on whom to learn from. In essence, prestige cues represent a kind of second-order cultural learning in which we figure out who to learn from by inferring from the behavior of others who they think are worthy of learning from—that is, we culturally learn from whom to learn.

Despite the seeming ubiquity of this phenomenon in the real world, there is actually relatively little direct experimental evidence that people use prestige cues. There is an immense amount of indirect evidence that shows how the prestige of a person or source, such as a newspaper or celebrity, increases the persuasiveness of what they say or the tendency of people to remember what they say. This effect occurs even when the prestige of a person comes from a domain, like golf, that is far removed from the issue they are commenting on (like automobile quality). This provides some evidence, though it does not get at the specific cues that learners might actually use to guide them, aside from being told that someone is an "expert" or "the best."[17]

To address this in our laboratory, Maciej Chudek, Sue Birch, and I tested this prestige idea more directly. Sue is a developmental psychologist and Maciej was my graduate student (he did all the real work). We had preschoolers watch a video in which they saw two different potential models use the same object in one of two different ways. In the video, two bystanders entered, looked at both models, and then preferentially watched one of them. The visual attention of the bystanders provided a "prestige cue" that seemingly marked one of the two potential models. Then, participants saw each model select one of two different types of unfamiliar foods and one of two differently colored beverages. They also saw each model use a toy in one of two distinct ways. After the video, the kids were permitted to select one of the two novel foods and one of the two colorful beverages. They could also use the toy any way they wanted. Children were 13 times more likely to use the toy in the same manner as the prestige-cued model compared to the other model. They were also about 4 times more likely to select the food or beverage preferred by the prestige-cued model. Based on questions asked at the end of the experiment, the children had no conscious or expressible awareness of the prestige cues or their effects. These experiments show that young children rapidly and unconsciously tune into the visual attention of others and use it to direct their cultural learning. We are prestige biased, as well as being skill and success biased.[18]

Chapter 8 expands on these ideas to explore how selective cultural learning drove the evolution of a second form of social status in humans

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a person's grades, choice of major, or career preferences. Formal education is, after all, primarily an institution for intensive cultural transmission. Of course, identifying this learning bias as a causal influence is tricky in the real world because teachers have biases too, which may lead them to preferentially assist or reward those who share their sex or ethnic markers. Isolating causality in the real world is what economists are best at, so let's bring in some economists.

By exploiting large data sets of students, courses, and instructors, my UBC colleague Florian Hoffman and his collaborators unearthed real-world evidence consistent with the experimental findings discussed above: being taught by instructors whom you match on ethnicity/race reduces your dropout rate and raises your grades. In fact, for African-American students at a community college, being taught by an African-American instructor reduced class dropout rates by 6 percentage points and increased the fraction attaining a B or better by 13 percentage points. Similarly, using data from freshman (first-years) at the University of Toronto, Florian's team has also shown that getting assigned to a same-sex instructor increased students' grades a bit.

Unlike many researchers before them, Florian and his colleagues addressed concerns that these patterns are created by the instructors' biases by focusing on large undergraduate lectures where students (1) could not influence which instructors they got, (2) were anonymous to the professor, and (3) were graded by teaching assistants, not by the professors.[21] All this points to biases that influence whom learners readily tune in to and learn from.

Our cultural learning biases are why role models matter so much.

Older Individuals Often Do Know More

Both as an indirect measure of competence or experience, and as a measure of self-similarity, age cues may be important for cultural learning for two separate evolutionary reasons. For children, focusing on and learning from older children allows them to learn from more experienced individuals while at the same time providing a means of self-scaffolding, allowing them to bridge gradually from less to more complex skills. The idea here is that although a learner may be able to locate, and sometimes learn from, the most successful or skilled person in his community (say, the best hunter in a foraging band), many young learners will be too inexperienced or ill-equipped to take advantage of the

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nuances and fine points that distinguish the top hunters. Instead, by focusing on older children, young learners can isolate models who are operating at an appropriate increment of skill and complexity above their own. This creates a smoother and more continuous process of gradual skill acquisition, as learners move back and forth from observing older models to practicing, and repeat the process as they grow up. This is why, for example, younger children are often so desperate to hang around their "big cousins" or older siblings, and why mixed-age playgroups are the standard in small-scale societies.

Consistent with evolutionary expectations, young children do assess the age of potential models, perhaps by assessing physical size. Young children often prefer older models unless those individuals have proven unreliable. They trade off *age* against *competence* and in some cases will prefer younger but more competent models to older, less competent ones. For example, in one experiment second graders preferentially imitated the fruit choices of their fellow second graders over kindergarten models. However, when shown that some kindergarteners and second graders were superior puzzle solvers, many second graders shifted to the fruit choices of these good puzzle solvers, even if they were sometimes kindergarteners. In general, children and infants shift their food preferences in response to observing older, same-sex, models enjoying certain foods. Even infants, as young as 14 months, are sensitive to age cues.[22]

At the other end of the age spectrum, merely getting to be old was a major accomplishment in the societies of our evolutionary past. By the time ancient hunter-gatherers reached 65, and some did, natural selection had already filtered many out of their cohort. This means that not only were the senior members of a community the most experienced, but also that they had emerged from decades of natural selection acting selectively to shrink their age cohort. To see how this works, imagine you have a community with 100 people between the ages of 20 and 30. Of these 100, only 40 people routinely prepare their meat dishes using chili peppers. Suppose that using chili peppers, by virtue of their antimicrobial properties, suppresses food-borne pathogens and thereby reduces a person's chances of getting sick. If eating chili peppers year after year increases a person's chances of living past 65 from 10% to 20%, then a majority of this cohort, 57%, will be chili-pepper eaters by the time they reach 65. If learners preferentially copy the older cohort, instead of the younger cohort, they will have a greater chance of acquiring this

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survival-enhancing cultural trait. This is true even if they have no idea that chili peppers have any health impacts (see chapter 7). Age-biased cultural learning here can thus amplify the action of natural selection, as it creates differential mortality.[23]

Why Care What Others Think? Conformist Transmission

Suppose you are in a foreign city, hungry, and trying to pick one of ten possible restaurants on a busy street. You can't read the menus because you don't know the local language, but you can tell that the prices and atmospheres of each establishment are identical. One place has 40 diners, six have 10 diners, and three are empty, except for the waitstaff. If you would pick the restaurant with 40 people (out of the 100 you've observed) *more than* 40% of the time then you are using conformist transmission—you are strongly inclined to copy the most common trait—the majority or the plurality.

Evolutionary models, which are built to mathematically capture the logic of natural selection, predict that learners ought to use what's called *conformist transmission* to tackle a variety of learning problems. As long as individual learning, intuitions, direct experience, and other cultural learning mechanisms tend to produce adaptive practices, beliefs, and motivations, then conformist transmission can help learners aggregate the information that is distributed across a group. For example, suppose long experience fishing will tend to cause anglers to prefer the blood knot to other potential knots (for connecting monofilament line) because the blood knot is objectively the best. However, individual experiences will vary, so suppose that long experience alone leads to only a 50% chance of an angler converging on the blood knot, a 30% chance of using the fisherman's knot, and a 20% chance of using one of five other knots. A conformist learner can exploit this situation and jump directly to the blood knot without experience. Thus, the wisdom of crowds is built into our psychology.

There is some laboratory evidence for conformist transmission, both in humans and sticklebacks (a fish), though there is not nearly as much as for the model-based cues discussed above. Nevertheless, when problems are difficult, uncertainty is high, or payoffs are on the line, people tend to use conformist transmission.[24]

Of course, we should expect learners to combine the learning heuristics I've described. For example, with regard to chili peppers, learners

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who apply conformist transmission to only the older cohort (sorting with age cues) will increase their chances of adopting this adaptive practice. If they are strong conformist learners, they will get the adaptive answer 100% of the time.

Culturally Transmitted Suicide

You probably know that committing suicide is prestige biased: when celebrities commit suicide there is a spike in suicide rates (celebrities: keep this in mind!). This pattern has been observed in the United States, Germany, Australia, South Korea, and Japan, among other countries. Alongside prestige, the cultural transmission of suicide is also influenced by self-similarity cues. The individuals who kill themselves soon after celebrities tend to match their models on sex, age, and ethnicity. Moreover, it's not just that a celebrity suicide vaguely triggers the suicide of others. We know that people are imitating because they copy not only the act of suicide itself but also the specific methods used, such as throwing oneself in front of a train. Moreover, most celebrity-induced copycat suicides are ***not*** *tragedies that would have occurred anyway*. If that were the case, there would be an eventual dip in suicide rates below the long-run average at some point after the spike, but there is not.[25] These are extra suicides that otherwise would not have occurred.

These effects can also be seen in suicide epidemics. Beginning in 1960, a striking pattern of suicide rippled through the pacific islands of Micronesia for about twenty-five years. As the epidemic spread, the suicides assumed a distinct pattern. The typical victim was a young male between 15 and 24 (modal age of 18) who still lived with his parents. After a disagreement with his parents or girlfriend, the victim experienced a vision in which past victims beckoned for him to come to them (we know this from attempted suicides). In heeding their call, the victim performed a "lean hanging," sometimes in an abandoned house. In a lean hanging, victims lean into the noose from a standing or kneeling position. This gradually depletes the victim's supply of oxygen, resulting in a loss of consciousness and then death. These suicides occurred in localized and sporadic outbreaks among socially interconnected adolescents and young men, a pattern common elsewhere. Sometimes these epidemics could be traced to a particular spark, such as the suicide of a 29-year-old prominent son of a wealthy family. In 75% of the cases, there was no prior hint of suicide or depression. Interestingly, these epidemics were restricted to only two ethnic groups within Micronesia, the Trukese

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and Marshallese.[26] Here we see that prestige and self-similarity, including both sex and ethnicity, shaped the diffusion of suicide.

While most people don't copy suicide, this domain illustrates just how potent our cultural learning abilities can be and how they influence broad social patterns. If people will acquire suicidal behavior via cultural learning, it's not clear what the boundaries are on the power of culture in our species. Copying suicide highlights the potency of our imitative tendencies and means that under the right conditions we can acquire practices via cultural learning that natural selection has directly acted to eliminate under most conditions. If humans will imitate something that is so starkly not in our self-interest, or that of our genes, imagine all the other less costly things we are willing to acquire by cultural transmission.

In addition to using model-based mechanisms for cultural learning, we should also expect natural selection to have equipped us with psychological abilities and biases for learning about certain predictable content domains, such as food, fire, edible plants, animals, tools, social norms, ethnic groups, and reputations (gossip), which have probably been important over long stretches of our species' evolutionary history. Here, natural selection may have favored attention and interest in these domains, as well as inferential biases, leading to ready encoding in memory and greater learnability. In the coming chapters, we'll explore how culture-gene coevolution drove the emergence of some of these specialized cognitive abilities, or *content biases*, and examine key lines of supporting evidence.

What's Mentalizing For?

If humans are a cultural species, then one of our most crucial adaptations is our ability to keenly observe and learn from other people. Central to our cultural learning is our ability to make inferences about the goals, preferences, motivations, intentions, beliefs, and strategies in the minds of others. These cognitive abilities relate to what is variously termed *mentalizing*, or *theory of mind*. Any learners who miss the boat on mentalizing and cultural learning, or get started too late, will be at a serious disadvantage because they won't have acquired all the norms, skills, and know-how necessary to compete with other, better, cultural learners. This logic suggests that the mental machinery we need for cultural learning ought to fire up relatively early in our development. It's this mental machinery that we will rely on to figure out what to eat, how

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improve relative to chimpanzees not reared by humans, they still pale in comparison to human children reared in the identical environments for the same time periods. Such evidence suggests that cultural learning may have initially developed as a response to the enriched environments created by the very earliest accumulations of cultural evolution (see chapter 16).[33] This learned increase in cultural learning would have permitted a greater accumulation of cultural know-how and further driven genetic evolution to make us better cultural learners. Now, the vast differences we observe between apes and human infants raised in the same environments suggests that the emergence of cultural learning is relatively canalized and rapid in our species, though, of course, it can still be modified by experience.[34]

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CHAPTER 5

WHAT ARE BIG BRAINS FOR? OR, HOW CULTURE STOLE OUR GUTS

By selectively attending to certain types of cultural content, like food, sex, and tools, and to particular models based on cues related to prestige, success, and health, individuals can most efficiently equip themselves with the best available cultural know-how. This acquired repertoire can then be honed and augmented by an individual's experience in the world. Crucially, however, these individually adaptive pursuits have an unintended consequence, which we saw when the MBAs were allowed to copy each other—the whole group gradually zeroed in on the optimal investment allocation. As individuals go about their business of learning from others in their group, the overall body of cultural information contained and distributed across the minds in the group can improve and accumulate over generations.

To see more precisely how cumulative cultural evolution works, imagine a small group of forest-dwelling primates. Figure 5.1 represents this group along the top row, labeled Generation 0, with individuals represented by circles. One member of this generation has, on her own, figured out how to use a stick to extract termites from a termite mound (this trait is labeled T). Figuring this out is plausible for our ancestors, since modern chimpanzees do it. In Generation 1 (row 2), two of the offspring from Generation 1 copy the elder termite fisher because they note her success and are generally interested in "things related to food." However, while copying this termite-harvesting technique, one member

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