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The LANGUAGE INSTINCT

How the Mind Creates Language

STEVEN PINKER

The Language Instinct

Steven Pinker

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for
Harry and Roslyn Pinker
who gave me language

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Preface

I have never met a person who is not interested in language. I wrote this book to try to satisfy that curiosity. Language is beginning to submit to that uniquely satisfying kind of understanding that we call science, but the news has been kept a secret.

For the language lover, I hope to show that there is a world of elegance and richness in quotidian speech that far outshines the local curiosities of etymologies, unusual words, and fine points of usage.

For the reader of popular science, I hope to explain what is behind the recent discoveries (or, in many cases, nondiscoveries) reported in the press: universal deep structures, brainy babies, grammar genes, artificially intelligent computers, neural networks, signing chimps, talking Neanderthals, idiot savants, feral children, paradoxical brain damage, identical twins separated at birth, color pictures of the thinking brain, and the search for the mother of all languages. I also hope to answer many natural questions about languages, like why there are so many of them, why they are so hard for adults to learn, and why no one seems to know the plural of *Walkman*.

For students unaware of the science of language and mind, or worse, burdened with memorizing word frequency effects on lexical decision reaction time or the fine points of the Empty Category Principle, I hope to convey the grand intellectual excitement that launched the modern study of language several decades ago.

For my professional colleagues, scattered across so many disciplines and studying so many seemingly unrelated topics, I hope to offer a semblance of an integration of this vast territory. Although I am an opinionated, obsessional researcher who dislikes insipid compromises that fuzz up the issues, many academic controversies remind me of the blind men palpating the elephant. If my personal synthesis seems to embrace both sides of debates like "formalism versus functionalism" or "syntax versus semantics versus pragmatics," perhaps it is because there was never an issue there to begin with.

For the general nonfiction reader, interested in language and human beings in the broadest sense, I hope to offer something different from the airy platitudes—Language Lite—that typify discussions of language (generally by people who have never studied it) in the humanities and sciences alike. For better or worse, I can write in only one way, with a passion for powerful, explanatory ideas, and a torrent of relevant detail. Given this last habit, I am lucky to be explaining a subject whose principles underlie wordplay, poetry, rhetoric, wit, and good writing. I have not hesitated to show off my favorite examples of language in action from pop culture, ordinary children and adults, the more flamboyant academic writers in my field, and some of the finest stylists in English.

This book, then, is intended for everyone who uses language, and that means everyone!

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My home institution, the Massachusetts Institute of Technology, is a special environment for the study of language, and I am grateful to the colleagues, students, and former students who shared their expertise. Noam Chomsky made penetrating criticisms and helpful suggestions, and Ned Block, Paul Bloom, Susan Carey, Ted Gibson, Morris Halle, and Michael Jordan helped me think through the issues in several chapters. Thanks go also to Hilary Bromberg, Jacob Feldman, John Houde, Samuel Jay Keyser, John J. Kim, Gary Marcus, Neal Perlmutter, David Pesetsky, David Pöppel, Annie Senghas, Karin Stromswold, Michael Tarr, Marianne Teuber, Michael Ullman, Kenneth Wexler, and Karen Wynn for erudite answers to questions ranging from sign language to obscure ball players and guitarists. The Department of Brain and Cognitive Sciences' librarian, Pat Claffey, and computer system manager, Stephen G. Wadlow, those most

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My own research on language has been supported by the National Institutes of Health (grant HD 18381) and the National Science Foundation (grant BNS 91-09766), and by the McDonnell-Pew Center for Cognitive Neuroscience at MIT.

Contents

The Language Instinct

1

An Instinct to Acquire an Art

As you are reading these words, you are taking part in one of the wonders of the natural world. For you and I belong to a species with a remarkable ability: we can shape events in each other's brains with exquisite precision. I am not referring to telepathy or mind control or the other obsessions of fringe science; even in the depictions of believers these are blunt instruments compared to an ability that is uncontroversially present in every one of us. That ability is language. Simply by making noises with our mouths, we can reliably cause precise new combinations of ideas to arise in each other's minds. The ability comes so naturally that we are apt to forget what a miracle it is. So let me remind you with some simple demonstrations. Asking you only to surrender your imagination to my words for a few moments, I can cause you to think some very specific thoughts:

> When a male octopus spots a female, his normally grayish body suddenly becomes striped. He swims above the female and begins caressing her with seven of his arms. If she allows this, he will quickly reach toward her and slip his eighth arm into her breathing tube. A series of sperm packets moves slowly through a groove in his arm, finally to slip into the mantle cavity of the female.
>
> Cherries jubilee on a white suit? Wine on an altar cloth? Apply club soda immediately. It works beautifully to remove the stains from fabrics.
>
> When Dixie opens the door to Tad, she is stunned, because she thought he was dead. She slams it in his face and then tries to

> escape. However, when Tad says, "I love you," she lets him in. Tad comforts her, and they become passionate. When Brian interrupts, Dixie tells a stunned Tad that she and Brian were married earlier that day. With much difficulty, Dixie informs Brian that things are nowhere near finished between her and Tad. Then she spills the news that Jamie is Tad's son. "My what?" says a shocked Tad.

Think about what these words have done. I did not simply remind you of octopuses; in the unlikely event that you ever see one develop stripes, you now know what will happen next. Perhaps the next time you are in a supermarket you will look for club soda, one out of the tens of thousands of items available, and then not touch it until months later when a particular substance and a particular object accidentally come together. You now share with millions of other people the secrets of protagonists in a world that is the product of some stranger's imagination, the daytime drama *All My Children*. True, my demonstrations depended on our ability to read and write, and this makes our communication even more impressive by bridging gaps of time, space, and acquaintanceship. But writing is clearly an optional accessory; the real engine of verbal communication is the spoken language we acquired as children.

In any natural history of the human species, language would stand out as the preeminent trait. To be sure, a solitary human is an impressive problem-solver and engineer. But a race of Robinson Crusoes would not give an extraterrestrial observer all that much to remark on. What is truly arresting about our kind is better captured in the story of the Tower of Babel, in which humanity, speaking a single language, came so close to reaching heaven that God himself felt threatened. A common language connects the members of a community into an information-sharing network with formidable collective powers. Anyone can benefit from the strokes of genius, lucky accidents, and trial-and-error wisdom accumulated by anyone else, present or past. And people can work in teams, their efforts coordinated by negotiated agreements. As a result, *Homo sapiens* is a species, like blue-green algae and earthworms, that has wrought far-reaching changes on the planet. Archeologists have discovered the bones of ten thousand wild horses at the bottom of a cliff in France, the remains of herds stampeded over the clifftop by groups of paleolithic hunters seventeen thousand years ago. These fossils of ancient cooperation and shared ingenuity may shed light on why saber-tooth tigers, mastodons, giant woolly rhinoceroses, and dozens of other large mammals went extinct around the time that modern humans arrived in their habitats. Our ancestors, apparently, killed them off.

Language is so tightly woven into human experience that it is scarcely possible to imagine life without it. Chances are that if you find two or more people together anywhere on earth, they will soon be exchanging words. When there is no one to talk with, people talk to themselves, to their dogs, even to their plants. In our social relations, the race is not to the swift but to the verbal—the spellbinding orator, the silver-tongued seducer, the persuasive child who wins the battle of wills against a brawnier parent. Aphasia, the loss of language following brain injury, is devastating, and in severe cases family members may feel that the whole person is lost forever.

This book is about human language. Unlike most books with "language" in the title, it will not chide you about proper usage, trace the origins of idioms and slang, or divert you with palindromes, anagrams, eponyms, or those precious names for groups of animals like "exaltation of larks." For I will be writing not about the English language or any other language, but about something much more basic: the instinct to learn, speak, and understand language. For the first time in history, there is something to write about it. Some thirty-five years ago a new science was born. Now called "cognitive science," it combines tools from psychology, computer science, linguistics, philosophy, and neurobiology to explain the workings of human intelligence. The science of language, in particular, has seen spectacular advances in the years since. There are many phenomena of language that we are coming to understand nearly as well as we understand how a camera works or what the spleen is for. I hope to communicate these exciting discoveries, some of them as elegant as anything in modern science, but I have another agenda as well.

The recent illumination of linguistic abilities has revolutionary implications for our understanding of language and its role in human affairs, and for our view of humanity itself. Most educated people already have opinions about language. They know that it is man's most important cultural invention, the quintessential example of his capacity to use symbols, and a biologically unprecedented event irrevocably separating him from other animals. They know that language pervades thought, with different languages causing their speakers to construe reality in different ways. They know that children learn to talk from role models and caregivers. They know that grammatical sophistication used to be nurtured in the schools, but sagging educational standards and the debasements of popular culture have led to a frightening decline in the ability of the average person to construct a grammatical sentence. They also know that English is a zany, logic-defying tongue, in which one drives on a parkway and parks in a driveway, plays at a recital and recites at a play. They know that English spelling takes such wackiness to even greater heights—George Bernard Shaw complained that *fish* could just as sensibly be spelled *ghoti* (*gh* as in *tough, o* as in *women, ti* as in *nation*)—and that only institutional inertia prevents the adoption of a more rational, spell-it-like-it-sounds system.

In the pages that follow, I will try to convince you that every one of these common opinions is wrong! And they are all wrong for a single reason. Language is not a cultural artifact that we learn the way we learn to tell time or how the federal government works. Instead, it is a distinct piece of the biological makeup of our brains. Language is a complex, specialized skill, which develops in the child spontaneously, without conscious effort or formal instruction, is deployed without awareness of its underlying logic, is qualitatively the same in every individual, and is distinct from more general abilities to process information or behave intelligently. For these reasons some cognitive scientists have described language as a psychological faculty, a mental organ, a neural system, and a computational module. But I prefer the admittedly quaint term "instinct." It conveys the idea that people know how to talk in more or less the sense that spiders know how to spin webs. Web-spinning was not invented by some unsung spider genius and does not depend on having had the right education or on having an aptitude for architecture or the construction trades. Rather, spiders spin spider webs because they have spider brains, which give them the urge to spin and the competence to succeed. Although there are differences between webs and words, I will encourage you to see language in this way, for it helps to make sense of the phenomena we will explore.

Thinking of language as an instinct inverts the popular wisdom, especially as it has been passed down in the canon of the humanities and social sciences. Language is no more a cultural invention than is upright posture. It is not a manifestation of a general capacity to use symbols: a three-year-old, we shall see, is a grammatical genius, but is quite incompetent at the visual arts, religious iconography, traffic signs, and the other staples of the semiotics curriculum. Though language is a magnificent ability unique to *Homo sapiens* among living species, it does not call for sequestering the study of humans from the domain of biology, for a magnificent ability unique to a particular living species is far from unique in the animal kingdom. Some kinds of bats home in on flying insects using Doppler sonar. Some kinds of migratory birds navigate thousands of miles by calibrating the positions of the constellations against the time of day and year. In nature's talent show we are simply a species of primate with our own act, a knack for communicating information about who did what to whom by modulating the sounds we make when we exhale.

Once you begin to look at language not as the ineffable essence of human uniqueness but as a biological adaptation to communicate information, it is no longer as tempting to see language as an insidious shaper of thought, and, we shall see, it is not. Moreover, seeing language as one of nature's engineering marvels—an organ with "that perfection of structure and co-adaptation which justly excites our admiration," in Darwin's words—gives us a new respect for your ordinary Joe and the much-maligned English language (or any language). The complexity of language, from the scientist's point of view, is part of our biological birthright; it is not something that parents teach their children or something that must be elaborated in school—as Oscar Wilde said, "Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught." A preschooler's tacit knowledge of grammar is more sophisticated than the thickest style manual or the most state-of-the-art computer language system, and the same applies to all healthy human beings, even the notorious syntax-fracturing professional athlete and the, you know, like, inarticulate teenage skateboarder. Finally, since language is the product of a well-engineered biological instinct, we shall see that it is not the nutty barrel of monkeys that entertainer-columnists make it out to be. I will try to restore some dignity to the English vernacular, and will even have some nice things to say about its spelling system.

The conception of language as a kind of instinct was first articulated in 1871 by Darwin himself. In *The Descent of Man* he had to contend with language because its confinement to humans seemed to present a challenge to his theory. As in all matters, his observations are uncannily modern:

> As . . . one of the founders of the noble science of philology observes, language is an art, like brewing or baking; but writing would have been a better simile. It certainly is not a true instinct, for every language has to be learned. It differs, however, widely from all ordinary arts, for man has an instinctive tendency to speak, as we see in the babble of our young children; while no child has an instinctive tendency to brew, bake, or write. Moreover, no philologist now supposes that any language has been deliberately invented; it has been slowly and unconsciously developed by many steps.

Darwin concluded that language ability is "an instinctive tendency to acquire an art," a design that is not peculiar to humans but seen in other species such as song-learning birds.

A language instinct may seem jarring to those who think of language as the zenith of the human intellect and who think of instincts as brute impulses that compel furry or feathered zombies to build a dam or up and fly south. But one of Darwin's followers, William James, noted that an instinct possessor need not act as a "fatal automaton." He argued that we have all the instincts that animals do, and many more besides; our flexible intelligence comes from the interplay of many instincts competing. Indeed, the instinctive nature of human thought is just what makes it so hard for us to see that it is an instinct:

> It takes . . . a mind debauched by learning to carry the process of making the natural seem strange, so far as to ask for the *why* of any instinctive human act. To the metaphysician alone can such questions occur as: Why do we smile, when pleased, and not scowl? Why are we unable to talk to a crowd as we talk to a single friend? Why does a particular maiden turn our wits so upside-down? The common man can only say, "*Of course* we smile, *of course* our heart palpitates at the sight of the crowd, *of course* we love the maiden, that beautiful soul clad in that perfect form, so palpably and flagrantly made for all eternity to be loved!"
>
> And so, probably, does each animal feel about the particular things it tends to do in presence of particular objects. . . . To the lion it is the lioness which is made to be loved; to the bear, the she-

> bear. To the broody hen the notion would probably seem monstrous that there should be a creature in the world to whom a nestful of eggs was not the utterly fascinating and precious and never-to-be-too-much-sat-upon object which it is to her.
>
> Thus we may be sure that, however mysterious some animals' instincts may appear to us, our instincts will appear no less mysterious to them. And we may conclude that, to the animal which obeys it, every impulse and every step of every instinct shines with its own sufficient light, and seems at the moment the only eternally right and proper thing to do. What voluptuous thrill may not shake a fly, when she at last discovers the one particular leaf, or carrion, or bit of dung, that out of all the world can stimulate her ovipositor to its discharge? Does not the discharge then seem to her the only fitting thing? And need she care or know anything about the future maggot and its food?

I can think of no better statement of my main goal. The workings of language are as far from our awareness as the rationale for egg-laying is from the fly's. Our thoughts come out of our mouths so effortlessly that they often embarrass us, having eluded our mental censors. When we are comprehending sentences, the stream of words is transparent; we see through to the meaning so automatically that we can forget that a movie is in a foreign language and subtitled. We think children pick up their mother tongue by imitating their mothers, but when a child says *Don't giggle me!* or *We holded the baby rabbits*, it cannot be an act of imitation. I want to debauch your mind with learning, to make these natural gifts seem strange, to get you to ask the "why" and "how" of these seemingly homely abilities. Watch an immigrant struggling with a second language or a stroke patient with a first one, or deconstruct a snatch of baby talk, or try to program a computer to understand English, and ordinary speech begins to look different. The effortlessness, the transparency, the automaticity are illusions, masking a system of great richness and beauty.

In this century, the most famous argument that language is like an instinct comes from Noam Chomsky, the linguist who first unmasked the intricacy of the system and perhaps the person most responsible for the modern revolution in language and cognitive science. In the 1950s the social sciences were dominated by behaviorism, the school of thought popularized by John Watson and B. F. Skinner. Mental terms like "know" and "think" were branded as unscientific; "mind" and "innate" were dirty words. Behavior was explained by a few laws of stimulus-response learning that could be studied with rats pressing bars and dogs salivating to tones. But Chomsky called attention to two fundamental facts about language. First, virtually every sentence that a person utters or understands is a brand-new combination of words, appearing for the first time in the history of the universe. Therefore a language cannot be a repertoire of responses; the brain must contain a recipe or program that can build an unlimited set of sentences out of a finite list of words. That program may be called a mental grammar (not to be confused with pedagogical or stylistic "grammars," which are just guides to the etiquette of written prose). The second fundamental fact is that children develop these complex grammars rapidly and without formal instruction and grow up to give consistent interpretations to novel sentence constructions that they have never before encountered. Therefore, he argued, children must innately be equipped with a plan common to the grammars of all languages, a Universal Grammar, that tells them how to distill the syntactic patterns out of the speech of their parents. Chomsky put it as follows:

> It is a curious fact about the intellectual history of the past few centuries that physical and mental development have been approached in quite different ways. No one would take seriously the proposal that the human organism learns through experience to have arms rather than wings, or that the basic structure of particular organs results from accidental experience. Rather, it is taken for granted that the physical structure of the organism is genetically determined, though of course variation along such dimensions as size, rate of development, and so forth will depend in part on external factors. . . .
>
> The development of personality, behavior patterns, and cognitive structures in higher organisms has often been approached in a very different way. It is generally assumed that in these domains, social environment is the dominant factor. The structures of mind that develop over time are taken to be arbitrary and accidental; there is no "human nature" apart from what develops as a specific historical product. . . .
>
> But human cognitive systems, when seriously investigated, prove

> to be no less marvelous and intricate than the physical structures that develop in the life of the organism. Why, then, should we not study the acquisition of a cognitive structure such as language more or less as we study some complex bodily organ?
>
> At first glance, the proposal may seem absurd, if only because of the great variety of human languages. But a closer consideration dispels these doubts. Even knowing very little of substance about linguistic universals, we can be quite sure that the possible variety of language is sharply limited. . . . The language each person acquires is a rich and complex construction hopelessly underdetermined by the fragmentary evidence available [to the child]. Nevertheless individuals in a speech community have developed essentially the same language. This fact can be explained only on the assumption that these individuals employ highly restrictive principles that guide the construction of grammar.

By performing painstaking technical analyses of the sentences ordinary people accept as part of their mother tongue, Chomsky and other linguists developed theories of the mental grammars underlying people's knowledge of particular languages and of the Universal Grammar underlying the particular grammars. Early on, Chomsky's work encouraged other scientists, among them Eric Lenneberg, George Miller, Roger Brown, Morris Halle, and Alvin Liberman, to open up whole new areas of language study, from child development and speech perception to neurology and genetics. By now, the community of scientists studying the questions he raised numbers in the thousands. Chomsky is currently among the ten most-cited writers in all of the humanities (beating out Hegel and Cicero and trailing only Marx, Lenin, Shakespeare, the Bible, Aristotle, Plato, and Freud) and the only living member of the top ten.

What those citations *say* is another matter. Chomsky gets people exercised. Reactions range from the awe-struck deference ordinarily reserved for gurus of weird religious cults to the withering invective that academics have developed into a high art. In part this is because Chomsky attacks what is still one of the foundations of twentieth-century intellectual life—the "Standard Social Science Model," according to which the human psyche is molded by the surrounding culture. But it is also because no thinker can afford to ignore him. As one of his severest critics, the philosopher Hilary Putnam, acknowledges,

> When one reads Chomsky, one is struck by a sense of great intellectual power; one knows one is encountering an extraordinary mind. And this is as much a matter of the spell of his powerful personality as it is of his obvious intellectual virtues: originality, scorn for the faddish and the superficial; willingness to revive (and the ability to revive) positions (such as the "doctrine of innate ideas") that had seemed passé; concern with topics, such as the structure of the human mind, that are of central and perennial importance.

The story I will tell in this book has, of course, been deeply influenced by Chomsky. But it is not his story exactly, and I will not tell it as he would. Chomsky has puzzled many readers with his skepticism about whether Darwinian natural selection (as opposed to other evolutionary processes) can explain the origins of the language organ that he argues for; I think it is fruitful to consider language as an evolutionary adaptation, like the eye, its major parts designed to carry out important functions. And Chomsky's arguments about the nature of the language faculty are based on technical analyses of word and sentence structure, often couched in abstruse formalisms. His discussions of flesh-and-blood speakers are perfunctory and highly idealized. Though I happen to agree with many of his arguments, I think that a conclusion about the mind is convincing only if many kinds of evidence converge on it. So the story in this book is highly eclectic, ranging from how DNA builds brains to the pontifications of newspaper language columnists. The best place to begin is to ask why anyone should believe that human language is a part of human biology—an instinct—at all.

2

Chatterboxes

By the 1920s it was thought that no corner of the earth fit for human habitation had remained unexplored. New Guinea, the world's second largest island, was no exception. The European missionaries, planters, and administrators clung to its coastal lowlands, convinced that no one could live in the treacherous mountain range that ran in a solid line down the middle of the island. But the mountains visible from each coast in fact belonged to two ranges, not one, and between them was a temperate plateau crossed by many fertile valleys. A million Stone Age people lived in those highlands, isolated from the rest of the world for forty thousand years. The veil would not be lifted until gold was discovered in a tributary of one of the main rivers. The ensuing gold rush attracted Michael Leahy, a footloose Australian prospector, who on May 26, 1930, set out to explore the mountains with a fellow prospector and a group of indigenous lowland people hired as carriers. After scaling the heights, Leahy was amazed to see grassy open country on the other side. By nightfall his amazement turned to alarm, because there were points of light in the distance, obvious signs that the valley was populated. After a sleepless night in which Leahy and his party loaded their weapons and assembled a crude bomb, they made their first contact with the highlanders. The astonishment was mutual. Leahy wrote in his diary:

> It was a relief when the [natives] came in sight, the men . . . in front, armed with bows and arrows, the women behind bringing stalks of sugarcane. When he saw the women, Ewunga told me at once that

> there would be no fight. We waved to them to come on, which they did cautiously, stopping every few yards to look us over. When a few of them finally got up courage to approach, we could see that they were utterly thunderstruck by our appearance. When I took off my hat, those nearest to me backed away in terror. One old chap came forward gingerly with open mouth, and touched me to see if I was real. Then he knelt down, and rubbed his hands over my bare legs, possibly to find if they were painted, and grabbed me around the knees and hugged them, rubbing his bushy head against me. . . . The women and children gradually got up courage to approach also, and presently the camp was swarming with the lot of them, all running about and jabbering at once, pointing to . . . everything that was new to them.

That "jabbering" was language—an unfamiliar language, one of eight hundred different ones that would be discovered among the isolated highlanders right up through the 1960s. Leahy's first contact repeated a scene that must have taken place hundreds of times in human history, whenever one people first encountered another. All of them, as far as we know, already had language. Every Hottentot, every Eskimo, every Yanomamö. No mute tribe has ever been discovered, and there is no record that a region has served as a "cradle" of language from which it spread to previously languageless groups.

As in every other case, the language spoken by Leahy's hosts turned out to be no mere jabber but a medium that could express abstract concepts, invisible entities, and complex trains of reasoning. The highlanders conferred intensively, trying to agree upon the nature of the pallid apparitions. The leading conjecture was that they were reincarnated ancestors or other spirits in human form, perhaps ones that turned back into skeletons at night. They agreed upon an empirical test that would settle the matter. "One of the people hid," recalls the highlander Kirupano Eza'e, "and watched them going to excrete. He came back and said, 'Those men from heaven went to excrete over there.' Once they had left many men went to take a look. When they saw that it smelt bad, they said, 'Their skin might be different, but their shit smells bad like ours.' "

The universality of complex language is a discovery that fills linguists with awe, and is the first reason to suspect that language is not just any cultural invention but the product of a special human instinct.

Cultural inventions vary widely in their sophistication from society to society; within a society, the inventions are generally at the same level of sophistication. Some groups count by carving notches on bones and cook on fires ignited by spinning sticks in logs; others use computers and microwave ovens. Language, however, ruins this correlation. There are Stone Age societies, but there is no such thing as a Stone Age language. Earlier in this century the anthropological linguist Edward Sapir wrote, "When it comes to linguistic form, Plato walks with the Macedonian swineherd, Confucius with the head-hunting savage of Assam."

To pick an example at random of a sophisticated linguistic form in a nonindustrialized people, the linguist Joan Bresnan recently wrote a technical article comparing a construction in Kivunjo, a Bantu language spoken in several villages on the slopes of Mount Kilimanjaro in Tanzania, with its counterpart construction in English, which she describes as "a West Germanic language spoken in England and its former colonies." The English construction is called the dative* and is found in sentences like *She baked me a brownie* and *He promised her Arpège*, where an indirect object like *me* or *her* is placed after the verb to indicate the beneficiary of an act. The corresponding Kivunjo construction is called the applicative, whose resemblance to the English dative, Bresnan notes, "can be likened to that of the game of chess to checkers." The Kivunjo construction fits entirely inside the verb, which has seven prefixes and suffixes, two moods, and fourteen tenses; the verb agrees with its subject, its object, and its benefactive nouns, each of which comes in sixteen genders. (In case you are wondering, these "genders" do not pertain to things like cross-dressers, transsexuals, hermaphrodites, androgynous people, and so on, as one reader of this chapter surmised. To a linguist, the term *gender* retains its original meaning of "kind," as in the related words *generic, genus*, and *genre*. The Bantu "genders" refer to kinds like humans, animals, extended objects, clusters of objects, and body parts. It just happens that in many European languages the genders correspond to the sexes, at least in pronouns. For this reason the linguistic term *gender* has been pressed into service by nonlinguists

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*All the technical terms from linguistics, biology, and cognitive science that I use in this book are defined in the Glossary on pages 473–483.

as a convenient label for sexual dimorphism; the more accurate term *sex* seems now to be reserved as the polite way to refer to copulation.) Among the other clever gadgets I have glimpsed in the grammars of so-called primitive groups, the complex Cherokee pronoun system seems especially handy. It distinguishes among "you and I," "another person and I," "several other people and I," and "you, one or more other persons, and I," which English crudely collapses into the all-purpose pronoun *we*.

Actually, the people whose linguistic abilities are most badly underestimated are right here in our society. Linguists repeatedly run up against the myth that working-class people and the less educated members of the middle class speak a simpler or coarser language. This is a pernicious illusion arising from the effortlessness of conversation. Ordinary speech, like color vision or walking, is a paradigm of engineering excellence—a technology that works so well that the user takes its outcome for granted, unaware of the complicated machinery hidden behind the panels. Behind such "simple" sentences as *Where did he go?* and or *The guy I met killed himself*, used automatically by any English speaker, are dozens of subroutines that arrange the words to express the meaning. Despite decades of effort, no artificially engineered language system comes close to duplicating the person in the street, HAL and C3PO notwithstanding.

But though the language engine is invisible to the human user, the trim packages and color schemes are attended to obsessively. Trifling differences between the dialect of the mainstream and the dialect of other groups, like *isn't any* versus *ain't no, those books* versus *them books*, and *dragged him away* versus *drug him away*, are dignified as badges of "proper grammar." But they have no more to do with grammatical sophistication than the fact that people in some regions of the United States refer to a certain insect as a *dragonfly* and people in other regions refer to it as a *darning needle*, or that English speakers call canines *dogs* whereas French speakers call them *chiens*. It is even a bit misleading to call Standard English a "language" and these variations "dialects," as if there were some meaningful difference between them. The best definition comes from the linguist Max Weinreich: a language is a dialect with an army and a navy.

The myth that nonstandard dialects of English are grammatically deficient is widespread. In the 1960s some well-meaning educational psychologists announced that American black children had been so culturally deprived that they lacked true language and were confined instead to a "non-logical mode of expressive behavior." The conclusions were based on the students' shy or sullen reactions to batteries of standardized tests. If the psychologists had listened to spontaneous conversations, they would have rediscovered the commonplace fact that American black culture is everywhere highly verbal; the subculture of street youths in particular is famous in the annals of anthropology for the value placed on linguistic virtuosity. Here is an example, from an interview conducted by the linguist William Labov on a stoop in Harlem. The interviewee is Larry, the roughest member of a teenage gang called the Jets. (Labov observes in his scholarly article that "for most readers of this paper, first contact with Larry would produce some fairly negative reactions on both sides.")

> You know, like some people say if you're good an' shit, your spirit goin' t'heaven . . . 'n' if you bad, your spirit goin' to hell. Well, bullshit! Your spirit goin' to hell anyway, good or bad.
>
> [Why?]
>
> Why? I'll tell you why. 'Cause, you see, doesn' nobody really know that it's a God, y'know, 'cause I mean I have seen black gods, white gods, all color gods, and don't nobody know it's really a God. An' when they be sayin' if you good, you goin' t'heaven, tha's bullshit, 'cause you ain't goin' to no heaven, 'cause it ain't no heaven for you to go to.
>
> [. . . jus' suppose that there is a God, would he be white or black?]
>
> He'd be white, man.
>
> [Why?]
>
> Why? I'll tell you why. 'Cause the average whitey out here got everything, you dig? And the nigger ain't got shit, y'know? Y'understan'? So—um—for—in order for *that* to happen, you know it ain't no black God that's doin' that bullshit.

First contact with Larry's grammar may produce negative reactions as well, but to a linguist it punctiliously conforms to the rules of the dialect called Black English Vernacular (BEV). The most linguistically interesting thing about the dialect is how linguistically uninteresting it is: if Labov did not have to call attention to it to debunk the claim that ghetto children lack true linguistic competence, it would have been filed away as just another language. Where Standard American English (SAE) uses *there* as a meaningless dummy subject for the copula, BEV uses *it* as a meaningless dummy subject for the copula (compare SAE's *There's really a God* with Larry's *It's really a God*). Larry's negative concord (*You ain't goin' to no heaven*) is seen in many languages, such as French (*ne . . . pas*). Like speakers of SAE, Larry inverts subjects and auxiliaries in nondeclarative sentences, but the exact set of the sentence types allowing inversion differs slightly. Larry and other BEV speakers invert subjects and auxiliaries in negative main clauses like *Don't nobody know*; SAE speakers invert them only in questions like *Doesn't anybody know*? and a few other sentence types. BEV allows its speakers the option of deleting copulas (*If you bad*); this is not random laziness but a systematic rule that is virtually identical to the contraction rule in SAE that reduces *He is* to *He's, You are* to *You're*, and *I am* to *I'm*. In both dialects, *be* can erode only in certain kinds of sentences. No SAE speaker would try the following contractions:

> Yes he is! → Yes he's!
> I don't care what you are. → I don't care what you're.
> Who is it? → Who's it?

For the same reasons, no BEV speaker would try the following deletions:

> Yes he is! → Yes he!
> I don't care what you are. → I don't care what you.
> Who is it? → Who it?

Note, too, that BEV speakers are not just more prone to eroding words. BEV speakers use the full forms of certain auxiliaries (*I have seen*), whereas SAE speakers usually contract them (*I've seen*). And as we would expect from comparisons between languages, there are areas in which BEV is more precise than standard English. *He be working* means that he generally works, perhaps that he has a regular job; *He working* means only that he is working at the moment that the sentence is uttered. In SAE, *He is working* fails to make that distinction. Moreover, sentences like *In order for that to happen, you* *know it ain't no black God that's doin' that bullshit* show that Larry's speech uses the full inventory of grammatical paraphernalia that computer scientists struggle unsuccessfully to duplicate (relative clauses, complement structures, clause subordination, and so on), not to mention some fairly sophisticated theological argumentation.

Another project of Labov's involved tabulating the percentage of grammatical sentences in tape recordings of speech in a variety of social classes and social settings. "Grammatical," for these purposes, means "well-formed according to consistent rules in the dialect of the speakers." For example, if a speaker asked the question *Where are you going?*, the respondent would not be penalized for answering *To the store*, even though it is in some sense not a complete sentence. Such ellipses are obviously part of the grammar of conversational English; the alternative, *I am going to the store*, sounds stilted and is almost never used. "Ungrammatical" sentences, by this definition, include randomly broken-off sentence fragments, tongue-tied hemming and hawing, slips of the tongue, and other forms of word salad. The results of Labov's tabulation are enlightening. The great majority of sentences were grammatical, especially in casual speech, with higher percentages of grammatical sentences in working-class speech than in middle-class speech. The highest percentage of ungrammatical sentences was found in the proceedings of learned academic conferences.

The ubiquity of complex language among human beings is a gripping discovery and, for many observers, compelling proof that language is innate. But to tough-minded skeptics like the philosopher Hilary Putnam, it is no proof at all. Not everything that is universal is innate. Just as travelers in previous decades never encountered a tribe without a language, nowadays anthropologists have trouble finding a people beyond the reach of VCR's, Coca-Cola, and Bart Simpson T-shirts. Language was universal before Coca-Cola was, but then, language is more useful than Coca-Cola. It is more like eating with one's hands rather than one's feet, which is also universal, but we need not invoke a special hand-to-mouth instinct to explain why. Language is invaluable for all the activities of daily living in a community of people: preparing food and shelter, loving, arguing, negotiating, teaching. Necessity being the mother of invention, language could have been invented by resourceful people a number of times long ago. (Perhaps, as Lily Tomlin said, man invented language to satisfy his deep need to complain.) Universal grammar would simply reflect the universal exigencies of human experience and the universal limitations on human information processing. All languages have words for "water" and "foot" because all people need to refer to water and feet; no language has a word a million syllables long because no person would have time to say it. Once invented, language would entrench itself within a culture as parents taught their children and children imitated their parents. From cultures that had language, it would spread like wildfire to other, quieter cultures. At the heart of this process is wondrously flexible human intelligence, with its general multipurpose learning strategies.

So the universality of language does not lead to an innate language instinct as night follows day. To convince you that there is a language instinct, I will have to fill in an argument that leads from the jabbering of modern peoples to the putative genes for grammar. The crucial intervening steps come from my own professional specialty, the study of language development in children. The crux of the argument is that complex language is universal because *children actually reinvent it*, generation after generation—not because they are taught, not because they are generally smart, not because it is useful to them, but because they just can't help it. Let me now take you down this trail of evidence.

The trail begins with the study of how the particular languages we find in the world today arose. Here, one would think, linguistics runs into the problem of any historical science: no one recorded the crucial events at the time they happened. Although historical linguists can trace modern complex languages back to earlier ones, this just pushes the problem back a step; we need to see how people create a complex language from scratch. Amazingly, we can.

The first cases were wrung from two of the more sorrowful episodes of world history, the Atlantic slave trade and indentured servitude in the South Pacific. Perhaps mindful of the Tower of Babel, some of the masters of tobacco, cotton, coffee, and sugar plantations deliberately mixed slaves and laborers from different language backgrounds; others preferred specific ethnicities but had to accept mixtures because that was all that was available. When speakers of different languages have to communicate to carry out practical tasks but do not have the opportunity to learn one another's languages, they develop a makeshift jargon called a pidgin. Pidgins are choppy strings of words borrowed from the language of the colonizers or plantation owners, highly variable in order and with little in the way of grammar. Sometimes a pidgin can become a lingua franca and gradually increase in complexity over decades, as in the "Pidgin English" of the modern South Pacific. (Prince Philip was delighted to learn on a visit to New Guinea that he is referred to in that language as *fella belong Mrs. Queen*.)

But the linguist Derek Bickerton has presented evidence that in many cases a pidgin can be transmuted into a full complex language in one fell swoop: all it takes is for a group of children to be exposed to the pidgin at the age when they acquire their mother tongue. That happened, Bickerton has argued, when children were isolated from their parents and were tended collectively by a worker who spoke to them in the pidgin. Not content to reproduce the fragmentary word strings, the children injected grammatical complexity where none existed before, resulting in a brand-new, richly expressive language. The language that results when children make a pidgin their native tongue is called a creole.

Bickerton's main evidence comes from a unique historical circumstance. Though the slave plantations that spawned most creoles are, fortunately, a thing of the remote past, one episode of creolization occurred recently enough for us to study its principal players. Just before the turn of the century there was a boom in Hawaiian sugar plantations, whose demands for labor quickly outstripped the native pool. Workers were brought in from China, Japan, Korea, Portugal, the Philippines, and Puerto Rico, and a pidgin quickly developed. Many of the immigrant laborers who first developed that pidgin were alive when Bickerton interviewed them in the 1970s. Here are some typical examples of their speech:

> Me capé buy, me check make.
> Building—high place—wall pat—time—nowtime—an' den —a new tempecha eri time show you.
> Good, dis one. Kaukau any-kin' dis one. Pilipine islan' no good. No mo money.

From the individual words and the context, it was possible for the listener to infer that the first speaker, a ninety-two-year-old Japanese immigrant talking about his earlier days as a coffee farmer, was trying to say "He bought my coffee; he made me out a check." But the utterance itself could just as easily have meant "I bought coffee; I made him out a check," which would have been appropriate if he had been referring to his current situation as a store owner. The second speaker, another elderly Japanese immigrant, had been introduced to the wonders of civilization in Los Angeles by one of his many children, and was saying that there was an electric sign high up on the wall of the building which displayed the time and temperature. The third speaker, a sixty-nine-year-old Filipino, was saying "It's better here than in the Philippines; here you can get all kinds of food, but over there there isn't any money to buy food with." (One of the kinds of food was "pfrawg," which he caught for himself in the marshes by the method of "kank da head.") In all these cases, the speaker's intentions had to be filled in by the listener. The pidgin did not offer the speakers the ordinary grammatical resources to convey these messages—no consistent word order, no prefixes or suffixes, no tense or other temporal and logical markers, no structure more complex than a simple clause, and no consistent way to indicate who did what to whom.

But the children who had grown up in Hawaii beginning in the 1890s and were exposed to the pidgin ended up speaking quite differently. Here are some sentences from the language they invented, Hawaiian Creole. The first two are from a Japanese papaya grower born in Maui; the next two, from a Japanese/Hawaiian ex-plantation laborer born on the big island; the last, from a Hawaiian motel manager, formerly a farmer, born in Kauai:

> Da firs japani came ran away from japan come.
> "The first Japanese who arrived ran away from Japan to here."
>
> Some filipino wok o'he-ah dey wen' couple ye-ahs in filipin islan'.
> "Some Filipinos who worked over here went back to the Philippines for a couple of years."
>
> People no like t'come fo' go wok.
> "People don't want to have him go to work [for them]."

One time when we go home inna night dis ting stay fly up.
"Once when we went home at night this thing was flying about."

One day had pleny of dis mountain fish come down.
"One day there were a lot of these fish from the mountains that came down [the river]."

Do not be misled by what look like crudely placed English verbs, such as *go, stay*, and *came*, or phrases like *one time*. They are not haphazard uses of English words but systematic uses of Hawaiian Creole grammar: the words have been converted by the creole speakers into auxiliaries, prepositions, case markers, and relative pronouns. In fact, this is probably how many of the grammatical prefixes and suffixes in established languages arose. For example, the English past-tense ending *-ed* may have evolved from the verb *do: He hammered* was originally something like *He hammer-did*. Indeed, creoles *are* bona fide languages, with standardized word orders and grammatical markers that were lacking in the pidgin of the immigrants and, aside from the sounds of words, not taken from the language of the colonizers.

Bickerton notes that if the grammar of a creole is largely the product of the minds of children, unadulterated by complex language input from their parents, it should provide a particularly clear window on the innate grammatical machinery of the brain. He argues that creoles from unrelated language mixtures exhibit uncanny resemblances—perhaps even the same basic grammar. This basic grammar also shows up, he suggests, in the errors children make when acquiring more established and embellished languages, like some underlying design bleeding through a veneer of whitewash. When English-speaking children say

Why he is leaving?
Nobody don't likes me.
I'm gonna full Angela's bucket.
Let Daddy hold it hit it,

they are unwittingly producing sentences that are grammatical in many of the world's creoles.

Bickerton's particular claims are controversial, depending as they do on his reconstruction of events that occurred decades or centuries in the past. But his basic idea has been stunningly corroborated by two recent natural experiments in which creolization by children can be observed in real time. These fascinating discoveries are among many that have come from the study of the sign languages of the deaf. Contrary to popular misconceptions, sign languages are not pantomimes and gestures, inventions of educators, or ciphers of the spoken language of the surrounding community. They are found wherever there is a community of deaf people, and each one is a distinct, full language, using the same kinds of grammatical machinery found worldwide in spoken languages. For example, American Sign Language, used by the deaf community in the United States, does not resemble English, or British Sign Language, but relies on agreement and gender systems in a way that is reminiscent of Navajo and Bantu.

Until recently there were no sign languages at all in Nicaragua, because its deaf people remained isolated from one another. When the Sandinista government took over in 1979 and reformed the educational system, the first schools for the deaf were created. The schools focused on drilling the children in lip reading and speech, and as in every case where that is tried, the results were dismal. But it did not matter. On the playgrounds and schoolbuses the children were inventing their own sign system, pooling the makeshift gestures that they used with their families at home. Before long the system congealed into what is now called the Lenguaje de Signos Nicaragüense (LSN). Today LSN is used, with varying degrees of fluency, by young deaf adults, aged seventeen to twenty-five, who developed it when they were ten or older. Basically, it is a pidgin. Everyone uses it differently, and the signers depend on suggestive, elaborate circumlocutions rather than on a consistent grammar.

But children like Mayela, who joined the school around the age of four, when LSN was already around, and all the pupils younger than her, are quite different. Their signing is more fluid and compact, and the gestures are more stylized and less like a pantomime. In fact, when their signing is examined close up, it is so different from LSN that it is referred to by a different name, Idioma de Signos Nicaragüense (ISN). LSN and ISN are currently being studied by the psycholinguists Judy Kegl, Miriam Hebe Lopez, and Annie Senghas. ISN appears to be a creole, created in one leap when the younger children were exposed to the pidgin signing of the older children—just as Bickerton would have predicted. ISN has spontaneously standardized itself; all the young children sign it in the same way. The children have introduced many grammatical devices that were absent in LSN, and hence they rely far less on circumlocutions. For example, an LSN (pidgin) signer might make the sign for "talk to" and then point from the position of the talker to the position of the hearer. But an ISN (creole) signer modifies the sign itself, sweeping it in one motion from a point representing the talker to a point representing the hearer. This is a common device in sign languages, formally identical to inflecting a verb for agreement in spoken languages. Thanks to such consistent grammar, ISN is very expressive. A child can watch a surrealistic cartoon and describe its plot to another child. The children use it in jokes, poems, narratives, and life histories, and it is coming to serve as the glue that holds the community together. A language has been born before our eyes.

But ISN was the collective product of many children communicating with one another. If we are to attribute the richness of language to the mind of the child, we really want to see a single child adding some increment of grammatical complexity to the input the child has received. Once again the study of the deaf grants our wish.

When deaf infants are raised by signing parents, they learn sign language in the same way that hearing infants learn spoken language. But deaf children who are not born to deaf parents—the majority of deaf children—often have no access to sign language users as they grow up, and indeed are sometimes deliberately kept from them by educators in the "oralist" tradition who want to force them to master lip reading and speech. (Most deaf people deplore these authoritarian measures.) When deaf children become adults, they tend to seek out deaf communities and begin to acquire the sign language that takes proper advantage of the communicative media available to them. But by then it is usually too late; they must then struggle with sign language as a difficult intellectual puzzle, much as a hearing adult does in foreign language classes. Their proficiency is notably below that of deaf people who acquired sign language as infants, just as adult immigrants are often permanently burdened with accents and conspicuous grammatical errors. Indeed, because the deaf are virtually the only neurologically normal people who make it to adulthood without having acquired a language, their difficulties offer particularly good evidence that successful language acquisition must take place during a critical window of opportunity in childhood.

The psycholinguists Jenny Singleton and Elissa Newport have studied a nine-year-old profoundly deaf boy, to whom they gave the pseudonym Simon, and his parents, who are also deaf. Simon's parents did not acquire sign language until the late ages of fifteen and sixteen, and as a result they acquired it badly. In ASL, as in many languages, one can move a phrase to the front of a sentence and mark it with a prefix or suffix (in ASL, raised eyebrows and a lifted chin) to indicate that it is the topic of the sentence. The English sentence *Elvis I really like* is a rough equivalent. But Simon's parents rarely used this construction and mangled it when they did. For example, Simon's father once tried to sign the thought *My friend, he thought my second child was deaf.* It came out as *My friend thought, my second child, he thought he was deaf*—a bit of sign salad that violates not only ASL grammar but, according to Chomsky's theory, the Universal Grammar that governs all naturally acquired human languages (later in this chapter we will see why). Simon's parents had also failed to grasp the verb inflection system of ASL. In ASL, the verb *to blow* is signed by opening a fist held horizontally in front of the mouth (like a puff of air). Any verb in ASL can be modified to indicate that the action is being done continuously: the signer superimposes an arclike motion on the sign and repeats it quickly. A verb can also be modified to indicate that the action is being done to more than one object (for example, several candles): the signer terminates the sign in one location in space, then repeats it but terminates it at another location. These inflections can be combined in either of two orders: *blow* toward the left and then toward the right and repeat, or *blow* toward the left twice and then *blow* toward the right twice. The first order means "to blow out the candles on one cake, then another cake, then the first cake again, then the second cake again"; the second means "to blow out the candles on one cake continuously, and then blow out the candles on another cake continuously." This elegant set of rules was lost on Simon's parents. They used the inflections inconsistently and never combined them onto a verb two at a time, though they would occasionally use the inflections separately, crudely linked with signs like *then*. In many ways Simon's parents were like pidgin speakers.

Astoundingly, though Simon saw no ASL but his parents' defective version, his own signing was far better ASL than theirs. He understood sentences with moved topic phrases without difficulty, and when he had to describe complex videotaped events, he used the ASL verb inflections almost perfectly, even in sentences requiring two of them in particular orders. Simon must somehow have shut out his parents' ungrammatical "noise." He must have latched on to the inflections that his parents used inconsistently, and reinterpreted them as mandatory. And he must have seen the logic that was implicit, though never realized, in his parents' use of two kinds of verb inflection, and reinvented the ASL system of superimposing both of them onto a single verb in a specific order. Simon's superiority to his parents is an example of creolization by a single living child.

Actually, Simon's achievements are remarkable only because he is the first one who showed them to a psycholinguist. There must be thousands of Simons: ninety to ninety-five percent of deaf children are born to hearing parents. Children fortunate enough to be exposed to ASL at all often get it from hearing parents who themselves learned it, incompletely, to communicate with their children. Indeed, as the transition from LSN to ISN shows, sign languages themselves are surely products of creolization. Educators at various points in history have tried to invent sign systems, sometimes based on the surrounding spoken language. But these crude codes are always unlearnable, and when deaf children learn from them at all, they do so by converting them into much richer natural languages.

Extraordinary acts of creation by children do not require the extraordinary circumstances of deafness or plantation Babels. The same kind of linguistic genius is involved every time a child learns his or her mother tongue.

First, let us do away with the folklore that parents teach their children language. No one supposes that parents provide explicit grammar lessons, of course, but many parents (and some child psychologists who should know better) think that mothers provide children with implicit lessons. These lessons take the form of a special speech variety called Motherese (or, as the French call it, Mamanaise): intensive sessions of conversational give-and-take, with repetitive drills and simplified grammar. ("Look at the *doggie*! See the *doggie*? There's a *doggie*!") In contemporary middle-class American culture, parenting is seen as an awesome responsibility, an unforgiving vigil to keep the helpless infant from falling behind in the great race of life. The belief that Motherese is essential to language development is part of the same mentality that sends yuppies to "learning centers" to buy little mittens with bull's-eyes to help their babies find their hands sooner.

One gets some perspective by examining the folk theories about parenting in other cultures. The !Kung San of the Kalahari Desert in southern Africa believe that children must be drilled to sit, stand, and walk. They carefully pile sand around their infants to prop them upright, and sure enough, every one of these infants soon sits up on its own. We find this amusing because we have observed the results of the experiment that the San are unwilling to chance: we don't teach our children to sit, stand, and walk, and they do it anyway, on their own schedule. But other groups enjoy the same condescension toward us. In many communities of the world, parents do not indulge their children in Motherese. In fact, they do not speak to their prelinguistic children at all, except for occasional demands and rebukes. This is not unreasonable. After all, young children plainly can't understand a word you say. So why waste your breath in soliloquies? Any sensible person would surely wait until a child has developed speech and more gratifying two-way conversations become possible. As Aunt Mae, a woman living in the South Carolina Piedmont, explained to the anthropologist Shirley Brice Heath: "Now just how crazy is dat? White folks uh hear dey kids say sump'n, dey say it back to 'em, dey aks 'em 'gain and 'gain 'bout things, like they 'posed to be born knowin'." Needless to say, the children in these communities, overhearing adults and other children, learn to talk, as we see in Aunt Mae's fully grammatical BEV.

Children deserve most of the credit for the language they acquire. In fact, we can show that they know things they could not have been taught. One of Chomsky's classic illustrations of the logic of language involves the process of moving words around to form questions. Consider how you might turn the declarative sentence *A unicorn is in the garden* into the corresponding question, *Is a unicorn in the garden?* You could scan the declarative sentence, take the auxiliary *is*, and move it to the front of the sentence:

a unicorn is in the garden. →
is a unicorn   in the garden?

Now take the sentence *A unicorn that is eating a flower is in the garden.* There are two *is*'s. Which gets moved? Obviously, not the first one hit by the scan; that would give you a very odd sentence:

a unicorn that is eating a flower is in the garden. →
is a unicorn that   eating a flower is in the garden?

But why can't you move that *is*? Where did the simple procedure go wrong? The answer, Chomsky noted, comes from the basic design of language. Though sentences are strings of words, our mental algorithms for grammar do not pick out words by their linear positions, such as "first word," "second word," and so on. Rather, the algorithms group words into phrases, and phrases into even bigger phrases, and give each one a mental label, like "subject noun phrase" or "verb phrase." The real rule for forming questions does not look for the first occurrence of the auxiliary word as one goes from left to right in the string; it looks for the auxiliary that comes after the phrase labeled as the subject. This phrase, containing the entire string of words *a unicorn that is eating a flower*, behaves as a single unit. The first *is* sits deeply buried in it, invisible to the question-forming rule. The second *is*, coming immediately after this subject noun phrase, is the one that is moved:

[a unicorn that is eating a flower] is in the garden. →
is [a unicorn that is eating a flower]   in the garden?

Chomsky reasoned that if the logic of language is wired into children, then the first time they are confronted with a sentence with two auxiliaries they should be capable of turning it into a question with the proper wording. This should be true even though the wrong rule, the one that scans the sentence as a linear string of words, is simpler and presumably easier to learn. And it should be true even though the sentences that would teach children that the linear rule is wrong and the structure-sensitive rule is right—questions with a second auxiliary embedded inside the subject phrase—are so rare as to be nonexistent in Motherese. Surely not every child learning English has heard Mother say *Is the doggie that is eating the flower in the garden?* For Chomsky, this kind of reasoning, which he calls "the argument from the poverty of the input," is the primary justification for saying that the basic design of language is innate.

Chomsky's claim was tested in an experiment with three-, four-, and five-year-olds at a daycare center by the psycholinguists Stephen Crain and Mineharu Nakayama. One of the experimenters controlled a doll of Jabba the Hutt, of *Star Wars* fame. The other coaxed the child to ask a set of questions, by saying, for example, "Ask Jabba if the boy who is unhappy is watching Mickey Mouse." Jabba would inspect a picture and answer yes or no, but it was really the child who was being tested, not Jabba. The children cheerfully provided the appropriate questions, and, as Chomsky would have predicted, not a single one of them came up with an ungrammatical string like *Is the boy who unhappy is watching Mickey Mouse?,* which the simple linear rule would have produced.

Now, you may object that this does not show that children's brains register the subject of a sentence. Perhaps the children were just going by the meanings of the words. *The man who is running* refers to a single actor playing a distinct role in the picture, and children could have been keeping track of which words are about particular actors, not which words belong to the subject noun phrase. But Crain and Nakayama anticipated the objection. Mixed into their list were commands like "Ask Jabba if it is raining in this picture." The *it* of the sentence, of course, does not refer to anything; it is a dummy element that is there only to satisfy the rules of syntax, which demand a subject. But the English question rule treats it just like any other subject: *Is it raining?* Now, how do children cope with this meaningless placeholder? Perhaps they are as literal-minded as the Duck in *Alice's Adventures in Wonderland:*

> "I proceed [said the Mouse]. 'Edwin and Morcar, the earls of Mercia and Northumbria, declared for him; and even Stigand, the patriotic archbishop of Canterbury, found it advisable—' "
>
> "Found *what?*" said the Duck.
>
> "Found *it,*" the Mouse replied rather crossly: "of course you know what 'it' means."
>
> "I know what 'it' means well enough, when *I* find a thing," said

> the Duck: "it's generally a frog, or a worm. The question is, what did the archbishop find?"

But children are not ducks. Crain and Nakayama's children replied, *Is it raining in this picture?* Similarly, they had no trouble forming questions with other dummy subjects, as in "Ask Jabba if there is a snake in this picture," or with subjects that are not things, as in "Ask Jabba if running is fun" and "Ask Jabba if love is good or bad."

The universal constraints on grammatical rules also show that the basic form of language cannot be explained away as the inevitable outcome of a drive for usefulness. Many languages, widely scattered over the globe, have auxiliaries, and like English, many languages move the auxiliary to the front of the sentence to form questions and other constructions, always in a structure-dependent way. But this is not the only way one could design a question rule. One could just as effectively move the leftmost auxiliary in the string to the front, or flip the first and last words, or utter the entire sentence in mirror-reversed order (a trick that the human mind is capable of; some people learn to talk backwards to amuse themselves and amaze their friends). The particular ways that languages do form questions are arbitrary, species-wide conventions; we don't find them in artificial systems like computer programming languages or the notation of mathematics. The universal plan underlying languages, with auxiliaries and inversion rules, nouns and verbs, subjects and objects, phrases and clauses, case and agreement, and so on, seems to suggest a commonality in the brains of speakers, because many other plans would have been just as useful. It is as if isolated inventors miraculously came up with identical standards for typewriter keyboards or Morse code or traffic signals.

Evidence corroborating the claim that the mind contains blueprints for grammatical rules comes, once again, out of the mouths of babes and sucklings. Take the English agreement suffix *-s* as in *He walks.* Agreement is an important process in many languages, but in modern English it is superfluous, a remnant of a richer system that flourished in Old English. If it were to disappear entirely, we would not miss it, any more than we miss the similar *-est* suffix in *Thou sayest.* But psychologically speaking, this frill does not come cheap. Any speaker committed to using it has to keep track of four details in every sentence uttered:

- whether the subject is in the third person or not: *He walks* versus *I walk.*
- whether the subject is singular or plural: *He walks* versus *They walk.*
- whether the action is present tense or not: *He walks* versus *He walked.*
- whether the action is habitual or going on at the moment of speaking (its "aspect"): *He walks to school* versus *He is walking to school.*

And all this work is needed just to use the suffix once one has learned it. To learn it in the first place, a child must (1) notice that verbs end in *-s* in some sentences but appear bare-ended in others, (2) begin a search for the grammatical causes of this variation (as opposed to just accepting it as part of the spice of life), and (3) not rest until those crucial factors—tense, aspect, and the number and person of the subject of the sentence—have been sifted out of the ocean of conceivable but irrelevant factors (like the number of syllables of the final word in the sentence, whether the object of a preposition is natural or man-made, and how warm it is when the sentence is uttered). Why would anyone bother?

But little children do bother. By the age of three and a half or earlier, they use the *-s* agreement suffix in more than ninety percent of the sentences that require it, and virtually never use it in the sentences that forbid it. This mastery is part of their grammar explosion, a period of several months in the third year of life during which children suddenly begin to speak in fluent sentences, respecting most of the fine points of their community's spoken language. For example, a preschooler with the pseudonym Sarah, whose parents had only a high school education, can be seen obeying the English agreement rule, useless though it is, in complex sentences like the following:

> When my mother *hangs* clothes, do you let 'em rinse out in rain?
> Donna *teases* all the time and Donna has false teeth.
> I know what a big chicken *looks* like.

Anybody *knows* how to scribble.
Hey, this part *goes* where this one is, stupid.
What *comes* after "C"?
It *looks* like a donkey face.
The person *takes* care of the animals in the barn.
After it *dries* off then you can make the bottom.
Well, someone *hurts* hisself and everything.
His tail *sticks* out like this.
What *happens* if ya press on this hard?
Do you have a real baby that *says* googoo gaga?

Just as interestingly, Sarah could not have been simply imitating her parents, memorizing verbs with the -*s*'s pre-attached. Sarah sometimes uttered word forms that she could not possibly have heard from her parents:

When she *be's* in the kindergarten . . .
He's a boy so he *gots* a scary one. [costume]
She *do's* what her mother tells her.

She must, then, have created these forms herself, using an unconscious version of the English agreement rule. The very concept of imitation is suspect to begin with (if children are general imitators, why don't they imitate their parents' habit of sitting quietly in airplanes?), but sentences like these show clearly that language acquisition cannot be explained as a kind of imitation.

One step remains to complete the argument that language is a specific instinct, not just the clever solution to a problem thought up by a generally brainy species. If language is an instinct, it should have an identifiable seat in the brain, and perhaps even a special set of genes that help wire it into place. Disrupt these genes or neurons, and language should suffer while the other parts of intelligence carry on; spare them in an otherwise damaged brain, and you should have a retarded individual with intact language, a linguistic idiot savant. If, on the other hand, language is just the exercise of human smarts, we might expect that injuries and impairments would make people stupider across the board, including their language. The only pattern we would expect is that the more brain tissue that is damaged, the duller and less articulate the person should be.

No one has yet located a language organ or a grammar gene, but the search is on. There are several kinds of neurological and genetic impairments that compromise language while sparing cognition and vice versa. One of them has been known for over a century, perhaps for millennia. When there is damage to certain circuits in the lower parts of the frontal lobe of the brain's left hemisphere—say, from a stroke or bullet wound—the person often suffers from a syndrome called Broca's aphasia. One of these victims, who eventually recovered his language ability, recalls the event, which he experienced with complete lucidity:

> When I woke up I had a bit of a headache and thought I must have been sleeping with my right arm under me because it felt all pins-and-needly and numb and I couldn't make it do what I wanted. I got out of bed but I couldn't stand; as a matter of fact I actually fell on the floor because my right leg was too weak to take my weight. I called out to my wife in the next room and no sound came—I couldn't speak. . . . I was astonished, horrified. I couldn't believe that this was happening to me and I began to feel bewildered and frightened and then I suddenly realized that I must have had a stroke. In a way this rationalization made me feel somewhat relieved but not for long because I had always thought that the effects of a stroke were permanent in every case. . . . I found I could speak a little but even to me the words seemed wrong and not what I meant to say.

As this writer noted, most stroke victims are not as lucky. Mr. Ford was a Coast Guard radio operator when he suffered a stroke at the age of thirty-nine. The neuropsychologist Howard Gardner interviewed him three months later. Gardner asked him about his work before he entered the hospital.

> "I'm a sig . . . no . . . man . . . uh, well, . . . again." These words were emitted slowly, and with great effort. The sounds were not clearly articulated; each syllable was uttered harshly, explosively, in a throaty voice. . . .

"Let me help you," I interjected. "You were a signal . . ."

"A sig-nal man . . . right," Ford completed my phrase triumphantly.

"Were you in the Coast Guard?"

"No, er, yes, yes . . . ship . . . Massachu . . . chusetts . . . Coastguard . . . years." He raised his hands twice, indicating the number "nineteen."

"Oh, you were in the Coast Guard for nineteen years."

"Oh . . . boy . . . right . . . right," he replied.

"Why are you in the hospital, Mr. Ford?"

Ford looked at me a bit strangely, as if to say, Isn't it patently obvious? He pointed to his paralyzed arm and said, "Arm no good," then to his mouth and said, "Speech . . . can't say . . . talk, you see."

"What happened to you to make you lose your speech?"

"Head, fall, Jesus Christ, me no good, str, str . . . oh Jesus . . . stroke."

"I see. Could you tell me, Mr. Ford, what you've been doing in the hospital?"

"Yes, sure. Me go, er, uh, P.T. nine o'cot, speech . . . two times . . . read . . . wr . . . ripe, er, rike, er, write . . . practice . . . get-ting better."

"And have you been going home on weekends?"

"Why, yes . . . Thursday, er, er, er, no, er, Friday . . . Bar-ba-ra . . . wife . . . and, oh, car . . . drive . . . purnpike . . . you know . . . rest and . . . tee-vee."

"Are you able to understand everything on television?"

"Oh, yes, yes . . . well . . . al-most."

Obviously Mr. Ford had to struggle to get speech out, but his problems were not in controlling his vocal muscles. He could blow out a candle and clear his throat, and he was as linguistically hobbled when he wrote as when he spoke. Most of his handicaps centered around grammar itself. He omitted endings like *-ed* and *-s* and grammatical function words like *or, be*, and *the*, despite their high frequency in the language. When reading aloud, he skipped over the function words, though he successfully read content words like *bee* and *oar* that had the same sounds. He named objects and recognized their names extremely well. He understood questions when their gist could be deduced from their content words, such as "Does a stone float on water?" or "Do you use a hammer for cutting?," but not ones that required grammatical analysis, like "The lion was killed by the tiger; which one is dead?"

Despite Mr. Ford's grammatical impairment, he was clearly in command of his other faculties. Gardner notes: "He was alert, attentive, and fully aware of where he was and why he was there. Intellectual functions not closely tied to language, such as knowledge of right and left, ability to draw with the left (unpracticed) hand, to calculate, read maps, set clocks, make constructions, or carry out commands, were all preserved. His Intelligence Quotient in nonverbal areas was in the high average range." Indeed, the dialogue shows that Mr. Ford, like many Broca's aphasics, showed an acute understanding of his handicap.

Injuries in adulthood are not the only ways that the circuitry underlying language can be compromised. A few otherwise healthy children just fail to develop language on schedule. When they do begin to talk, they have difficulty articulating words, and though their articulation improves with age, the victims persist in a variety of grammatical errors, often into adulthood. When obvious nonlinguistic causes are ruled out—cognitive disorders like retardation, perceptual disorders like deafness, and social disorders like autism—the children are given the accurate but not terribly helpful diagnostic label Specific Language Impairment (SLI).

Language therapists, who are often called upon to treat several members in a family, have long been under the impression that SLI is hereditary. Recent statistical studies show that the impression may be correct. SLI runs in families, and if one member of a set of identical twins has it, the odds are very high that the other will, too. Particularly dramatic evidence comes from one British family, the K's, recently studied by the linguist Myrna Gopnik and several geneticists. The grandmother of the family is language-impaired. She has five adult children. One daughter is linguistically normal, as are this daughter's children. The other four adults, like the grandmother, are impaired. Together these four had twenty-three children; of them, eleven were language-impaired, twelve were normal. The language-impaired children were randomly distributed among the families, the sexes, and the birth orders.

Of course, the mere fact that some behavioral pattern runs in families does not show that it is genetic. Recipes, accents, and lullabies run in families, but they have nothing to do with DNA. In this case, though, a genetic cause is plausible. If the cause were in the environment—poor nutrition, hearing the defective speech of an impaired parent or sibling, watching too much TV, lead contamination from old pipes, whatever—then why would the syndrome capriciously strike some family members while leaving their near age-mates (in one case, a fraternal twin) alone? In fact, the geneticists working with Gopnik noted that the pedigree suggests a trait controlled by a single dominant gene, just like pink flowers on Gregor Mendel's pea plants.

What does this hypothetical gene do? It does not seem to impair overall intelligence; most of the afflicted family members score in the normal range in the nonverbal parts of IQ tests. (Indeed, Gopnik studied one unrelated child with the syndrome who routinely received the best grade in his mainstream math class.) It is their language that is impaired, but they are not like Broca's aphasics; the impression is more of a tourist struggling in a foreign city. They speak somewhat slowly and deliberately, carefully planning what they will say and encouraging their interlocutors to come to their aid by completing sentences for them. They report that ordinary conversation is strenuous mental work and that when possible they avoid situations in which they must speak. Their speech contains frequent grammatical errors, such as misuse of pronouns and of suffixes like the plural and past tense:

> It's a flying finches, they are.
> She remembered when she hurts herself the other day.
> The neighbors phone the ambulance because the man fall off the tree.
> The boys eat four cookie.
> Carol is cry in the church.

In experimental tests they have difficulty with tasks that normal four-year-olds breeze through. A classic example is the *wug*-test, another demonstration that normal children do not learn language by imitating their parents. The testee is shown a line drawing of a birdlike creature and told that it is a *wug*. Then a picture of two of them is shown, and the child is told, "Now there are two of them; there are two ______." Your typical four-year-old will blurt out *wugs*, but the language-impaired adult is stymied. One of the adults Gopnik studied laughed nervously and said, "Oh, dear, well carry on." When pressed, she responded, "Wug . . . wugness, isn't it? No. I see. You want to pair . . . pair it up. OK." For the next animal, *zat*, she said, "Za . . . ka . . . za . . . zackle." For the next, *sas*, she deduced that it must be "sasses." Flushed with success, she proceeded to generalize too literally, converting *zoop* to "zoop-es" and *tob* to "tob-ye-es," revealing that she hadn't really grasped the English rule. Apparently the defective gene in this family somehow affects the development of the rules that normal children use unconsciously. The adults do their best to compensate by consciously reasoning the rules out, with predictably clumsy results.

Broca's aphasia and SLI are cases where language is impaired and the rest of intelligence seems more or less intact. But this does not show that language is separate from intelligence. Perhaps language imposes greater demands on the brain than any other problem the mind has to solve. For the other problems, the brain can limp along at less than its full capacity; for language, all systems have to be one hundred percent. To clinch the case, we need to find the opposite dissociation, linguistic idiot savants—that is, people with good language and bad cognition.

Here is another interview, this one between a fourteen-year-old girl called Denyse and the late psycholinguist Richard Cromer; the interview was transcribed and analyzed by Cromer's colleague Sigrid Lipka.

> I like opening cards. I had a pile of post this morning and not one of them was a Christmas card. A bank statement I got this morning!
>
> [A bank statement? I hope it was good news.]
>
> No it wasn't good news.
>
> [Sounds like mine.]
>
> I hate . . . , My mum works over at the, over on the ward and she said "not another bank statement." I said "it's the second one in two days." And she said "Do you want me to go to the bank for you at lunchtime?" and I went "No, I'll go this time and explain it myself." I tell you what, my bank are awful. They've lost my bank book, you see, and I can't find it anywhere. I belong to the TSB Bank and I'm thinking of changing my bank 'cause they're so awful.

> They keep, they keep losing . . . [someone comes in to bring some tea] Oh, isn't that nice.
>
> [Uhm. Very good.]
>
> They've got the habit of doing that. They lose, they've lost my bank book twice, in a month, and I think I'll scream. My mum went yesterday to the bank for me. She said "They've lost your bank book again." I went "Can I scream?" and I went, she went "Yes, go on." So I hollered. But it is annoying when they do things like that. TSB, Trustees aren't . . . uh the best ones to be with actually. They're hopeless.

I have seen Denyse on videotape, and she comes across as a loquacious, sophisticated conversationalist—all the more so, to American ears, because of her refined British accent. (*My bank are awful*, by the way, is grammatical in British, though not American, English.) It comes as a surprise to learn that the events she relates so earnestly are figments of her imagination. Denyse has no bank account, so she could not have received any statements in the mail, nor could her bank have lost her bankbook. Though she would talk about a joint bank account she shared with her boyfriend, she had no boyfriend, and obviously had only the most tenuous grasp of the concept "joint bank account" because she complained about the boyfriend taking money out of her side of the account. In other conversations Denyse would engage her listeners with lively tales about the wedding of her sister, her holiday in Scotland with a boy named Danny, and a happy airport reunion with a long-estranged father. But Denyse's sister is unmarried, Denyse has never been to Scotland, she does not know anyone named Danny, and her father has never been away for any length of time. In fact, Denyse is severely retarded. She never learned to read or write and cannot handle money or any of the other demands of everyday functioning.

Denyse was born with spina bifida ("split spine"), a malformation of the vertebrae that leaves the spinal cord unprotected. Spina bifida often results in hydrocephalus, an increase in pressure in the cerebrospinal fluid filling the ventricles (large cavities) of the brain, distending the brain from within. For reasons no one understands, hydrocephalic children occasionally end up like Denyse, significantly retarded but with unimpaired—indeed, overdeveloped—language skills. (Perhaps the ballooning ventricles crush much of the brain tissue necessary for everyday intelligence but leave intact some other portions that can develop language circuitry.) The various technical terms for the condition include "cocktail party conversation," "chatterbox syndrome," and "blathering."

Fluent grammatical language can in fact appear in many kinds of people with severe intellectual impairments, like schizophrenics, Alzheimer's patients, some autistic children, and some aphasics. One of the most fascinating syndromes recently came to light when the parents of a retarded girl with chatterbox syndrome in San Diego read an article about Chomsky's theories in a popular science magazine and called him at MIT, suggesting that their daughter might be of interest to him. Chomsky is a paper-and-pencil theoretician who wouldn't know Jabba the Hutt from the Cookie Monster, so he suggested that the parents bring their child to the laboratory of the psycholinguist Ursula Bellugi in La Jolla.

Bellugi, working with colleagues in molecular biology, neurology, and radiology, found that the child (whom they called Crystal), and a number of others they have subsequently tested, had a rare form of retardation called Williams syndrome. The syndrome seems to be associated with a defective gene on chromosome 11 involved in the regulation of calcium, and it acts in complex ways on the brain, skull, and internal organs during development, though no one knows why it has the effects it does. The children have an unusual appearance: they are short and slight, with narrow faces and broad foreheads, flat nasal bridges, sharp chins, star-shaped patterns in their irises, and full lips. They are sometimes called "elfin-faced" or "pixie people," but to me they look more like Mick Jagger. They are significantly retarded, with an IQ of about 50, and are incompetent at ordinary tasks like tying their shoes, finding their way, retrieving items from a cupboard, telling left from right, adding two numbers, drawing a bicycle, and suppressing their natural tendency to hug strangers. But like Denyse they are fluent, if somewhat prim, conversationalists. Here are two transcripts from Crystal when she was eighteen:

> And what an elephant is, it is one of the animals. And what the elephant does, it lives in the jungle. It can also live in the zoo. And what it has, it has long, gray ears, fan ears, ears that can blow in the wind. It has a long trunk that can pick up grass or pick up hay . . . If they're in a bad mood, it can be terrible . . . If the elephant gets

> mad, it could stomp; it could charge. Sometimes elephants can charge, like a bull can charge. They have big, long, tusks. They can damage a car . . . It could be dangerous. When they're in a pinch, when they're in a bad mood, it can be terrible. You don't want an elephant as a pet. You want a cat or a dog or a bird.

> This is a story about chocolates. Once upon a time, in Chocolate World there used to be a Chocolate Princess. She was such a yummy princess. She was on her chocolate throne and then some chocolate man came to see her. And the man bowed to her and he said these words to her. The man said to her, "Please, Princess Chocolate. I want you to see how I do my work. And it's hot outside in Chocolate World, and you might melt to the ground like melted butter. And if the sun changes to a different color, then the Chocolate World—and you—won't melt. You can be saved if the sun changes to a different color. And if it doesn't change to a different color, you and Chocolate World are doomed.

Laboratory tests confirm the impression of competence at grammar; the children understand complex sentences, and fix up ungrammatical sentences, at normal levels. And they have an especially charming quirk: they are fond of unusual words. Ask a normal child to name some animals, and you will get the standard inventory of pet store and barnyard: dog, cat, horse, cow, pig. Ask a Williams syndrome child, and you get a more interesting menagerie: unicorn, pteranodon, yak, ibex, water buffalo, sea lion, saber-tooth tiger, vulture, koala, dragon, and one that should be especially interesting to paleontologists, "brontosaurus rex." One eleven-year-old poured a glass of milk into the sink and said, "I'll have to evacuate it"; another handed Bellugi a drawing and announced, "Here, Doc, this is in remembrance of you."

People like Kirupano, Larry, the Hawaiian-born papaya grower, Mayela, Simon, Aunt Mae, Sarah, Mr. Ford, the K's, Denyse, and Crystal constitute a field guide to language users. They show that complex grammar is displayed across the full range of human habitats. You don't need to have left the Stone Age; you don't need to be middle class; you don't need to do well in school; you don't even need to be old enough for school. Your parents need not bathe you in language or even command a language. You don't need the intellectual wherewithal to function in society, the skills to keep house and home together, or a particularly firm grip on reality. Indeed, you can possess all these advantages and still not be a competent language user, if you lack just the right genes or just the right bits of brain.

3

Mentalese

The year 1984 has come and gone, and it is losing its connotation of the totalitarian nightmare of George Orwell's 1949 novel. But relief may be premature. In an appendix to *Nineteen Eighty-four*, Orwell wrote of an even more ominous date. In 1984, the infidel Winston Smith had to be converted with imprisonment, degradation, drugs, and torture; by 2050, there would be no Winston Smiths. For in that year the ultimate technology for thought control would be in place: the language Newspeak.

> The purpose of Newspeak was not only to provide a medium of expression for the world-view and mental habits proper to the devotees of Ingsoc [English Socialism], but to make all other modes of thought impossible. It was intended that when Newspeak had been adopted once and for all and Oldspeak forgotten, a heretical thought—that is, a thought diverging from the principles of Ingsoc—should be literally unthinkable, at least so far as thought is dependent on words. Its vocabulary was so constructed as to give exact and often very subtle expression to every meaning that a Party member could properly wish to express, while excluding all other meanings and also the possibility of arriving at them by indirect methods. This was done partly by the invention of new words, but chiefly by eliminating undesirable words and by stripping such words as remained of unorthodox meanings, and so far as possible of all secondary meanings whatever. To give a single example. The word *free* still existed in Newspeak, but it could only be used in

> such statements as "This dog is free from lice" or "This field is free from weeds." It could not be used in its old sense of "politically free" or "intellectually free," since political and intellectual freedom no longer existed even as concepts, and were therefore of necessity nameless.
>
> . . . A person growing up with Newspeak as his sole language would no more know that *equal* had once had the secondary meaning of "politically equal," or that *free* had once meant "intellectually free," than, for instance, a person who had never heard of chess would be aware of the secondary meanings attaching to *queen* and *rook*. There would be many crimes and errors which it would be beyond his power to commit, simply because they were nameless and therefore unimaginable.

But there is a straw of hope for human freedom: Orwell's caveat "at least so far as thought is dependent on words." Note his equivocation: at the end of the first paragraph, a concept is unimaginable and therefore nameless; at the end of the second, a concept is nameless and therefore unimaginable. *Is* thought dependent on words? Do people literally think in English, Cherokee, Kivunjo, or, by 2050, Newspeak? Or are our thoughts couched in some silent medium of the brain—a language of thought, or "mentalese"—and merely clothed in words whenever we need to communicate them to a listener? No question could be more central to understanding the language instinct.

In much of our social and political discourse, people simply assume that words determine thoughts. Inspired by Orwell's essay "Politics and the English Language," pundits accuse governments of manipulating our minds with euphemisms like *pacification* (bombing), *revenue enhancement* (taxes), and *nonretention* (firing). Philosophers argue that since animals lack language, they must also lack consciousness—Wittgenstein wrote, "A dog could not have the thought 'perhaps it will rain tomorrow' "—and therefore they do not possess the rights of conscious beings. Some feminists blame sexist thinking on sexist language, like the use of *he* to refer to a generic person. Inevitably, reform movements have sprung up. Many replacements for *he* have been suggested over the years, including *E, hesh, po, tey, co, jhe, ve, xe, he'er, thon*, and *na*. The most extreme of these movements is General Semantics, begun in 1933 by the engineer Count Alfred

Korzybski and popularized in long-time best-sellers by his disciples Stuart Chase and S. I. Hayakawa. (This is the same Hayakawa who later achieved notoriety as the protest-defying college president and snoozing U.S. senator.) General Semantics lays the blame for human folly on insidious "semantic damage" to thought perpetrated by the structure of language. Keeping a forty-year-old in prison for a theft he committed as a teenager assumes that the forty-year-old John and the eighteen-year-old John are "the same person," a cruel logical error that would be avoided if we referred to them not as *John* but as $John_{1972}$ and $John_{1994}$, respectively. The verb *to be* is a particular source of illogic, because it identifies individuals with abstractions, as in *Mary is a woman*, and licenses evasions of responsibility, like Ronald Reagan's famous nonconfession *Mistakes were made.* One faction seeks to eradicate the verb altogether.

And supposedly there is a scientific basis for these assumptions: the famous Sapir-Whorf hypothesis of linguistic determinism, stating that people's thoughts are determined by the categories made available by their language, and its weaker version, linguistic relativity, stating that differences among languages cause differences in the thoughts of their speakers. People who remember little else from their college education can rattle off the factoids: the languages that carve the spectrum into color words at different places, the fundamentally different Hopi concept of time, the dozens of Eskimo words for snow. The implication is heavy: the foundational categories of reality are not "in" the world but are imposed by one's culture (and hence can be challenged, perhaps accounting for the perennial appeal of the hypothesis to undergraduate sensibilities).

But it is wrong, all wrong. The idea that thought is the same thing as language is an example of what can be called a conventional absurdity: a statement that goes against all common sense but that everyone believes because they dimly recall having heard it somewhere and because it is so pregnant with implications. (The "fact" that we use only five percent of our brains, that lemmings commit mass suicide, that the *Boy Scout Manual* annually outsells all other books, and that we can be coerced into buying by subliminal messages are other examples.) Think about it. We have all had the experience of uttering or writing a sentence, then stopping and realizing that it wasn't exactly what we meant to say. To have that feeling, there has to be a "what we meant to say" that is different from what we said.

Sometimes it is not easy to find *any* words that properly convey a thought. When we hear or read, we usually remember the gist, not the exact words, so there has to be such a thing as a gist that is not the same as a bunch of words. And if thoughts depended on words, how could a new word ever be coined? How could a child learn a word to begin with? How could translation from one language to another be possible?

The discussions that assume that language determines thought carry on only by a collective suspension of disbelief. A dog, Bertrand Russell noted, may not be able to tell you that its parents were honest though poor, but can anyone really conclude from this that the dog is *unconscious*? (Out cold? A zombie?) A graduate student once argued with me using the following deliciously backwards logic: language must affect thought, because if it didn't, we would have no reason to fight sexist usage (apparently, the fact that it is offensive is not reason enough). As for government euphemism, it is contemptible not because it is a form of mind control but because it is a form of lying. (Orwell was quite clear about this in his masterpiece essay.) For example, "revenue enhancement" has a much broader meaning than "taxes," and listeners naturally assume that if a politician had meant "taxes" he would have said "taxes." Once a euphemism is pointed out, people are not so brainwashed that they have trouble understanding the deception. The National Council of Teachers of English annually lampoons government doublespeak in a widely reproduced press release, and calling attention to euphemism is a popular form of humor, like the speech from the irate pet store customer in *Monty Python's Flying Circus*:

> This parrot is no more. It has ceased to be. It's expired and gone to meet its maker. This is a late parrot. It's a stiff. Bereft of life, it rests in peace. If you hadn't nailed it to the perch, it would be pushing up the daisies. It's rung down the curtain and joined the choir invisible. This is an ex-parrot.

As we shall see in this chapter, there is no scientific evidence that languages dramatically shape their speakers' ways of thinking. But I want to do more than review the unintentionally comical history of attempts to prove that they do. The idea that language shapes thinking seemed plausible when scientists were in the dark about how thinking works or even how to study it. Now that cognitive scientists know how to think about thinking, there is less of a temptation to equate it with language just because words are more palpable than thoughts. By understanding *why* linguistic determinism is wrong, we will be in a better position to understand how language itself works when we turn to it in the next chapters.

The linguistic determinism hypothesis is closely linked to the names Edward Sapir and Benjamin Lee Whorf. Sapir, a brilliant linguist, was a student of the anthropologist Franz Boas. Boas and his students (who also include Ruth Benedict and Margaret Mead) were important intellectual figures in this century, because they argued that nonindustrial peoples were not primitive savages but had systems of language, knowledge, and culture as complex and valid in their world view as our own. In his study of Native American languages Sapir noted that speakers of different languages have to pay attention to different aspects of reality simply to put words together into grammatical sentences. For example, when English speakers decide whether or not to put *-ed* onto the end of a verb, they must pay attention to tense, the relative time of occurrence of the event they are referring to and the moment of speaking. Wintu speakers need not bother with tense, but when they decide which suffix to put on their verbs, they must pay attention to whether the knowledge they are conveying was learned through direct observation or by hearsay.

Sapir's interesting observation was soon taken much farther. Whorf was an inspector for the Hartford Fire Insurance Company and an amateur scholar of Native American languages, which led him to take courses from Sapir at Yale. In a much-quoted passage, he wrote:

> We dissect nature along lines laid down by our native languages. The categories and types that we isolate from the world of phenomena we do not find there because they stare every observer in the face; on the contrary, the world is presented in a kaleidoscopic flux of impressions which has to be organized by our minds—and this means largely by the linguistic systems in our minds. We cut nature up, organize it into concepts, and ascribe significances as we do, largely because we are parties to an agreement to organize it in this way—an agreement that holds throughout our speech community

> and is codified in the patterns of our language. The agreement is, of course, an implicit and unstated one, *but its terms are absolutely obligatory*; we cannot talk at all except by subscribing to the organization and classification of data which the agreement decrees.

What led Whorf to this radical position? He wrote that the idea first occurred to him in his work as a fire prevention engineer when he was struck by how language led workers to misconstrue dangerous situations. For example, one worker caused a serious explosion by tossing a cigarette into an "empty" drum that in fact was full of gasoline vapor. Another lit a blowtorch near a "pool of water" that was really a basin of decomposing tannery waste, which, far from being "watery," was releasing inflammable gases. Whorf's studies of American languages strengthened his conviction. For example, in Apache, *It is a dripping spring* must be expressed "As water, or springs, whiteness moves downward." "How utterly unlike our way of thinking!" he wrote.

But the more you examine Whorf's arguments, the less sense they make. Take the story about the worker and the "empty" drum. The seeds of disaster supposedly lay in the semantics of *empty*, which, Whorf claimed, means both "without its usual contents" and "null and void, empty, inert." The hapless worker, his conception of reality molded by his linguistic categories, did not distinguish between the "drained" and "inert" senses, hence, flick . . . boom! But wait. Gasoline vapor is invisible. A drum with nothing but vapor in it looks just like a drum with nothing in it at all. Surely this walking catastrophe was fooled by his eyes, not by the English language.

The example of whiteness moving downward is supposed to show that the Apache mind does not cut up events into distinct objects and actions. Whorf presented many such examples from Native American languages. The Apache equivalent of *The boat is grounded on the beach* is "It is on the beach pointwise as an event of canoe motion." *He invites people to a feast* becomes "He, or somebody, goes for eaters of cooked food." *He cleans a gun with a ramrod* is translated as "He directs a hollow moving dry spot by movement of tool." All this, to be sure, is utterly unlike our way of talking. But do we know that it is utterly unlike our way of thinking?

As soon as Whorf's articles appeared, the psycholinguists Eric Lenneberg and Roger Brown pointed out two non sequiturs in his argument. First, Whorf did not actually study any Apaches; it is not clear that he ever met one. His assertions about Apache psychology are based entirely on Apache grammar—making his argument circular. Apaches speak differently, so they must think differently. How do we know that they think differently? Just listen to the way they speak!

Second, Whorf rendered the sentences as clumsy, word-for-word translations, designed to make the literal meanings seem as odd as possible. But looking at the actual glosses that Whorf provided, I could, with equal grammatical justification, render the first sentence as the mundane "Clear stuff—water—is falling." Turning the tables, I could take the English sentence "He walks" and render it "As solitary masculinity, leggedness proceeds." Brown illustrates how strange the German mind must be, according to Whorf's logic, by reproducing Mark Twain's own translation of a speech he delivered in flawless German to the Vienna Press Club:

> I am indeed the truest friend of the German language—and not only now, but from long since—yes, before twenty years already. . . . I would only some changes effect. I would only the language method—the luxurious, elaborate construction compress, the eternal parenthesis suppress, do away with, annihilate; the introduction of more than thirteen subjects in one sentence forbid; the verb so far to the front pull that one it without a telescope discover can. With one word, my gentlemen, I would your beloved language simplify so that, my gentlemen, when you her for prayer need, One her yonder-up understands.
>
> . . . I might gladly the separable verb also a little bit reform. I might none do let what Schiller did: he has the whole history of the Thirty Years' War between the two members of a separate verb inpushed. That has even Germany itself aroused, and one has Schiller the permission refused the History of the Hundred Years' War to compose—God be it thanked! After all these reforms established be will, will the German language the noblest and the prettiest on the world be.

Among Whorf's "kaleidoscopic flux of impressions," color is surely the most eye-catching. He noted that we see objects in different hues, depending on the wavelengths of the light they reflect, but that physicists tell us that wavelength is a continuous dimension with nothing delineating red, yellow, green, blue, and so on. Languages differ in their inventory of color words: Latin lacks generic "gray" and "brown"; Navajo collapses blue and green into one word; Russian has distinct words for dark blue and sky blue; Shona speakers use one word for the yellower greens and the greener yellows, and a different one for the bluer greens and the nonpurplish blues. You can fill in the rest of the argument. It is language that puts the frets in the spectrum; Julius Caesar would not know shale from Shinola.

But although physicists see no basis for color boundaries, physiologists do. Eyes do not register wavelength the way a thermometer registers temperature. They contain three kinds of cones, each with a different pigment, and the cones are wired to neurons in a way that makes the neurons respond best to red patches against a green background or vice versa, blue against yellow, black against white. No matter how influential language might be, it would seem preposterous to a physiologist that it could reach down into the retina and rewire the ganglion cells.

Indeed, humans the world over (and babies and monkeys, for that matter) color their perceptual worlds using the same palette, and this constrains the vocabularies they develop. Although languages may disagree about the wrappers in the sixty-four crayon box—the burnt umbers, the turquoises, the fuchsias—they agree much more on the wrappers in the eight-crayon box—the fire-engine reds, grass greens, lemon yellows. Speakers of different languages unanimously pick these shades as the best examples of their color words, as long as the language has a color word in that general part of the spectrum. And where languages do differ in their color words, they differ predictably, not according to the idiosyncratic tastes of some word-coiner. Languages are organized a bit like the Crayola product line, the fancier ones adding colors to the more basic ones. If a language has only two color words, they are for black and white (usually encompassing dark and light, respectively). If it has three, they are for black, white, and red; if four, black, white, red, and either yellow or green. Five adds in both yellow and green; six, blue; seven, brown; more than seven, purple, pink, orange, or gray. But the clinching experiment was carried out in the New Guinea highlands with the Grand Valley Dani, a people speaking one of the black-and-white languages. The psychologist Eleanor Rosch found that the Dani were quicker at learning a new color category that was based on fire-engine red than a category based on an off-red. The way we see colors determines how we learn words for them, not vice versa.

The fundamentally different Hopi concept of time is one of the more startling claims about how minds can vary. Whorf wrote that the Hopi language contains "no words, grammatical forms, constructions, or expressions that refer directly to what we call 'time,' or to past, or future, or to enduring or lasting." He suggested, too, that the Hopi had "no general notion or intuition of TIME as a smooth flowing continuum in which everything in the universe proceeds at an equal rate, out of a future, through a present, into a past." According to Whorf, they did not conceptualize events as being like points, or lengths of time like days as countable things. Rather, they seemed to focus on change and process itself, and on psychological distinctions between presently known, mythical, and conjecturally distant. The Hopi also had little interest in "exact sequences, dating, calendars, chronology."

What, then, are we to make of the following sentence translated from Hopi?

> Then indeed, the following day, quite early in the morning at the hour when people pray to the sun, around that time then he woke up the girl again.

Perhaps the Hopi are not as oblivious to time as Whorf made them out to be. In his extensive study of the Hopi, the anthropologist Ekkehart Malotki, who reported this sentence, also showed that Hopi speech contains tense, metaphors for time, units of time (including days, numbers of days, parts of the day, yesterday and tomorrow, days of the week, weeks, months, lunar phases, seasons, and the year), ways to quantify units of time, and words like "ancient," "quick," "long time," and "finished." Their culture keeps records with sophisticated methods of dating, including a horizon-based sun calendar, exact ceremonial day sequences, knotted calendar strings, notched calendar sticks, and several devices for timekeeping using the principle of the sundial. No one is really sure how Whorf came up with his outlandish claims, but his limited, badly analyzed sample of Hopi speech and his long-time leanings toward mysticism must have contributed.

Speaking of anthropological canards, no discussion of language and thought would be complete without the Great Eskimo Vocabulary Hoax. Contrary to popular belief, the Eskimos do not have more words for snow than do speakers of English. They do not have four hundred words for snow, as it has been claimed in print, or two hundred, or one hundred, or forty-eight, or even nine. One dictionary puts the figure at two. Counting generously, experts can come up with about a dozen, but by such standards English would not be far behind, with *snow, sleet, slush, blizzard, avalanche, hail, hardpack, powder, flurry, dusting*, and a coinage of Boston's WBZ-TV meteorologist Bruce Schwoegler, *snizzling*.

Where did the myth come from? Not from anyone who has actually studied the Yupik and Inuit-Inupiaq families of polysynthetic languages spoken from Siberia to Greenland. The anthropologist Laura Martin has documented how the story grew like an urban legend, exaggerated with each retelling. In 1911 Boas casually mentioned that Eskimos used four unrelated word roots for snow. Whorf embellished the count to seven and implied that there were more. His article was widely reprinted, then cited in textbooks and popular books on language, which led to successively inflated estimates in other textbooks, articles, and newspaper columns of Amazing Facts.

The linguist Geoffrey Pullum, who popularized Martin's article in his essay "The Great Eskimo Vocabulary Hoax," speculates about why the story got so out of control: "The alleged lexical extravagance of the Eskimos comports so well with the many other facets of their polysynthetic perversity: rubbing noses; lending their wives to strangers; eating raw seal blubber; throwing Grandma out to be eaten by polar bears." It is an ironic twist. Linguistic relativity came out of the Boas school, as part of a campaign to show that nonliterate cultures were as complex and sophisticated as European ones. But the supposedly mind-broadening anecdotes owe their appeal to a patronizing willingness to treat other cultures' psychologies as weird and exotic compared to our own. As Pullum notes,

> Among the many depressing things about this credulous transmission and elaboration of a false claim is that even if there *were* a large number of roots for different snow types in some Arctic language, this would *not*, objectively, be intellectually interesting; it would be a most mundane and unremarkable fact. Horsebreeders have various

> names for breeds, sizes, and ages of horses; botanists have names for leaf shapes; interior decorators have names for shades of mauve; printers have many different names for fonts (Carlson, Garamond, Helvetica, Times Roman, and so on), naturally enough. . . . Would anyone think of writing about printers the same kind of slop we find written about Eskimos in bad linguistics textbooks? Take [the following] random textbook . . ., with its earnest assertion "It is quite obvious that in the culture of the Eskimos . . . snow is of great enough importance to split up the conceptual sphere that corresponds to one word and one thought in English into several distinct classes . . ." Imagine reading: "It is quite obvious that in the culture of printers . . . fonts are of great enough importance to split up the conceptual sphere that corresponds to one word and one thought among non-printers into several distinct classes . . ." Utterly boring, even if true. Only the link to those legendary, promiscuous, blubber-gnawing hunters of the ice-packs could permit something this trite to be presented to us for contemplation.

If the anthropological anecdotes are bunk, what about controlled studies? The thirty-five years of research from the psychology laboratory is distinguished by how little it has shown. Most of the experiments have tested banal "weak" versions of the Whorfian hypothesis, namely that words can have some effect on memory or categorization. Some of these experiments have actually worked, but that is hardly surprising. In a typical experiment, subjects have to commit paint chips to memory and are tested with a multiple-choice procedure. In some of these studies, the subjects show slightly better memory for colors that have readily available names in their language. But even colors without names are remembered fairly well, so the experiment does not show that the colors are remembered by verbal labels alone. All it shows is that subjects remembered the chips in two forms, a nonverbal visual image and a verbal label, presumably because two kinds of memory, each one fallible, are better than one. In another type of experiment subjects have to say which two out of three color chips go together; they often put the ones together that have the same name in their language. Again, no surprise. I can imagine the subjects thinking to themselves, "Now how on earth does this guy expect me to pick two chips to put together? He didn't give me any hints, and they're all pretty similar. Well, I'd probably call those two 'green' and that one 'blue,' and that seems as good a reason to put them together as any." In these experiments, language is, technically speaking, influencing a form of thought in some way, but so what? It is hardly an example of incommensurable world views, or of concepts that are nameless and therefore unimaginable, or of dissecting nature along lines laid down by our native languages according to terms that are absolutely obligatory.

The only really dramatic finding comes from the linguist and now Swarthmore College president Alfred Bloom in his book *The Linguistic Shaping of Thought.* English grammar, says Bloom, provides its speakers with the subjunctive construction: *If John were to go to the hospital, he would meet Mary.* The subjunctive is used to express "counterfactual" situations, events that are known to be false but entertained as hypotheticals. (Anyone familiar with Yiddish knows a better example, the ultimate riposte to someone reasoning from improbable premises: *Az di bobe volt gehat beytsim volt zi geven mayn zeyde,* "If my grandmother had balls, she'd be my grandfather.") Chinese, in contrast, lacks a subjunctive and any other simple grammatical construction that directly expresses a counterfactual. The thought must be expressed circuitously, something like "If John is going to the hospital . . . but he is not going to the hospital . . . but if he is going, he meets Mary."

Bloom wrote stories containing sequences of implications from a counterfactual premise and gave them to Chinese and American students. For example, one story said, in outline, "Bier was an eighteenth-century European philosopher. There was some contact between the West and China at that time, but very few works of Chinese philosophy had been translated. Bier could not read Chinese, but if he had been able to read Chinese, he would have discovered B; what would have most influenced him would have been C; once influenced by that Chinese perspective, Bier would then have done D," and so on. The subjects were then asked to check off whether B, C, and D actually occurred. The American students gave the correct answer, no, ninety-eight percent of the time; the Chinese students gave the correct answer only seven percent of the time! Bloom concluded that the Chinese language renders its speakers unable to entertain hypothetical false worlds without great mental effort. (As far as I know, no one has tested the converse prediction on speakers of Yiddish.)

The cognitive psychologists Terry Au, Yohtaro Takano, and Lisa Liu were not exactly enchanted by these tales of the concreteness of the Oriental mind. Each one identified serious flaws in Bloom's experiments. One problem was that his stories were written in stilted Chinese. Another was that some of the science stories turned out, upon careful rereading, to be genuinely ambiguous. Chinese college students tend to have more science training than American students, and thus they were *better* at detecting the ambiguities that Bloom himself missed. When these flaws were fixed, the differences vanished.

People can be forgiven for overrating language. Words make noise, or sit on a page, for all to hear and see. Thoughts are trapped inside the head of the thinker. To know what someone else is thinking, or to talk to each other about the nature of thinking, we have to use—what else, words! It is no wonder that many commentators have trouble even conceiving of thought without words—or is it that they just don't have the language to talk about it?

As a cognitive scientist I can afford to be smug about common sense being true (thought is different from language) and linguistic determinism being a conventional absurdity. For two sets of tools now make it easier to think clearly about the whole problem. One is a body of experimental studies that break the word barrier and assess many kinds of nonverbal thought. The other is a theory of how thinking might work that formulates the questions in a satisfyingly precise way.

We have already seen an example of thinking without language: Mr. Ford, the fully intelligent aphasic discussed in Chapter 2. (One could, however, argue that his thinking abilities had been constructed before his stroke on the scaffolding of the language he then possessed.) We have also met deaf children who lack a language and soon invent one. Even more pertinent are the deaf adults occasionally discovered who lack any form of language whatsoever—no sign language, no writing, no lip reading, no speech. In her recent book *A Man Without Words*, Susan Schaller tells the story of Ildefonso, a twenty-seven-year-old illegal immigrant from a small Mexican village whom she met while working as a sign language interpreter in Los Angeles. Ildefonso's animated eyes conveyed an unmistakable intelligence and curiosity, and Schaller became his volunteer teacher and companion. He soon showed her that he had a full grasp of number: he learned to do addition on paper in three minutes and had little trouble understanding the base-ten logic behind two-digit numbers. In an epiphany reminiscent of the story of Helen Keller, Ildefonso grasped the principle of naming when Schaller tried to teach him the sign for "cat." A dam burst, and he demanded to be shown the signs for all the objects he was familiar with. Soon he was able to convey to Schaller parts of his life story: how as a child he had begged his desperately poor parents to send him to school, the kinds of crops he had picked in different states, his evasions of immigration authorities. He led Schaller to other languageless adults in forgotten corners of society. Despite their isolation from the verbal world, they displayed many abstract forms of thinking, like rebuilding broken locks, handling money, playing card games, and entertaining each other with long pantomimed narratives.

Our knowledge of the mental life of Ildefonso and other languageless adults must remain impressionistic for ethical reasons: when they surface, the first priority is to teach them language, not to study how they manage without it. But there are other languageless beings who have been studied experimentally, and volumes have been written about how they reason about space, time, objects, number, rate, causality, and categories. Let me recount three ingenious examples. One involves babies, who cannot think in words because they have not yet learned any. One involves monkeys, who cannot think in words because they are incapable of learning them. The third involves human adults, who, whether or not they think in words, claim their best thinking is done without them.

The developmental psychologist Karen Wynn has recently shown that five-month-old babies can do a simple form of mental arithmetic. She used a technique common in infant perception research. Show a baby a bunch of objects long enough, and the baby gets bored and looks away; change the scene, and if the baby notices the difference, he or she will regain interest. The methodology has shown that babies as young as five days old are sensitive to number. In one experiment, an experimenter bores a baby with an object, then occludes the object with an opaque screen. When the screen is removed, if the same object is present, the babies look for a little while, then get bored again. But if, through invisible subterfuge, two or three objects have ended up there, the surprised babies stare longer.

In Wynn's experiment, the babies were shown a rubber Mickey Mouse doll on a stage until their little eyes wandered. Then a screen came up, and a prancing hand visibly reached out from behind a curtain and placed a second Mickey Mouse behind the screen. When the screen was removed, if there were two Mickey Mouses visible (something the babies had never actually seen), the babies looked for only a few moments. But if there was only one doll, the babies were captivated—even though this was exactly the scene that had bored them before the screen was put in place. Wynn also tested a second group of babies, and this time, after the screen came up to obscure a *pair* of dolls, a hand visibly reached behind the screen and removed one of them. If the screen fell to reveal a single Mickey, the babies looked briefly; if it revealed the old scene with two, the babies had more trouble tearing themselves away. The babies must have been keeping track of how many dolls were behind the screen, updating their counts as dolls were added or subtracted. If the number inexplicably departed from what they expected, they scrutinized the scene, as if searching for some explanation.

Vervet monkeys live in stable groups of adult males and females and their offspring. The primatologists Dorothy Cheney and Robert Seyfarth have noticed that extended families form alliances like the Montagues and Capulets. In a typical interaction they observed in Kenya, one juvenile monkey wrestled another to the ground screaming. Twenty minutes later the victim's sister approached the perpetrator's sister and without provocation bit her on the tail. For the retaliator to have identified the proper target, she would have had to solve the following analogy problem: A (victim) is to B (myself) as C (perpetrator) is to X, using the correct relationship "sister of" (or perhaps merely "relative of"; there were not enough vervets in the park for Cheney and Seyfarth to tell).

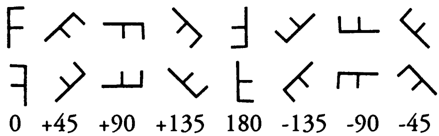
But do monkeys really know how their groupmates are related to each other, and, more impressively, do they realize that different pairs of individuals like brothers and sisters can be related in the same way? Cheney and Seyfarth hid a loudspeaker behind a bush and played tapes of a two-year-old monkey screaming. The females in the area reacted by looking at the mother of the infant who had been recorded—showing that they not only recognized the infant by its scream but recalled who its mother was. Similar abilities have been shown in the longtailed macaques that Verena Dasser coaxed into a laboratory adjoining a large outdoor enclosure. Three slides were projected: a mother at the center, one of her offspring on one side, and an unrelated juvenile of the same age and sex on the other. Each screen had a button under it. After the monkey had been trained to press a button under the offspring slide, it was tested on pictures of other mothers in the group, each one flanked by a picture of that mother's offspring and a picture of another juvenile. More than ninety percent of the time the monkey picked the offspring. In another test, the monkey was shown two slides, each showing a pair of monkeys, and was trained to press a button beneath the slide showing a particular mother and her juvenile daughter. When presented with slides of new monkeys in the group, the subject monkey always picked the mother-and-offspring pair, whether the offspring was male, female, infant, juvenile, or adult. Moreover, the monkeys appeared to be relying not only on physical resemblance between a given pair of monkeys, or on the sheer number of hours they had previously spent together, as the basis for recognizing they were kin, but on something more subtle in the history of their interaction. Cheney and Seyfarth, who work hard at keeping track of who is related to whom in what way in the groups of animals they study, note that monkeys would make excellent primatologists.

Many creative people insist that in their most inspired moments they think not in words but in mental images. Samuel Taylor Coleridge wrote that visual images of scenes and words once appeared involuntarily before him in a dreamlike state (perhaps opium-induced). He managed to copy the first forty lines onto paper, resulting in the poem we know as "Kubla Khan," before a knock on the door shattered the images and obliterated forever what would have been the rest of the poem. Many contemporary novelists, like Joan Didion, report that their acts of creation begin not with any notion of a character or a plot but with vivid mental pictures that dictate their choice of words. The modern sculptor James Surls plans his projects lying on a couch listening to music; he manipulates the sculptures in his mind's eye, he says, putting an arm on, taking an arm off, watching the images roll and tumble.

Physical scientists are even more adamant that their thinking is geometrical, not verbal. Michael Faraday, the originator of our modern conception of electric and magnetic fields, had no training in mathematics but arrived at his insights by visualizing lines of force as narrow tubes curving through space. James Clerk Maxwell formalized the concepts of electromagnetic fields in a set of mathematical equations and is considered the prime example of an abstract theoretician, but he set down the equations only after mentally playing with elaborate imaginary models of sheets and fluids. Nikola Tesla's idea for the electrical motor and generator, Friedrich Kekulé's discovery of the benzene ring that kicked off modern organic chemistry, Ernest Lawrence's conception of the cyclotron, James Watson and Francis Crick's discovery of the DNA double helix—all came to them in images. The most famous self-described visual thinker is Albert Einstein, who arrived at some of his insights by imagining himself riding a beam of light and looking back at a clock, or dropping a coin while standing in a plummeting elevator. He wrote:

> The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined. . . . This combinatory play seems to be the essential feature in productive thought—before there is any connection with logical construction in words or other kinds of signs which can be communicated to others. The above-mentioned elements are, in my case, of visual and some muscular type. Conventional words or other signs have to be sought for laboriously only in a secondary state, when the mentioned associative play is sufficiently established and can be reproduced at will.

Another creative scientist, the cognitive psychologist Roger Shepard, had his own moment of sudden visual inspiration, and it led to a classic laboratory demonstration of mental imagery in mere mortals. Early one morning, suspended between sleep and awakening in a state of lucid consciousness, Shepard experienced "a spontaneous kinetic image of three-dimensional structures majestically turning in space." Within moments and before fully awakening, Shepard had a clear idea for the design of an experiment. A simple variant of his idea was later carried out with his then-student Lynn Cooper. Cooper and Shepard flashed thousands of slides, each showing a single letter of the alphabet, to their long-suffering student volunteers. Sometimes the letter was upright, but sometimes it was tilted or mirror-reversed or both. As an example, here are the sixteen versions of the letter *F*:



The subjects were asked to press one button if the letter was normal (that is, like one of the letters in the top row of the diagram), another if it was a mirror image (like one of the letters in the bottom row). To do the task, the subjects had to compare the letter in the slide against some memory record of what the normal version of the letter looks like right-side up. Obviously, the right-side-up slide (0 degrees) is the quickest, because it matches the letter in memory exactly, but for the other orientations, some mental transformation to the upright is necessary first. Many subjects reported that they, like the famous sculptors and scientists, "mentally rotated" an image of the letter to the upright. By looking at the reaction times, Shepard and Cooper showed that this introspection was accurate. The upright letters were fastest, followed by the 45 degree letters, the 90 degree letters, and the 135 degree letters, with the 180 degree (upside-down) letters the slowest. In other words, the farther the subjects had to mentally rotate the letter, the longer they took. From the data, Cooper and Shepard estimated that letters revolve in the mind at a rate of 56 RPM.

Note that if the subjects had been manipulating something resembling *verbal descriptions* of the letters, such as "an upright spine with one horizontal segment that extends rightwards from the top and another horizontal segment that extends rightwards from the middle," the results would have been very different. Among all the topsy-turvy letters, the upside-down versions (180 degrees) should be fastest: one simply switches all the "top"s to "bottom"s and vice versa, and the "left"s to "right"s and vice versa, and one has a new description of the shape as it would appear right-side up, suitable for matching against memory. Sideways letters (90 degrees) should be slower, because "top" gets changed either to "right" or to "left," depending on whether it lies clockwise (+90 degrees) or counterclockwise (−90 degrees) from the upright. Diagonal letters (45 and 135 degrees) should be slowest, because every word in the description has to be replaced: "top" has to be replaced with either "top right" or "top left," and so on. So the order of difficulty should be 0, 180, 90, 45, 135, not the majestic rotation of 0, 45, 90, 135, 180 that Cooper and Shepard saw in the data. Many other experiments have corroborated the idea that visual thinking uses not language but a mental graphics system, with operations that rotate, scan, zoom, pan, displace, and fill in patterns of contours.

What sense, then, can we make of the suggestion that images, numbers, kinship relations, or logic can be represented in the brain without being couched in words? In the first half of this century, philosophers had an answer: none. Reifying thoughts as things in the head was a logical error, they said. A picture or family tree or number in the head would require a little man, a homunculus, to look at it. And what would be inside *his* head—even smaller pictures, with an even smaller man looking at them? But the argument was unsound. It took Alan Turing, the brilliant British mathematician and philosopher, to make the idea of a mental representation scientifically respectable. Turing described a hypothetical machine that could be said to engage in reasoning. In fact this simple device, named a Turing Machine in his honor, is powerful enough to solve any problem that any computer, past, present, or future, can solve. And it clearly uses an internal symbolic representation—a kind of mentalese—without requiring a little man or any occult processes. By looking at how a Turing machine works, we can get a grasp of what it would mean for a human mind to think in mentalese as opposed to English.

In essence, to reason is to deduce new pieces of knowledge from old ones. A simple example is the old chestnut from introductory logic: if you know that Socrates is a man and that all men are mortal, you can figure out that Socrates is mortal. But how could a hunk of matter like a brain accomplish this feat? The first key idea is a *representation*: a physical object whose parts and arrangement correspond piece for piece to some set of ideas or facts. For example, the pattern of ink on this page

```
Socrates isa man
```

is a representation of the idea that Socrates is a man. The shape of one group of ink marks, `Socrates`, is a symbol that stands for the concept of Socrates. The shape of another set of ink marks, `isa`, stands for the concept of being an instance of, and the shape of the third, `man`, stands for the concept of man. Now, it is crucial to keep one thing in mind. I have put these ink marks in the shape of English words as a courtesy to you, the reader, so that you can keep them straight as we work through the example. But all that really matters is that they have different shapes. I could have used a star of David, a smiley face, and the Mercedes-Benz logo, as long as I used them consistently.

Similarly, the fact that the `Socrates` ink marks are to the left of the `isa` ink marks on the page, and the `man` ink marks are to the right, stands for the idea that Socrates is a man. If I change any part of the representation, like replacing `isa` with `isasonofa`, or flipping the positions of `Socrates` and `man`, we would have a representation of a different idea. Again, the left-to-right English order is just a mnemonic device for your convenience. I could have done it right-to-left or up-and-down, as long as I used that order consistently.

Keeping these conventions in mind, now imagine that the page has a second set of ink marks, representing the proposition that every man is mortal:

```
Socrates isa man
Every man ismortal
```

To get reasoning to happen, we now need a *processor.* A processor is not a little man (so one needn't worry about an infinite regress of homunculi inside homunculi) but something much stupider: a gadget with a fixed number of reflexes. A processor can react to different pieces of a representation and do something in response, including altering the representation or making new ones. For example, imagine a machine that can move around on a printed page. It has a cutout in the shape of the letter sequence `isa`, and a light sensor that can tell when the cutout is superimposed on a set of ink marks in the exact shape of the cutout. The sensor is hooked up to a little pocket copier, which can duplicate any set of ink marks, either by printing identical ink marks somewhere else on the page or by burning them into a new cutout.

Now imagine that this sensor-copier-creeper machine is wired up with four reflexes. First, it rolls down the page, and whenever it detects some `isa` ink marks, it moves to the left, and copies the ink marks it finds there onto the bottom left corner of the page. Let loose on our page, it would create the following:

```
Socrates isa man
Every man ismortal



Socrates
```

Its second reflex, also in response to finding an isa, is to get itself to the right of that isa and copy any ink marks it finds there into the holes of a new cutout. In our case, this forces the processor to make a cutout in the shape of man. Its third reflex is to scan down the page checking for ink marks shaped like Every, and if it finds some, seeing if the ink marks to the right align with its new cutout. In our example, it finds one: the man in the middle of the second line. Its fourth reflex, upon finding such a match, is to move to the right and copy the ink marks it finds there onto the bottom center of the page. In our example, those are the ink marks ismortal. If you are following me, you'll see that our page now looks like this:

```
Socrates isa man
Every man ismortal



Socrates  ismortal
```

A primitive kind of reasoning has taken place. Crucially, although the gadget and the page it sits on collectively display a kind of intelligence, there is nothing in either of them that is itself intelligent. Gadget and page are just a bunch of ink marks, cutouts, photocells, lasers, and wires. What makes the whole device smart is the exact *correspondence* between the logician's rule "If X is a Y and all Y's are Z, then X is Z" and the way the device scans, moves, and prints. Logically speaking, "X is a Y" means that what is true of Y is also true of X, and mechanically speaking, X isa Y causes what is printed next to the Y to be also printed next to the X. The machine, blindly following the laws of physics, just responds to the shape of the ink marks isa (without understanding what it means to us) and copies other ink marks in a way that ends up mimicking the operation of the logical rule. What makes it "intelligent" is that the sequence of sensing and moving and copying results in its printing a representation of a conclusion that is true if and only if the page contains representations of premises that are true. If one gives the device as much paper as it needs, Turing showed, the machine can do anything that any computer can do—and perhaps, he conjectured, anything that any physically embodied mind can do.

Now, this example uses ink marks on paper as its representation and a copying-creeping-sensing machine as its processor. But the representation can be in any physical medium at all, as long as the patterns are used consistently. In the brain, there might be three groups of neurons, one used to represent the individual that the proposition is about (Socrates, Aristotle, Rod Stewart, and so on), one to represent the logical relationship in the proposition (is a, is not, is like, and so on), and one to represent the class or type that the individual is being categorized as (men, dogs, chickens, and so on). Each concept would correspond to the firing of a particular neuron; for example, in the first group of neurons, the fifth neuron might fire to represent Socrates and the seventeenth might fire to represent Aristotle; in the third group, the eighth neuron might fire to represent men, the twelfth neuron might fire to represent dogs. The processor might be a network of other neurons feeding into these groups, connected together in such a way that it reproduces the firing pattern in one group of neurons in some other group (for example, if the eighth neuron is firing in group 3, the processor network would turn on the eighth neuron in some fourth group, elsewhere in the brain). Or the whole thing could be done in silicon chips. But in all three cases the principles are the same. The way the elements in the processor are wired up would cause them to sense and copy pieces of a representation, and to produce new representations, in a way that mimics the rules of reasoning. With many thousands of representations and a set of somewhat more sophisticated processors (perhaps different kinds of representations and processors for different kinds of thinking), you might have a genuinely intelligent brain or computer. Add an eye that can detect certain contours in the world and turn on representations that symbolize them, and muscles that can act on the world whenever certain representations symbolizing goals are turned on, and you have a behaving organism (or add a TV camera and set of levers and wheels, and you have a robot).

This, in a nutshell, is the theory of thinking called "the physical symbol system hypothesis" or the "computational" or "representational" theory of mind. It is as fundamental to cognitive science as the cell doctrine is to biology and plate tectonics is to geology. Cognitive psychologists and neuroscientists are trying to figure out what kinds of representations and processors the brain has. But there are ground rules that must be followed at all times: no little men inside, and no peeking. The representations that one posits in the mind have to be arrangements of symbols, and the processor has to be a device with a fixed set of reflexes, period. The combination, acting all by itself, has to produce the intelligent conclusions. The theorist is forbidden to peer inside and "read" the symbols, "make sense" of them, and poke around to nudge the device in smart directions like some deus ex machina.

Now we are in a position to pose the Whorfian question in a precise way. Remember that a representation does not have to look like English or any other language; it just has to use symbols to represent concepts, and arrangements of symbols to represent the logical relations among them, according to some consistent scheme. But though internal representations in an English speaker's mind don't *have* to look like English, they *could*, in principle, look like English—or like whatever language the person happens to speak. So here is the question: Do they in fact? For example, if we know that Socrates is a man, is it because we have neural patterns that correspond one-to-one to the English words *Socrates, is, a*, and *man*, and groups of neurons in the brain that correspond to the subject of an English sentence, the verb, and the object, laid out in that order? Or do we use some other code for representing concepts and their relations in our heads, a language of thought or mentalese that is not the same as any of the world's languages? We can answer this question by seeing whether English sentences embody the information that a processor would need to perform valid sequences of reasoning—without requiring any fully intelligent homunculus inside doing the "understanding."

The answer is a clear no. English (or any other language people speak) is hopelessly unsuited to serve as our internal medium of computation. Consider some of the problems.

The first is ambiguity. These headlines actually appeared in newspapers:

Child's Stool Great for Use in Garden
Stud Tires Out
Stiff Opposition Expected to Casketless Funeral Plan
Drunk Gets Nine Months in Violin Case
Iraqi Head Seeks Arms
Queen Mary Having Bottom Scraped
Columnist Gets Urologist in Trouble with His Peers

Each headline contains a word that is ambiguous. But surely the thought underlying the word is *not* ambiguous; the writers of the headlines surely knew which of the two senses of the words *stool, stud,* and *stiff* they themselves had in mind. And if there can be two thoughts corresponding to one word, thoughts can't be words.

The second problem with English is its lack of logical explicitness. Consider the following example, devised by the computer scientist Drew McDermott:

Ralph is an elephant.
Elephants live in Africa.
Elephants have tusks.

Our inference-making device, with some minor modifications to handle the English grammar of the sentences, would deduce "Ralph lives in Africa" and "Ralph has tusks." This sounds fine but isn't. Intelligent you, the reader, knows that the Africa that Ralph lives in is the same Africa that all the other elephants live in, but that Ralph's tusks are his own. But the symbol-copier-creeper-sensor that is supposed to be a model of you *doesn't* know that, because the distinction is nowhere to be found in any of the statements. If you object that this is just common sense, you would be right—but it's common sense that we're trying to account for, and English sentences do not embody the information that a processor needs to carry out common sense.

A third problem is called "co-reference." Say you start talking about an individual by referring to him as *the tall blond man with one black shoe*. The second time you refer to him in the conversation you are likely to call him *the man*; the third time, just *him*. But the three expressions do not refer to three people or even to three ways of thinking about a single person; the second and third are just ways of saving breath. Something in the brain must treat them as the same thing; English isn't doing it.

A fourth, related problem comes from those aspects of language that can only be interpreted in the context of a conversation or text—what linguists call "deixis." Consider articles like *a* and *the*. What is the difference between *killed a policeman* and *killed the policeman*? Only that in the second sentence, it is assumed that some specific policeman was mentioned earlier or is salient in the context. Thus in isolation the two phrases are synonymous, but in the following contexts (the first from an actual newspaper article) their meanings are completely different:

> A policeman's 14-year-old son, apparently enraged after being disciplined for a bad grade, opened fire from his house, *killing a policeman* and wounding three people before he was shot dead.
>
> A policeman's 14-year-old son, apparently enraged after being disciplined for a bad grade, opened fire from his house, *killing the policeman* and wounding three people before he was shot dead.

Outside of a particular conversation or text, then, the words *a* and *the* are quite meaningless. They have no place in one's permanent mental database. Other conversation-specific words like *here, there, this, that, now, then, I, me, my, her, we*, and *you* pose the same problems, as the following old joke illustrates:

> First guy: I didn't sleep with my wife before we were married, did you?
>
> Second guy: I don't know. What was her maiden name?

A fifth problem is synonymy. The sentences

> Sam sprayed paint onto the wall.
> Sam sprayed the wall with paint.
> Paint was sprayed onto the wall by Sam.
> The wall was sprayed with paint by Sam.

refer to the same event and therefore license many of the same inferences. For example, in all four cases, one may conclude that the wall has paint on it. But they are four distinct arrangements of words. You know that they mean the same thing, but no simple processor, crawling over them as marks, would know that. Something else that is not one of those arrangements of words must be representing the single event that you know is common to all four. For example, the event might be represented as something like

$$\texttt{(Sam spray paint}_1\texttt{) cause (paint}_1\texttt{ go to (on wall))}$$

—which, assuming we don't take the English words seriously, is not too far from one of the leading proposals about what mentalese looks like.

These examples (and there are many more) illustrate a single important point. The representations underlying thinking, on the one hand, and the sentences in a language, on the other, are in many ways at cross-purposes. Any particular thought in our head embraces a vast amount of information. But when it comes to communicating a thought to someone else, attention spans are short and mouths are slow. To get information into a listener's head in a reasonable amount of time, a speaker can encode only a fraction of the message into words and must count on the listener to fill in the rest. But *inside a single head*, the demands are different. Air time is not a limited resource: different parts of the brain are connected to one another directly with thick cables that can transfer huge amounts of information quickly. Nothing can be left to the imagination, though, because the internal representations *are* the imagination.

We end up with the following picture. People do not think in English or Chinese or Apache; they think in a language of thought. This language of thought probably looks a bit like all these languages; presumably it has symbols for concepts, and arrangements of symbols that correspond to who did what to whom, as in the paint-spraying representation shown above. But compared with any given language, mentalese must be richer in some ways and simpler in others. It must be richer, for example, in that several concept symbols must correspond to a given English word like *stool* or *stud*. There must be extra paraphernalia that differentiate logically distinct kinds of concepts, like Ralph's tusks versus tusks in general, and that link different symbols that refer to the same thing, like *the tall blond man with one black shoe* and *the man*. On the other hand, mentalese must be simpler than spoken languages; conversation-specific words and constructions (like *a* and *the*) are absent, and information about pronouncing words, or even ordering them, is unnecessary. Now, it could be that English speakers think in some kind of simplified and annotated quasi-English, with the design I have just described, and that Apache speakers think in a simplified and annotated quasi-Apache. But to get these languages of thought to subserve reasoning properly, they would have to look much more like each other than either one does to its spoken counterpart, and it is likely that they are the same: a universal mentalese.

Knowing a language, then, is knowing how to translate mentalese into strings of words and vice versa. People without a language would still have mentalese, and babies and many nonhuman animals presumably have simpler dialects. Indeed, if babies did not have a mentalese to translate to and from English, it is not clear how learning English could take place, or even what learning English would mean.

So where does all this leave Newspeak? Here are my predictions for the year 2050. First, since mental life goes on independently of particular languages, concepts of freedom and equality will be thinkable even if they are nameless. Second, since there are far more concepts than there are words, and listeners must always charitably fill in what the speaker leaves unsaid, existing words will quickly gain new senses, perhaps even regain their original senses. Third, since children are not content to reproduce any old input from adults but create a complex grammar that can go beyond it, they would creolize Newspeak into a natural language, possibly in a single generation. The twenty-first-century toddler may be Winston Smith's revenge.

4

How Language Works

Journalists say that when a dog bites a man that is not news, but when a man bites a dog that is news. This is the essence of the language instinct: language conveys news. The streams of words called "sentences" are not just memory prods, reminding you of man and man's best friend and letting you fill in the rest; they tell you who in fact did what to whom. Thus we get more from most stretches of language than Woody Allen got from *War and Peace,* which he read in two hours after taking speed-reading lessons: "It was about some Russians." Language allows us to know how octopuses make love and how to remove cherry stains and why Tad was heartbroken, and whether the Red Sox will win the World Series without a good relief pitcher and how to build an atom bomb in your basement and how Catherine the Great died, among other things.

When scientists see some apparent magic trick in nature, like bats homing in on insects in pitch blackness or salmon returning to breed in their natal stream, they look for the engineering principles behind it. For bats, the trick turned out to be sonar; for salmon, it was locking in to a faint scent trail. What is the trick behind the ability of *Homo sapiens* to convey that man bites dog?

In fact there is not one trick but two, and they are associated with the names of two European scholars who wrote in the nineteenth century. The first principle, articulated by the Swiss linguist Ferdinand de Saussure, is "the arbitrariness of the sign," the wholly conventional pairing of a sound with a meaning. The word *dog* does not look like a dog, walk like a dog, or woof like a dog, but it means "dog" just the same. It does so because every English speaker has undergone an identical act of rote learning in childhood that links the sound to the meaning. For the price of this standardized memorization, the members of a language community receive an enormous benefit: the ability to convey a concept from mind to mind virtually instantaneously. Sometimes the gunshot marriage between sound and meaning can be amusing. As Richard Lederer points out in *Crazy English*, we drive on a parkway but park in a driveway, there is no ham in hamburger or bread in sweetbreads, and blueberries are blue but cranberries are not cran. But think about the "sane" alternative of depicting a concept so that receivers can apprehend the meaning in the form. The process is so challenging to the ingenuity, so comically unreliable, that we have made it into party games like Pictionary and charades.

The second trick behind the language instinct is captured in a phrase from Wilhelm Von Humboldt that presaged Chomsky: language "makes infinite use of finite media." We know the difference between the forgettable *Dog bites man* and the newsworthy *Man bites dog* because of the order in which *dog*, *man*, and *bites* are combined. That is, we use a code to translate between orders of words and combinations of thoughts. That code, or set of rules, is called a generative grammar; as I have mentioned, it should not be confused with the pedagogical and stylistic grammars we encountered in school.

The principle underlying grammar is unusual in the natural world. A grammar is an example of a "discrete combinatorial system." A finite number of discrete elements (in this case, words) are sampled, combined, and permuted to create larger structures (in this case, sentences) with properties that are quite distinct from those of their elements. For example, the meaning of *Man bites dog* is different from the meaning of any of the three words inside it, and different from the meaning of the same words combined in the reverse order. In a discrete combinatorial system like language, there can be an unlimited number of completely distinct combinations with an infinite range of properties. Another noteworthy discrete combinatorial system in the natural world is the genetic code in DNA, where four kinds of nucleotides are combined into sixty-four kinds of codons, and the codons can be strung into an unlimited number of different genes. Many biologists have capitalized on the close parallel between the principles of grammatical combination and the principles of genetic combination. In the technical language of genetics, sequences of DNA are said to contain "letters" and "punctuation"; may be "palindromic," "meaningless," or "synonymous"; are "transcribed" and "translated"; and are even stored in "libraries." The immunologist Niels Jerne entitled his Nobel Prize address "The Generative Grammar of the Immune System."

Most of the complicated systems we see in the world, in contrast, are *blending systems*, like geology, paint mixing, cooking, sound, light, and weather. In a blending system the properties of the combination lie *between* the properties of its elements, and the properties of the elements are lost in the average or mixture. For example, combining red paint and white paint results in pink paint. Thus the range of properties that can be found in a blending system are highly circumscribed, and the only way to differentiate large numbers of combinations is to discriminate tinier and tinier differences. It may not be a coincidence that the two systems in the universe that most impress us with their open-ended complex design—life and mind—are based on discrete combinatorial systems. Many biologists believe that if inheritance were not discrete, evolution as we know it could not have taken place.

The way language works, then, is that each person's brain contains a lexicon of words and the concepts they stand for (a mental dictionary) and a set of rules that combine the words to convey relationships among concepts (a mental grammar). We will explore the world of words in the next chapter; this one is devoted to the design of grammar.

The fact that grammar is a discrete combinatorial system has two important consequences. The first is the sheer vastness of language. Go into the Library of Congress and pick a sentence at random from any volume, and chances are you would fail to find an exact repetition no matter how long you continued to search. Estimates of the number of sentences that an ordinary person is capable of producing are breathtaking. If a speaker is interrupted at a random point in a sentence, there are on average about ten different words that could be inserted at that point to continue the sentence in a grammatical and meaningful way. (At some points in a sentence, only one word can be inserted, and at others, there is a choice from among thousands; ten is the average.) Let's assume that a person is capable of producing sentences up to twenty words long. Therefore the number of sentences that a speaker can deal with in principle is at least 10^{20} (a one with twenty zeros after it, or a hundred million trillion). At a rate of five seconds a sentence, a person would need a childhood of about a hundred trillion years (with no time for eating or sleeping) to memorize them all. In fact, a twenty-word limitation is far too severe. The following comprehensible sentence from George Bernard Shaw, for example, is 110 words long:

> Stranger still, though Jacques-Dalcroze, like all these great teachers, is the completest of tyrants, knowing what is right and that he must and will have the lesson just so or else break his heart (not somebody else's, observe), yet his school is so fascinating that every woman who sees it exclaims: "Oh why was I not taught like this!" and elderly gentlemen excitedly enroll themselves as students and distract classes of infants by their desperate endeavours to beat two in a bar with one hand and three with the other, and start off on earnest walks around the room, taking two steps backward whenever M. Dalcroze calls out "Hop!"

Indeed, if you put aside the fact that the days of our age are threescore and ten, each of us is capable of uttering an *infinite* number of different sentences. By the same logic that shows that there are an infinite number of integers—if you ever think you have the largest integer, just add 1 to it and you will have another—there must be an infinite number of sentences. The *Guinness Book of World Records* once claimed to recognize the longest English sentence: a 1,300-word stretch in William Faulkner's novel *Absalom, Absalom!* that begins:

> They both bore it as though in deliberate flagellant exaltation . . .

I am tempted to achieve immortality by submitting the following record-breaker:

> Faulkner wrote, "They both bore it as though in deliberate flagellant exaltation . . ."

But it would be only the proverbial fifteen minutes of fame, for soon I could be bested by:

> Pinker wrote that Faulkner wrote, "They both bore it as though in deliberate flagellant exaltation . . ."

And that record, too, would fall when someone submitted:

> Who cares that Pinker wrote that Faulkner wrote, "They both bore it as though in deliberate flagellant exaltation . . ."?

And so on, ad infinitum. The infinite use of finite media distinguishes the human brain from virtually all the artificial language devices we commonly come across, like pull-string dolls, cars that nag you to close the door, and cheery voice-mail instructions ("Press the pound key for more options"), all of which use a fixed list of prefabricated sentences.

The second consequence of the design of grammar is that it is a code that is *autonomous* from cognition. A grammar specifies how words may combine to express meanings; that specification is independent of the particular meanings we typically convey or expect others to convey to us. Thus we all sense that some strings of words that can be given common-sense interpretations do not conform to the grammatical code of English. Here are some strings that we can easily interpret but that we sense are not properly formed:

> Welcome to Chinese Restaurant. Please try your Nice Chinese Food with Chopsticks: the traditional and typical of Chinese glorious history and cultual.
> It's a flying finches, they are.
> The child seems sleeping.
> Is raining.
> Sally poured the glass with water.
> Who did a book about impress you?
>
> Skid crash hospital.
> Drum vapor worker cigarette flick boom.
>
> This sentence no verb.
> This sentence has contains two verbs.
> This sentence has cabbage six words.
> This is not a complete. This either.

These sentences are "ungrammatical," not in the sense of split infinitives, dangling participles, and the other hobgoblins of the schoolmarm, but in the sense that every ordinary speaker of the casual vernacular has a gut feeling that something is wrong with them, despite their interpretability. Ungrammaticality is simply a consequence of our having a fixed code for interpreting sentences. For some strings a meaning can be guessed, but we lack confidence that the speaker has used the same code in producing the sentence as we used in interpreting it. For similar reasons, computers, which are less forgiving of ungrammatical input than human listeners, express their displeasure in all-too-familiar dialogues like this one:

```
› PRINT (x + 1
*****SYNTAX ERROR*****
```

The opposite can happen as well. Sentences can make no sense but can still be recognized as grammatical. The classic example is a sentence from Chomsky, his only entry in *Bartlett's Familiar Quotations*:

> Colorless green ideas sleep furiously.

The sentence was contrived to show that syntax and sense can be independent of each other, but the point was made long before Chomsky; the genre of nonsense verse and prose, popular in the nineteenth century, depends on it. Here is an example from Edward Lear, the acknowledged master of nonsense:

> It's a fact the whole world knows,
> That Pobbles are happier without their toes.

Mark Twain once parodied the romantic description of nature written more for its mellifluousness than its content:

> It was a crisp and spicy morning in early October. The lilacs and laburnums, lit with the glory-fires of autumn, hung burning and flashing in the upper air, a fairy bridge provided by kind Nature for the wingless wild things that have their homes in the tree-tops and would visit together; the larch and the pomegranate flung their purple and yellow flames in brilliant broad splashes along

> the slanting sweep of the woodland; the sensuous fragrance of innumerable deciduous flowers rose upon the swooning atmosphere; far in the empty sky a solitary esophagus slept upon motionless wing; everywhere brooded stillness, serenity, and the peace of God.

And almost everyone knows the poem in Lewis Carroll's *Through the Looking-Glass* that ends:

> And, as in uffish thought he stood,
> The Jabberwock, with eyes of flame,
> Came whiffling through the tulgey wood,
> And burbled as it came!
>
> One, two! One, two! And through and through
> The vorpal blade went snicker-snack!
> He left it dead, and with its head
> He went galumphing back.
>
> "And hast thou slain the Jabberwock?
> Come to my arms, my beamish boy!
> O frabjous day! Callooh! Callay!"
> He chortled in his joy.
>
> 'Twas brillig, and the slithy toves
> Did gyre and gimble in the wabe:
> All mimsy were the borogoves,
> And the mome raths outgrabe.

As Alice said, "Somehow it seems to fill my head with ideas—only I don't exactly know what they are!" But though common sense and common knowledge are of no help in understanding these passages, English speakers recognize that they are grammatical, and their mental rules allow them to extract precise, though abstract, frameworks of meaning. Alice deduced, "*Somebody* killed *something*: that's clear, at any rate—." And after reading Chomsky's entry in *Bartlett's*, anyone can answer questions like "What slept? How? Did one thing sleep, or several? What kind of ideas were they?"

How might the combinatorial grammar underlying human language work? The most straightforward way to combine words in order is explained in Michael Frayn's novel *The Tin Men*. The protagonist, Goldwasser, is an engineer working at an institute for automation. He must devise a computer system that generates the standard kinds of stories found in the daily papers, like "Paralyzed Girl Determined to Dance Again." Here he is hand-testing a program that composes stories about royal occasions:

> He opened the filing cabinet and picked out the first card in the set. *Traditionally*, it read. Now there was a random choice between cards reading *coronations, engagements, funerals, weddings, comings of age, births, deaths*, or *the churching of women*. The day before he had picked *funerals*, and been directed on to a card reading with simple perfection *are occasions for mourning*. Today he closed his eyes, drew *weddings*, and was signposted on to *are occasions for rejoicing*.
>
> *The wedding of X and Y* followed in logical sequence, and brought him a choice between *is no exception* and *is a case in point*. Either way there followed *indeed*. Indeed, whichever occasion one had started off with, whether coronations, deaths, or births, Goldwasser saw with intense mathematical pleasure, one now reached this same elegant bottleneck. He paused on *indeed*, then drew in quick succession *it is a particularly happy occasion, rarely*, and *can there have been a more popular young couple*.
>
> From the next selection, Goldwasser drew *X has won himself/herself a special place in the nation's affections*, which forced him to go on to *and the British people have clearly taken Y to their hearts already*.
>
> Goldwasser was surprised, and a little disturbed, to realise that the word "fitting" had still not come up. But he drew it with the next card—*it is especially fitting that*.
>
> This gave him *the bride/bridegroom should be*, and an open choice between *of such a noble and illustrious line, a commoner in these democratic times, from a nation with which this country has long enjoyed a particularly close and cordial relationship*, and *from a nation with which this country's relations have not in the past been always happy*.
>
> Feeling that he had done particularly well with "fitting" last time, Goldwasser now deliberately selected it again. *It is also fitting that*, read the card, to be quickly followed by *we should remember*, and

X and Y are not merely symbols—they are a lively young man and a very lovely young woman.

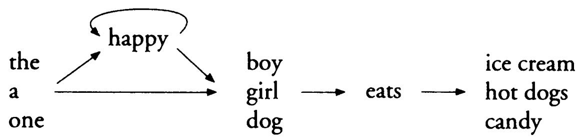
Goldwasser shut his eyes to draw the next card. It turned out to read *in these days when*. He pondered whether to select *it is fashionable to scoff at the traditional morality of marriage and family life* or *it is no longer fashionable to scoff at the traditional morality of marriage and family life*. The latter had more of the form's authentic baroque splendour, he decided.

Let's call this a word-chain device (the technical name is a "finite-state" or "Markov" model). A word-chain device is a bunch of lists of words (or prefabricated phrases) and a set of directions for going from list to list. A processor builds a sentence by selecting a word from one list, then a word from another list, and so on. (To recognize a sentence spoken by another person, one just checks the words against each list in order.) Word-chain systems are commonly used in satires like Frayn's, usually as do-it-yourself recipes for composing examples of a kind of verbiage. For example, here is a Social Science Jargon Generator, which the reader may operate by picking a word at random from the first column, then a word from the second, then one from the third, and stringing them together to form an impressive-sounding term like *inductive aggregating interdependence*:

dialectical	participatory	interdependence
defunctionalized	degenerative	diffusion
positivistic	aggregating	periodicity
predicative	appropriative	synthesis
multilateral	simulated	sufficiency
quantitative	homogeneous	equivalence
divergent	transfigurative	expectancy
synchronous	diversifying	plasticity
differentiated	cooperative	epigenesis
inductive	progressive	constructivism
integrated	complementary	deformation
distributive	eliminative	solidification

Recently I saw a word-chain device that generates breathless book jacket blurbs, and another for Bob Dylan song lyrics.

A word-chain device is the simplest example of a discrete combinatorial system, since it is capable of creating an unlimited number of distinct combinations from a finite set of elements. Parodies notwithstanding, a word-chain device can generate infinite sets of grammatical English sentences. For example, the extremely simple scheme



assembles many sentences, such as *A girl eats ice cream* and *The happy dog eats candy*. It can assemble an infinite number because of the loop at the top that can take the device from the *happy* list back to itself any number of times: *The happy dog eats ice cream, The happy happy dog eats ice cream*, and so on.

When an engineer has to build a system to combine words in particular orders, a word-chain device is the first thing that comes to mind. The recorded voice that gives you a phone number when you dial directory assistance is a good example. A human speaker is recorded uttering the ten digits, each in seven different sing-song patterns (one for the first position in a phone number, one for the second position, and so on). With just these seventy recordings, ten million phone numbers can be assembled; with another thirty recordings for three-digit area codes, ten billion numbers are possible (in practice, many are never used because of restrictions like the absence of 0 and 1 from the beginning of a phone number). In fact there have been serious efforts to model the English language as a very large word chain. To make it as realistic as possible, the transitions from one word list to another can reflect the actual probabilities that those kinds of words follow one another in English (for example, the word *that* is much more likely to be followed by *is* than by *indicates*). Huge databases of these "transition probabilities" have been compiled by having a computer analyze bodies of English text or by asking volunteers to name the words that first come to mind after a given word or series of words. Some psychologists have suggested that human language is based on a huge word chain stored in the brain. The idea is congenial to stimulus-response theories: a stimulus elicits a spoken word as a response, then the speaker perceives his or her own response, which serves as the next stimulus, eliciting one out of several words as the next response, and so on.

But the fact that word-chain devices seem ready-made for parodies like Frayn's raises suspicions. The point of the various parodies is that the genre being satirized is so mindless and cliché-ridden that a simple mechanical method can churn out an unlimited number of examples that can almost pass for the real thing. The humor works because of the discrepancy between the two: we all assume that people, even sociologists and reporters, are not really word-chain devices; they only seem that way.

The modern study of grammar began when Chomsky showed that word-chain devices are not just a bit suspicious; they are deeply, fundamentally, the wrong way to think about how human language works. They are discrete combinatorial systems, but they are the wrong kind. There are three problems, and each one illuminates some aspect of how language really does work.

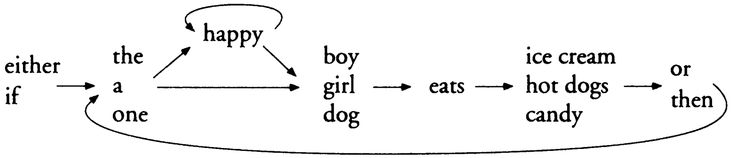
First, a sentence of English is a completely different thing from a string of words chained together according to the transition probabilities of English. Remember Chomsky's sentence *Colorless green ideas sleep furiously*. He contrived it not only to show that nonsense can be grammatical but also to show that improbable word sequences can be grammatical. In English texts the probability that the word *colorless* is followed by the word *green* is surely zero. So is the probability that *green* is followed by *ideas, ideas* by *sleep*, and *sleep* by *furiously*. Nonetheless, the string is a well-formed sentence of English. Conversely, when one actually assembles word chains using probability tables, the resulting word strings are very far from being well-formed sentences. For example, say you take estimates of the set of words most likely to come after every four-word sequence, and use those estimates to grow a string word by word, always looking at the four most recent words to determine the next one. The string will be eerily Englishy, but not English, like *House to ask for is to earn our living by working towards a goal for his team in old New-York was a wonderful place wasn't it even pleasant to talk about and laugh hard when he tells lies he should not tell me the reason why you are is evident.*

The discrepancy between English sentences and Englishy word chains has two lessons. When people learn a language, they are learning how to put words in order, but not by recording which word follows which other word. They do it by recording which word *category*—noun, verb, and so on—follows which other category. That is, we can recognize *colorless green ideas* because it has the same order of adjectives and nouns that we learned from more familiar sequences like *strapless black dresses*. The second lesson is that the nouns and verbs and adjectives are not just hitched end to end in one long chain; there is some overarching blueprint or plan for the sentence that puts each word in a specific slot.

If a word-chain device is designed with sufficient cleverness, it can deal with these problems. But Chomsky had a definitive refutation of the very idea that a human language is a word chain. He proved that certain sets of English sentences could not, even in principle, be produced by a word-chain device, no matter how big or how faithful to probability tables the device is. Consider sentences like the following:

> Either the girl eats ice cream, or the girl eats candy.
> If the girl eats ice cream, then the boy eats hot dogs.

At first glance it seems easy to accommodate these sentences:



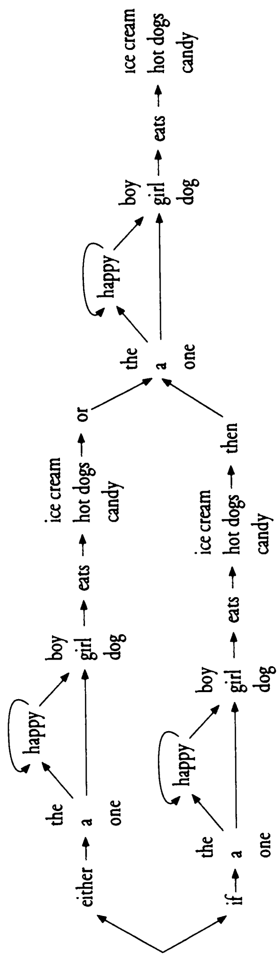
But the device does not work. *Either* must be followed later in a sentence by *or*; no one says *Either the girl eats ice cream, then the girl likes candy*. Similarly, *if* requires *then*; no one says *If the girl eats ice cream, or the girl likes candy*. But to satisfy the desire of a word early in a sentence for some other word late in the sentence, the device has to remember the early word while it is churning out all the words in between. And that is the problem: a word-chain device is an amnesiac, remembering only which word list it has just chosen from, nothing earlier. By the time it reaches the *or/then* list, it has no means of remembering whether it said *if* or *either* way back at the beginning. From our vantage point, peering down at the entire road map, we can remember which choice the device made at the first fork in the road, but the device itself, creeping antlike from list to list, has no way of remembering.

Now, you might think it would be a simple matter to redesign the device so that it does not have to remember early choices at late points in the sentence. For example, one could join up *either* and *or* and all the possible word sequences in between into one giant sequence, and *if* and *then* and all the sequences in between as a second giant sequence, before returning to a third copy of the sequence—yielding a chain so long I have to print it sideways (see page 96). There is something immediately disturbing about this solution: there are three identical subnetworks. Clearly, whatever people can say between an *either* and an *or*, they can say between an *if* and a *then*, and also after the *or* or the *then*. But this ability should come naturally out of the design of whatever the device is in people's heads that allows them to speak. It shouldn't depend on the designer's carefully writing down three identical sets of instructions (or, more plausibly, on the child's having to learn the structure of the English sentence three different times, once between *if* and *then*, once between *either* and *or*, and once after a *then* or an *or*).

But Chomsky showed that the problem is even deeper. Each of these sentences can be embedded in any of the others, including itself:

> If either the girl eats ice cream or the girl eats candy, then the boy eats hot dogs.
> Either if the girl eats ice cream then the boy eats ice cream, or if the girl eats ice cream then the boy eats candy.

For the first sentence, the device has to remember *if* and *either* so that it can continue later with *or* and *then*, in that order. For the second sentence, it has to remember *either* and *if* so that it can complete the sentence with *then* and *or*. And so on. Since there's no limit in principle to the number of *if*'s and *either*'s that can begin a sentence, each requiring its own order of *then*'s and *or*'s to complete it, it does no good to spell out each memory sequence as its own



chain of lists; you'd need an infinite number of chains, which won't fit inside a finite brain.

This argument may strike you as scholastic. No real person ever begins a sentence with *Either either if either if if*, so who cares whether a putative model of that person can complete it with *then . . . then . . . or . . . then . . . or . . . or*? But Chomsky was just adopting the esthetic of the mathematician, using the interaction between *either-or* and *if-then* as the simplest possible example of a property of language—its use of "long-distance dependencies" between an early word and a later one—to prove mathematically that word-chain devices cannot handle these dependencies.

The dependencies, in fact, abound in languages, and mere mortals use them all the time, over long distances, often handling several at once—just what a word-chain device cannot do. For example, there is an old grammarian's saw about how a sentence can end in five prepositions. Daddy trudges upstairs to Junior's bedroom to read him a bedtime story. Junior spots the book, scowls, and asks, "Daddy, what did you bring that book that I don't want to be read to out of up for?" By the point at which he utters *read*, Junior has committed himself to holding four dependencies in mind: *to be read* demands *to*, *that book that* requires *out of*, *bring* requires *up*, and *what* requires *for*. An even better, real-life example comes from a letter to *TV Guide*:

> How Ann Salisbury can claim that Pam Dawber's anger at not receiving her fair share of acclaim for *Mork and Mindy*'s success derives from a fragile ego escapes me.

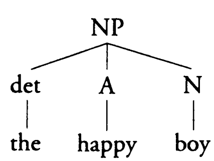
At the point just after the word *not*, the letter-writer had to keep four grammatical commitments in mind: (1) *not* requires *-ing* (her anger at *not* receiv*ing* acclaim); (2) *at* requires some kind of noun or gerund (her anger *at* not *receiving acclaim*); (3) the singular subject *Pam Dawber's anger* requires the verb fourteen words downstream to agree with it in number (Dawber's *anger* . . . *derives* from); (4) the singular subject beginning with *How* requires the verb twenty-seven words downstream to agree with it in number (*How* . . . *escapes* me). Similarly, a reader must keep these dependencies in mind while interpreting the sentence. Now, technically speaking, one could rig up a word-chain model to handle even these sentences, as long as there is some actual limit on the number of dependencies that the speaker need keep in mind (four, say). But the degree of redundancy in the device would be absurd; for each of the thousands of *combinations* of dependencies, an identical chain must be duplicated inside the device. In trying to fit such a superchain in a person's memory, one quickly runs out of brain.

The difference between the artificial combinatorial system we see in word-chain devices and the natural one we see in the human brain is summed up in a line from the Joyce Kilmer poem: "Only God can make a tree." A sentence is not a chain but a tree. In a human grammar, words are grouped into phrases, like twigs joined in a branch. The phrase is given a name—a mental symbol—and little phrases can be joined into bigger ones.

Take the sentence *The happy boy eats ice cream*. It begins with three words that hang together as a unit, the noun phrase *the happy boy*. In English a noun phrase (NP) is composed of a noun (N), sometimes preceded by an article or "determiner" (abbreviated "det") and any number of adjectives (A). All this can be captured in a rule that defines what English noun phrases look like in general. In the standard notation of linguistics, an arrow means "consists of," parentheses mean "optional," and an asterisk means "as many of them as you want," but I provide the rule just to show that all of its information can be captured precisely in a few symbols; you can ignore the notation and just look at the translation into ordinary words below it:

NP → (det) A* N
"A noun phrase consists of an optional determiner, followed by any number of adjectives, followed by a noun."

The rule defines an upside-down tree branch:



Here are two other rules, one defining the English sentence (S), the other defining the predicate or verb phrase (VP); both use the NP symbol as an ingredient:

S → NP VP
"A sentence consists of a noun phrase followed by a verb phrase."

VP → V NP
"A verb phrase consists of a verb followed by a noun phrase."

We now need a mental dictionary that specifies which words belong to which part-of-speech categories (noun, verb, adjective, preposition, determiner):

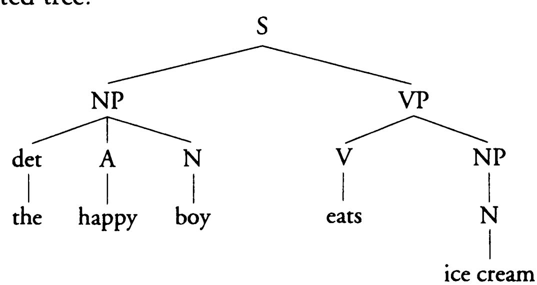
N → boy, girl, dog, cat, ice cream, candy, hot dogs
"Nouns may be drawn from the following list: *boy, girl, . . .*"

V → eats, likes, bites
"Verbs may be drawn from the following list: *eats, likes, bites.*"

A → happy, lucky, tall
"Adjectives may be drawn from the following list: *happy, lucky, tall.*"

det → a, the, one
"Determiners may be drawn from the following list: *a, the, one.*"

A set of rules like the ones I have listed—a "phrase structure grammar"—defines a sentence by linking the words to branches on an inverted tree:



The invisible superstructure holding the words in place is a powerful invention that eliminates the problems of word-chain devices. The key insight is that a tree is *modular*, like telephone jacks or garden hose couplers. A symbol like "NP" is like a connector or fitting of a certain shape. It allows one component (a phrase) to snap into any of several positions inside other components (larger phrases). Once a kind of phrase is defined by a rule and given its connector symbol, it never has to be defined again; the phrase can be plugged in anywhere there is a corresponding socket. For example, in the little grammar I have listed, the symbol "NP" is used both as the subject of a sentence (S → NP VP) and as the object of a verb phrase (VP → V NP). In a more realistic grammar, it would also be used as the object of a preposition (*near the boy*), in a possessor phrase (*the boy's hat*), as an indirect object (*give the boy a cookie*), and in several other positions. This plug-and-socket arrangement explains how people can use the same kind of phrase in many different positions in a sentence, including:

> [The happy happy boy] eats ice cream.
> I like [the happy happy boy].
> I gave [the happy happy boy] a cookie.
> [The happy happy boy]'s cat eats ice cream.

There is no need to learn that the adjective precedes the noun (rather than vice versa) for the subject, and then have to learn the same thing for the object, and again for the indirect object, and yet again for the possessor.

Note, too, that the promiscuous coupling of any phrase with any slot makes grammar autonomous from our common-sense expectations involving the meanings of the words. It thus explains why we can write and appreciate grammatical nonsense. Our little grammar defines all kinds of colorless green sentences, like *The happy happy candy likes the tall ice cream*, as well as conveying such newsworthy events as *The girl bites the dog*.

Most interestingly, the labeled branches of a phrase structure tree act as an overarching memory or plan for the whole sentence. This allows nested long-distance dependencies, like *if . . . then* and *either . . . or*, to be handled with ease. All you need is a rule defining a phrase that contains a copy of the very same kind of phrase, such as:

> S → either S or S
> "A sentence can consist of the word *either*, followed by a sentence, followed by the word *or*, followed by another sentence."