

anything but sing God's praises. I tried to get off the delivery table to kneel down and pray, but the nurses wouldn't let me."

Scientists, of course, cannot take such reports at face value; any important finding must be replicated. A replication of the Corsican miracle, this time from Taranto, Italy, occurred on October 31, 1989, when the *Sun* (a strong believer in recycling) ran the headline "BABY BORN TALKING—DESCRIBES HEAVEN. Infant's words prove reincarnation exists." A related discovery was reported on May 29, 1990: "BABY SPEAKS AND SAYS: I'M THE REINCARNATION OF NATALIE WOOD." Then, on September 29, 1992, a second replication, reported in the same words as the original. And on June 8, 1993, the clincher: "AMAZING 2-HEADED BABY IS PROOF OF REINCARNATION. ONE HEAD SPEAKS ENGLISH—THE OTHER ANCIENT LATIN."

Why do stories like Naomi's occur only in fiction, never in fact? Most children do not begin to talk until they are a year old, do not combine words until they are one and a half, and do not converse in fluent grammatical sentences until they are two or three. What is going on in those years? Should we ask why it takes children so long? Or is a three-year-old's ability to describe earth as miraculous as a newborn's ability to describe heaven?

All infants come into the world with linguistic skills. We know this because of the ingenious experimental technique (discussed in Chapter 3) in which a baby is presented with one signal over and over to the point of boredom, and then the signal is changed; if the baby perks up, he or she must be able to tell the difference. Since ears don't move the way eyes do, the psychologists Peter Eimas and Peter Jusczyk devised a different way to see what a one-month-old finds interesting. They put a switch inside a rubber nipple and hooked up the switch to a tape recorder, so that when the baby sucked, the tape played. As the tape droned on with *ba ba ba ba . . .*, the infants showed their boredom by sucking more slowly. But when the syllables changed to *pa pa pa . . .*, the infants began to suck more vigorously, to hear more syllables. Moreover, they were using the sixth sense, speech perception, rather than just hearing the syllables as raw sound: two *ba*'s that differed acoustically from each other as much as a *ba* differs from a *pa*, but that are both heard as *ba* by adults, did not revive the infants' interest. And infants must be recovering phonemes,

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Baby Born Talking— Describes Heaven

On May 21, 1985, a periodical called the *Sun* ran these intriguing headlines:

John Wayne Liked to Play with Dolls

Prince Charles' Blood Is Sold for \$10,000
by Dishonest Docs

Family Haunted by Ghost of Turkey

They Ate for Christmas

BABY BORN TALKING—DESCRIBES HEAVEN

Incredible proof of reincarnation

The last headline caught my eye—it seemed like the ultimate demonstration that language is innate. According to the article,

Life in heaven is grand, a baby told an astounded obstetrical team seconds after birth. Tiny Naomi Montefusco literally came into the world singing the praises of God's firmament. The miracle so shocked the delivery room team, one nurse ran screaming down the hall. "Heaven is a beautiful place, so warm and so serene," Naomi said. "Why did you bring me here?" Among the witnesses was mother Theresa Montefusco, 18, who delivered the child under local anesthetic . . . "I distinctly heard her describe heaven as a place where no one has to work, eat, worry about clothing, or do

like *b*, from the syllables they are smeared across. Like adults, they hear the same stretch of sound as a *b* if it appears in a short syllable and as a *w* if it appears in a long syllable.

Infants come equipped with these skills; they do not learn them by listening to their parents' speech. Kikuyu and Spanish infants discriminate English *ba*'s and *pa*'s, which are not used in Kikuyu or Spanish and which their parents cannot tell apart. English-learning infants under the age of six months distinguish phonemes used in Czech, Hindi, and Insekampx (a Native American language), but English-speaking adults cannot, even with five hundred trials of training or a year of university coursework. Adult ears can tell the sounds apart, though, when the consonants are stripped from the syllables and presented alone as chirpy sounds; they just cannot tell them apart as *phonemes*.

The *Sun* article is a bit sketchy on the details, but we can surmise that because Naomi was understood, she must have spoken in Italian, not Proto-World or Ancient Latin. Other infants may enter the world with some knowledge of their mother's language, too. The psychologists Jacques Mehler and Peter Jusczyk have shown that four-day-old French babies suck harder to hear French than Russian, and pick up their sucking more when a tape changes from Russian to French than from French to Russian. This is not an incredible proof of reincarnation; the melody of mothers' speech carries through their bodies and is audible in the womb. The babies still prefer French when the speech is electronically filtered so that the consonant and vowel sounds are muffled and only the melody comes through. But they are indifferent when the tapes are played backwards, which preserves the vowels and some of the consonants but distorts the melody. Nor does the effect prove the inherent beauty of the French language: non-French infants do not prefer French, and French infants do not distinguish Italian from English. The infants must have learned something about the prosody of French (its melody, stress, and timing) in the womb, or in their first days out of it.

Babies continue to learn the sounds of their language throughout the first year. By six months, they are beginning to lump together the distinct sounds that their language collapses into a single phoneme, while continuing to discriminate equivalently distinct ones that their language keeps separate. By ten months they are no longer universal phoneticians but have turned into their parents; they do not distin-

guish Czech or Insekampx phonemes unless they are Czech or Insekampx babies. Babies make this transition before they produce or understand words, so their learning cannot depend on correlating sound with meaning. That is, they cannot be listening for the difference in sound between a word they think means *bit* and a word they think means *beet*, because they have learned neither word. They must be sorting the sounds directly, somehow tuning their speech analysis module to deliver the phonemes used in their language. The module can then serve as the front end of the system that learns words and grammar.

During the first year, babies also get their speech production systems geared up. First, ontogeny recapitulates phylogeny. A newborn has a vocal tract like a nonhuman mammal. The larynx comes up like a periscope and engages the nasal passage, forcing the infant to breathe through the nose and making it anatomically possible to drink and breathe at the same time. By three months the larynx has descended deep into the throat, opening up the cavity behind the tongue (the pharynx) that allows the tongue to move forwards and backwards and produce the variety of vowel sounds used by adults.

Not much of linguistic interest happens during the first two months, when babies produce the cries, grunts, sighs, clicks, stops, and pops associated with breathing, feeding, and fussing, or even during the next three, when coos and laughs are added. Between five and seven months babies begin to play with sounds, rather than using them to express their physical and emotional states, and their sequences of clicks, hums, glides, trills, hisses, and smacks begin to sound like consonants and vowels. Between seven and eight months they suddenly begin to babble in real syllables like *ba-ba-ba*, *neh-neh-neh*, and *dee-dee-dee*. The sounds are the same in all languages, and consist of the phonemes and syllable patterns that are most common across languages. By the end of the first year, babies vary their syllables, like *neh-nee*, *da-dee*, and *meh-neh*, and produce that really cute sentencelike gibberish.

In recent years pediatricians have saved the lives of many babies with breathing abnormalities by inserting a tube into their tracheas (the pediatricians are trained on cats, whose airways are similar), or by surgically opening a hole in their trachea below the larynx. The infants are then unable to make voiced sounds during the normal period of babbling. When the normal airway is restored in the second

year of life, those infants are seriously retarded in speech development, though they eventually catch up, with no permanent problems. Deaf children's babbling is later and simpler—though if their parents use sign language, they babble, on schedule, with their hands!

Why is babbling so important? The infant is like a person who has been given a complicated piece of audio equipment bristling with unlabeled knobs and switches but missing the instruction manual. In such situations people resort to what hackers call fiddling—fiddling aimlessly with the controls to see what happens. The infant has been given a set of neural commands that can move the articulators every which way, with wildly varying effects on the sound. By listening to their own babbling, babies in effect write their own instruction manual; they learn how much to move which muscle in which way to make which change in the sound. This is a prerequisite to duplicating the speech of their parents. Some computer scientists, inspired by the infant, believe that a good robot should learn an internal software model of its articulators by observing the consequences of its own babbling and flailing.



Shortly before their first birthday, babies begin to understand words, and around that birthday, they start to produce them. Words are usually produced in isolation; this one-word stage can last from two months to a year. For over a century, and all over the globe, scientists have kept diaries of their infants' first words, and the lists are almost identical. About half the words are for objects: food (*juice, cookie*), body parts (*eye, nose*), clothing (*diaper, sock*), vehicles (*car, boat*), toys (*doll, block*), household items (*bottle, light*), animals (*dog, kitty*), and people (*dada, baby*). (My nephew Eric's first word was *Batman*.) There are words for actions, motions, and routines, like *up, off, open, peekaboo, eat, and go*, and modifiers, like *hot, allgone, more, dirty, and cold*. Finally, there are routines used in social interaction, like *yes, no, want, bye-bye*, and *hi*—a few of which, like *look at that* and *what is that*, are words in the sense of listemes (memorized chunks), but not, at least for the adult, words in the sense of morphological products and syntactic atoms. Children differ in how much they name objects or engage in social interaction using memorized routines. Psychologists have spent a lot of time speculating about the causes of those differences (sex, age, birth order, and socioeconomic

status have all been examined), but the most plausible to my mind is that babies are people, only smaller. Some are interested in objects, others like to shmooze.

Since word boundaries do not physically exist, it is remarkable that children are so good at finding them. A baby is like the dog being yelled at in the two-panel cartoon by Gary Larson:

WHAT WE SAY TO DOGS: "Okay, Ginger! I've had it! You stay out of the garbage! Understand, Ginger? Stay out of the garbage, or else!"

WHAT THEY HEAR: "Blah blah GINGER blah blah blah blah blah blah blah blah GINGER blah blah blah blah blah."

Presumably children record some words parents use in isolation, or in stressed final positions, like *Look-at-the BOTTLE*. Then they look for matches to these words in longer stretches of speech, and find other words by extracting the residues in between the matched portions. Occasionally there are near misses, providing great entertainment to family members:

I don't want to go to your ami. [from *Miami*]

I am heyv! [from *Behave!*]

Daddy, when you go tinkle you're an eight, and when I go tinkle I'm an eight, right? [from *urinate*]

I know I sound like Larry, but who's Gitis? [from *laryngitis*]

Daddy, why do you call your character Sam Alone? [from

Sam Malone, the bartender in *Cheers*]

The ants are my friends, they're blowing in the wind. [from

The answer, my friend, is blowing in the wind]

But these errors are surprisingly rare, and of course adults occasionally make them too, as in the Pullet Surprise and doggy-dog world of Chapter 6. In an episode of the television show *Hill Street Blues*, police officer JD Larue began to flirt with a pretty high school student. His partner, Neal Washington, said, "I have only three words to say to you, JD. Statue. Tory. Rape."



Around eighteen months, language takes off. Vocabulary growth jumps to the new-word-every-two-hours minimum rate that the child

will maintain through adolescence. And syntax begins, with strings of the minimum length that allows it: two. Here are some examples:

All dry.	All messy.	All wet.
I sit.	I shut.	No bed.
No pee.	See baby.	See pretty.
More cereal.	More hot.	Hi Calico.
Other pocket.	Boot off.	Siren by.
Mail come.	Airplane allgone.	Bye-bye car.
Our car.	Papa away.	Dry pants.

Children's two-word combinations are so similar in meaning the world over that they read as translations of one another. Children announce when objects appear, disappear, and move about, point out their properties and owners, comment on people doing things and seeing things, reject and request objects and activities, and ask about who, what, and where. These microsentences already reflect the language being acquired: in ninety-five percent of them, the words are properly ordered.

There is more going on in children's minds than in what comes out of their mouths. Even before they put two words together, babies can comprehend a sentence using its syntax. For example, in one experiment, babies who spoke only in single words were seated in front of two television screens, each of which featured a pair of adults improbably dressed up as Cookie Monster and Big Bird from *Sesame Street*. One screen showed Cookie Monster tickling Big Bird; the other showed Big Bird tickling Cookie Monster. A voiceover said, "OH LOOK!!! BIG BIRD IS TICKLING COOKIE MONSTER!! FIND BIG BIRD TICKLING COOKIE MONSTER!!" (or vice versa). The children must have understood the meaning of the ordering of subject, verb, and object—they looked more at the screen that depicted the sentence in the voiceover.

When children do put words together, the words seem to meet up with a bottleneck at the output end. Children's two-and three-word utterances look like samples drawn from longer potential sentences expressing a complete and more complicated idea. For example, the psychologist Roger Brown noted that although the children he studied never produced a sentence as complicated as *Mother gave John lunch*

in the *kitchen*, they did produce strings containing all of its components, and in the correct order:

AGENT	ACTION	RECIPIENT	OBJECT	LOCATION
(Mother	gave	John	lunch	in the kitchen.)
Mommy	fix.		pumpkin.	
Mommy				table.
Baby		doggie.		
Give	Put		light.	
	Put			floor.
I	ride		horsie.	
Tractor	go			floor.
	Give	doggie	paper.	
	Put		truck	window.
Adam	put		it	box.

If we divide language development into somewhat arbitrary stages, like Syllable Babbling, Gibberish Babbling, One-Word Utterances, and Two-Word Strings, the next stage would have to be called All Hell Breaks Loose. Between the late twos and the mid-threes, children's language blooms into fluent grammatical conversation so rapidly that it overwhelms the researchers who study it, and no one has worked out the exact sequence. Sentence length increases steadily, and because grammar is a discrete combinatorial system, the number of syntactic types increases exponentially, doubling every month, reaching the thousands before the third birthday. You can get a feel for this explosion by seeing how the speech of a little boy called Adam grows in sophistication over the period of a year, starting with his early word combinations at the age of two years and three months ("2;3"):

2;3: Play checkers. Big drum. I got horn. A bunny-rabbit walk.

2;4: See marching bear go? Screw part machine. That busy bulldozer truck.

2;5: Now put boots on. Where wrench go? Mommy talking bout lady. What that paper clip doing?

- 2;6: Write a piece a paper. What that egg doing? I lost a shoe. No, I don't want to sit seat.
- 2;7: Where piece a paper go? Ursula has a boot on. Going to see kitten. Put the cigarette down. Dropped a rubber band. Shadow has hat just like that. Rintintin don't fly, Mommy.
- 2;8: Let me get down with the boots on. Don't be afraid a horses. How tiger be so healthy and fly like kite? Joshua throw like a penguin.
- 2;9: Where Mommy keep her pocket book? Show you something funny. Just like turtle make mud pie.
- 2;10: Look at that train Ursula brought. I simply don't want put in chair. You don't have paper. Do you want little bit, Cromer? I can't wear it tomorrow.
- 2;11: That birdie hopping by Missouri in bag. Do want some pie on your face? Why you mixing baby chocolate? I finish drinking all up down my throat. I said why not you coming in? Look at that piece a paper and tell it. Do you want me tie that round? We going turn light on so you can't see.
- 3;0: I going come in fourteen minutes. I going wear that to wedding. I see what happens. I have to save them now. Those are not strong mens. They are going sleep in wintertime. You dress me up like a baby elephant.
- 3;1: I like to play with something else. You know how to put it back together. I gon' make it like a rocket to blast off with. I put another one on the floor. You went to Boston University? You want to give me some carrots and some beans? Press the button and catch it, sir. I want some other peanuts. Why you put the pacifier in his mouth? Doggies like to climb up.
- 3;2: So it can't be cleaned? I broke my racing car. Do you know the light vents off? What happened to the bridge? When it's got a flat tire it's need a go to the station. I dream sometimes. I'm going to mail this so the letter can't come off. I want to have some espresso. The sun is not too bright. Can I have some sugar? Can I put my head in the mailbox so the mailman can know where I are and put me in the mailbox? Can I

keep the screwdriver just like a carpenter keep the screwdriver?

Normal children can differ by a year or more in their rate of language development, though the stages they pass through are generally the same regardless of how stretched out or compressed. I chose to show you Adam's speech because his language development is rather *slow* compared with other children's. Eve, another child Brown studied, was speaking in sentences like this before she was two:

I got peanut butter on the paddle.
I sit in my high chair yesterday.
Fraser, the doll's not in your briefcase.
Fix it with the scissor.
Sue making more coffee for Fraser.

Her stages of language development were telescoped into just a few months.

Many things are going on during this explosion. Children's sentences are getting not only longer but more complex, with deeper, bushier trees, because the children can embed one constituent inside another. Whereas before they might have said *Give doggie paper* (a three-branch verb phrase) and *Big doggie* (a two-branch noun phrase), they now say *Give big doggie paper*, with the two-branch NP embedded inside the middle branch of three-branch VP. The earlier sentences resembled telegrams, missing unstressed function words like *of*, *the*, *on*, and *does*, as well as inflections like *-ed*, *-ing*, and *-s*. By the threes, children are using these function words more often than they omit them, many in more than ninety percent of the sentences that require them. A full range of sentence types flower—questions with words like *who*, *what*, and *where*, relative clauses, comparatives, negations, complements, conjunctions, and passives.

Though many—perhaps even most—of the young three-year-olds' sentences are ungrammatical for one reason or another, we should not judge them too harshly, because there are many things that can go wrong in any single sentence. When researchers focus on one grammatical rule and count how often a child obeys it and how often he or she flouts it, the results are astonishing: for any rule you choose, three-year-olds obey it most of the time. As we have seen, children

rarely scramble word order and, by the age of three, come to supply most inflections and function words in sentences that require them. Though our ears perk up when we hear errors like *mens, wents, Can you broke those?, What he can ride in?, That's a furniture, Button me the rest, and Going to see kitten*, the errors occur in only 0.1% to 8% of the opportunities for making them; more than 90% of the time, the child is on target. The psychologist Karin Stromswold analyzed sentences containing auxiliaries from the speech of thirteen preschoolers. The auxiliary system in English (including words like *can, should, must, be, have, and do*) is notorious among grammarians for its complexity. There are about twenty-four billion billion logically possible combinations of auxiliaries (for instance, *He have might eat, He did be eating*), of which only a hundred are grammatical (*He might have eaten; He has been eating*). Stromswold wanted to count how many times children were seduced by several dozen kinds of tempting errors in the auxiliary system—that is, errors that would be natural generalizations of the sentence patterns children heard from their parents:

PATTERN IN ADULT ENGLISH ERROR THAT MIGHT TEMPT A CHILD

He seems happy. → Does he seem happy?	He is smiling. → Does he be smiling?
He did eat. → He didn't eat.	She could go. → Does she could go?
He did eat. → Did he eat?	He did a few things. → He didn't a few things.
I like going. → He likes going.	He did a few things. → Did he a few things?
They want to sleep. → They wanted to sleep.	I can go. → He cans go.
He is happy. → He is not happy.	I am going. → He ams (or be's) going.
He is happy. → Is he happy?	They are sleeping. → They are'd (or be'd) sleeping.
	He ate something. → He ate not something.
	He ate something. → Ate he something?

For virtually all of these patterns, she found *no* errors among the 66,000 sentences in which they could have occurred.

The three-year-old child is grammatically correct in quality, not just quantity. In earlier chapters we learned of experiments showing that children's movement rules are structure-dependent ("Ask Jabba if the boy who is unhappy is watching Mickey Mouse") and showing that their morphological systems are organized into layers of roots, stems, and inflections ("This monster likes to eat rats; what do you call him?"). Children also seem fully prepared for the Babel of languages they may face: they swiftly acquire free word order, SOV and VSO orders, rich systems of case and agreement, strings of agglutinated suffixes, ergative case marking, or whatever else their language throws at them, with no lag relative to their English-speaking counterparts. Languages with grammatical gender like French and German are the bane of the Berlitz student. In his essay "The Horrors of the German Language," Mark Twain noted that "a tree is male, its buds are female, its leaves are neuter; horses are sexless, dogs are male, cats are female—tomcats included." He translated a conversation in a German Sunday school book as follows:

Gretchen: Wilhelm, where is the turnip?

Wilhelm: She has gone to the kitchen.

Gretchen: Where is the accomplished and beautiful English maiden?

Wilhelm: It has gone to the opera.

But little children learning German (and other languages with gender) are not horrified; they acquire gender marking quickly, make few errors, and never use the association with maleness and femaleness as a false criterion. It is safe to say that except for constructions that are rare, used predominantly in written language, or mentally taxing even to an adult (like *The horse that the elephant tickled kissed the pig*), all languages are acquired, with equal ease, before the child turns four.

The errors children do make are rarely random garbage. Often the errors follow the logic of grammar so beautifully that the puzzle is not why the children make the errors, but why they sound like errors to adult ears at all. Let me give you two examples that I have studied in great detail.

Perhaps the most conspicuous childhood error is to overgeneralize—the child puts a regular suffix, like the plural *-s* or the past tense *-ed*,

onto a word that forms its plural or its past tense in an irregular way. Thus the child says *tooths* and *mouses* and comes up with verb forms like these:

My teacher holded the baby rabbits and we patted them.

Hey, Horton hearded a Who.

I finded René.

I love cut-upped egg.

Once upon a time a alligator was eating a dinosaur and the dinosaur was eating the alligator and the dinosaur was eaten by the alligator and the alligator goed kerplunk.

These forms sound wrong to us because English contains about 180 irregular verbs like *held*, *heard*, *cut*, and *went*—many inherited from Proto-Indo-European!—whose past-tense forms cannot be predicted by rule but have to be memorized by rote. Morphology is organized so that whenever a verb has an idiosyncratic form listed in the mental dictionary, the regular *-ed* rule is blocked: *goed* sounds ungrammatical because it is blocked by *went*. Elsewhere, the regular rule applies freely.

So why do children make this kind of error? There is a simple explanation. Since irregular forms have to be memorized and memory is fallible, any time the child tries to use a sentence in the past tense with an irregular verb but cannot summon its past-tense form from memory, the regular rule fills the vacuum. If the child wants to use the past tense of *hold* but cannot dredge up *held*, the regular rule, applying by default, marks it as *holded*. We know fallible memory is the cause of these errors because the irregular verbs that are used the least often by parents (*drank* and *knew*, for instance) are the ones their children err on the most; for the more common verbs, children are correct most of the time. The same thing happens to adults: lower-frequency, less-well-remembered irregular forms like *trod*, *strove*, *dwelt*, *rent*, *slew*, and *smote* sound odd to modern American ears and are likely to be regularized to *treaded*, *strived*, *dwelled*, *rended*, *slayed*, and *smited*. Since it's we grownups who are forgetting the irregular past, we get to declare that the forms with *-ed* are not errors! Indeed, over the centuries many of these conversions have become permanent. Old English and Middle English had about twice as many irregular verbs as Modern English; if Chaucer were here today, he would tell

you that the past tenses of *to chide*, *to geld*, *to abide*, and *to cleave* are *chid*, *gelt*, *abode*, and *clove*. As time passes, verbs can wane in popularity, and one can imagine a time when, say, the verb *to geld* had slipped so far that a majority of adults could have lived their lives seldom having heard its past-tense form *gelt*. When pressed, they would have used *gelded*; the verb had become regular for them and all subsequent generations. The psychological process is no different from what happens when a young child has lived his or her brief life seldom having heard the past-tense form *built* and, when pressed, comes up with *builded*. The only difference is that the child is surrounded by grownups who are still using *built*. As the child lives longer and hears *built* more and more times, the mental dictionary entry for *built* becomes stronger and it comes to mind more and more readily, turning off the "add *-ed*" rule each time it does.

Here is another lovely set of examples of childhood grammatical logic, discovered by the psychologist Melissa Bowerman:

Go me to the bathroom before you go to bed.

The tiger will come and eat David and then he will be died

and I won't have a little brother any more.

I want you to take me a camel ride over your shoulders into my room.

Be a hand up your nose.

Don't giggle me!

Yawny Baby—you can push her mouth open to drink her.

These are examples of the causative rule, found in English and many other languages, which takes an intransitive verb meaning "to do something" and converts it to a transitive verb meaning "to cause to do something":

The butter melted. → Sally melted the butter.

The ball bounced. → Hiram bounced the ball.

The horse raced past the barn. → The jockey raced the horse past the barn.

The causative rule can apply to some verbs but not others; occasionally children apply it too zealously. But it is not easy, even for a linguist, to say why a ball can bounce or be bounced, and a horse can

race or be raced, but a brother can only die, not be died, and a girl can only giggle, not be giggled. Only a few kinds of verbs can easily undergo the rule: verbs referring to a change of the physical state of an object, like *melt* and *break*, verbs referring to a manner of motion, like *bounce* and *slide*, and verbs referring to an accompanied locomotion, like *race* and *dance*. Other verbs, like *go* and *die*, refuse to undergo the rule in English, and verbs involving fully voluntary actions, like *cook* and *play*, refuse to undergo the rule in almost every language (and children rarely err on them). Most of children's errors in English, in fact, would be grammatical in other languages. English-speaking adults, like their children, occasionally stretch the envelope of the rule:

In 1976 the Parti Québécois began to deteriorate the health care system.

Sparkle your table with Cape Cod classic glass-ware.
Well, that decided me.

This new golf ball could obsolete many golf courses.

If she subscribes us up, she'll get a bonus.

Sunbeam whips out the holes where staling air can hide.

So both children and adults stretch the language a bit to express causation; adults are just a tiny bit more fastidious in which verbs they stretch.



The three-year-old, then, is a grammatical genius—master of most constructions, obeying rules far more often than flouting them, respecting language universals, erring in sensible, adultlike ways, and avoiding many kinds of errors altogether. How do they do it? Children of this age are notably incompetent at most other activities. We won't let them drive, vote, or go to school, and they can be flummoxed by no-brainer tasks like sorting beads in order of size, reasoning whether a person could be aware of an event that took place while the person was out of the room, and knowing that the volume of a liquid does not change when it is poured from a short, wide glass into a tall, narrow one. So they are not doing it by the sheer power of their overall acumen. Nor could they be imitating what they hear, or else they would never say *goed* or *Don't giggle me*. It is plausible that the

basic organization of grammar is wired into the child's brain, but they still must reconstruct the nuances of English or Kivunjo or Ainu. So how does experience interact with wiring to give a three-year-old the grammar of a particular language?

We know that this experience must include, at a minimum, the speech of other human beings. For several thousand years thinkers have speculated about what would happen to infants deprived of speech input. In the seventh century B.C., according to the historian Herodotus, King Psamtik I of Egypt had two infants separated from their mothers at birth and raised in silence in a shepherd's hut. The king's curiosity about the original language of the world allegedly was satisfied two years later when the shepherd heard the infants use a word in Phrygian, an Indo-European language of Asia Minor. In the centuries since, there have been many stories about abandoned children who have grown up in the wild, from Romulus and Remus, the eventual founders of Rome, to Mowgli in Kipling's *The Jungle Book*. There have also been occasional real-life cases, like Victor, the Wild Boy of Aveyron (the subject of a lovely film by François Truffaut), and, in the twentieth century, Kamala, Amala, and Ramu from India. Legend has these children raised by bears or wolves, depending on which one has the greater affinity to humans in the prevailing mythology of the region, and this scenario is repeated as fact in many textbooks, but I am skeptical. (In a Darwinian animal kingdom it would be a spectacularly stupid bear that when faced with the good fortune of a baby in its lair would rear it rather than eat it. Though some species can be fooled by foster offspring, like birds by cuckoos, bears and wolves are predators of young mammals and are unlikely to be so gullible.) Occasionally other modern children have grown up wild because depraved parents have raised them silently in dark rooms and attics. The outcome is always the same: the children are mute, and often remain so. Whatever innate grammatical abilities there are, they are too schematic to generate speech, words, and grammatical constructions on their own.

The muteness of wild children in one sense emphasizes the role of nurture over nature in language development, but I think we gain more insight by thinking around that tired dichotomy. If Victor or Kamala had run out of the woods speaking fluent Phrygian or Proto-World, who could they have talked to? As I suggested in the preceding chapter, even if the genes themselves specify the basic design of

elliptical, fragmentary conversation we saw in the Watergate transcripts. But as we discovered in Chapter 2, Motherese is not an indispensable curriculum of Language-Made-Simple lessons. In some cultures, parents do not talk to their children until the children are capable of keeping up their end of the conversation (though other children might talk to them). Furthermore, Motherese is *not* grammatically simple. That impression is an illusion; grammar is so instinctive that we do not appreciate which constructions are complex until we try to work out the rules behind them. Motherese is riddled with questions containing *who*, *what*, and *where*, which are among the most complicated constructions in English. For example, to assemble the "simple" question *What did he eat?*, based on *He ate what*, one must move the *what* to the beginning of the sentence, leaving a "trace" that indicates its semantic role of "thing eaten," insert the meaningless auxiliary *do*, make sure that the *do* is in the tense appropriate to the verb, in this case *did*, convert the verb to the infinitive form *eat*, and invert the position of subject and auxiliary from the normal *He did* to the interrogative *Did he*. No mercifully designed language curriculum would use these sentences in Lesson 1, but that is just what mothers do when speaking to their babies.

A better way to think of Motherese is to liken it to the vocalizations that other animals direct to their young. Motherese has interpretable melodies: a rise-and-fall contour for approving, a set of sharp, staccato bursts for prohibiting, a rise pattern for directing attention, and smooth, low legato murmurs for comforting. The psychologist Anne Fernald has shown that these patterns are very widespread across language communities, and may be universal. The melodies attract the child's attention, mark the sounds as speech as opposed to stomach growlings or other noises, distinguish statements, questions, and imperatives, delineate major sentence boundaries, and highlight new words. When given a choice, babies prefer to listen to Motherese than to speech intended for adults.

Surprisingly, though practice is important in training for the gymnastics of speaking, it may be superfluous in learning grammar. For various neurological reasons children are sometimes unable to articulate, but parents report that their comprehension is excellent. Karin Stromswold recently tested one such four-year-old. Though he could not speak, he could understand subtle grammatical differences. He could identify which picture showed "The dog was bitten by the

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language, they might have to store the specifics of language in the environment, to ensure that a person's language is synchronized with everyone else's despite the genetic uniqueness of every individual. In this sense, language is like another quintessentially social activity. James Thurber and E. B. White once wrote:

There is a very good reason why the erotic side of Man has called forth so much more discussion lately than has his appetite for food. The reason is this: that while the urge to eat is a personal matter which concerns no one but the person hungry (or, as the German has it, *der hungrig Mensch*), the sex urge involves, for its true expression, another individual. It is this "other individual" that causes all the trouble.

Though speech input is necessary for speech development, a mere soundtrack is not sufficient. Deaf parents of hearing children were once advised to have the children watch a lot of television. In no case did the children learn English. Without already knowing the language, it is difficult for a child to figure out what the characters in those odd, unresponsive televised worlds are talking about. Live human speakers tend to talk about the here and now in the presence of children; the child can be more of a mind-reader, guessing what the speaker might mean, especially if the child already knows many content words. Indeed, if you are given a translation of the content words in parents' speech to children in some language whose grammar you do not know, it is quite easy to infer what the parents meant. If children can infer parents' meanings, they do not have to be pure cryptographers, trying to crack a code from the statistical structure of the transmissions. They can be a bit more like the archeologists with the Rosetta Stone, who had both a passage from an unknown language and its translation in a known one. For the child, the unknown language is English (or Japanese or Inslekampx or Arabic); the known one is mentalese.

Another reason why television soundtracks might be insufficient is that they are not in Motherese. Compared with conversations among adults, parents' speech to children is slower, more exaggerated in pitch, more directed to the here and now, and more grammatical (it is literally 99 and 44/100ths percent pure, according to one estimate). Surely this makes Motherese easier to learn from than the kind of

cat" and which showed "The cat was bitten by the dog." He could distinguish pictures that showed "The dogs chase the rabbit" and "The dog chases the rabbit." The boy also responded appropriately when Stromswold asked him, "Show me your room," "Show me your sister's room," "Show me your sister's old room," "Show me your old room," "Show me your new room," "Show me your sister's new room."

In fact, it is not surprising that grammar development does not depend on overt practice, because actually saying something aloud, as opposed to listening to what other people say, does not provide the child with information about the language he or she is trying to learn. The only conceivable information about grammar that speaking could provide would come from feedback from parents on whether the child's utterance was grammatical and meaningful. If a parent punished, corrected, misunderstood, or even reacted differently to a child's ungrammatical sentence, it could in theory inform the child that something in his growing rule system needed to be improved. But parents are remarkably unconcerned about their children's grammar; they care about truthfulness and good behavior. Roger Brown divided the sentences of Adam, Eve, and Sarah into grammatical and ungrammatical lists. For each sentence he checked whether the parent had at the time expressed approval (like "Yes, that's good") or disapproval. The proportion was the same for grammatical sentences and ungrammatical ones, which means that the parent's response had given the child no information about grammar. For example:

Child: Mamma isn't boy, he a girl.

Mother: That's right.

Child: And Walt Disney comes on Tuesday.

Mother: No, he does not.

Brown also checked whether children might learn about the state of their grammars by noticing whether they are being understood. He looked at children's well-formed and badly formed questions and whether their parents seemed to have answered them appropriately (that is, as if they understood them) or with non sequiturs. Again, there was no correlation; *What you can do?* may not be English, but it is perfectly understandable.

Indeed, when fussy parents or meddling experimenters do provide children with feedback, the children tune it out. The psycholinguist Martin Braine once tried for several weeks to stamp out one of his daughter's grammatical errors. Here is the result:

Child: Want other one spoon, Daddy.

Father: You mean, you want **THE OTHER SPOON**.

Child: Yes, I want other one spoon, please, Daddy.

Father: Can you say "the other spoon"?

Child: Other . . . one . . . spoon.

Father: Say . . . "other."

Child: Other.

Father: "Spoon."

Child: Spoon.

Father: "Other . . . Spoon."

Child: Other . . . spoon. Now give me other one spoon?

Braine wrote, "Further tuition is ruled out by her protest, vigorously supported by my wife."

As far as grammar learning goes, the child must be a naturalist, passively observing the speech of others, rather than an experimentalist, manipulating stimuli and recording the results. The implications are profound. Languages are infinite, childhoods finite. To become speakers, children cannot just memorize; they must leap into the linguistic unknown and generalize to an infinite world of as-yet-unspoken sentences. But there are untold numbers of seductive false leaps:

mind → minded; *but not* find → finded

The ice melted → He melted the ice; *but not* David died

→ He died David

She seems to be asleep → She seems asleep; *but not* She

seems to be sleeping → She seems sleeping

Sheila saw Mary with her best friend's husband → Who

did Sheila see Mary with? *but not* Sheila saw Mary and

her best friend's husband → Who did Sheila see Mary

and?

If children could count on being corrected for making such errors, they could take their chances. But in a world of grammatically obli-

ous parents, they must be more cautious—if they ever went too far and produced ungrammatical sentences together with the grammatical ones, the world would never tell them they were wrong. They would speak ungrammatically all their lives—though a better way of putting it is that that part of the language, the prohibition against the sentence types that the child was using, would not last beyond a single generation. Thus any no-feedback situation presents a difficult challenge to the design of a learning system, and it is of considerable interest to mathematicians, psychologists, and engineers studying learning in general.

How is the child designed to cope with the problem? A good start would be to build in the basic organization of grammar, so the child would try out only the kinds of generalizations that are possible in the world's languages. Dead ends like *Who did Sheila see Mary and?*, not grammatical in any language, should not even occur to a child, and indeed, no child (or adult) we know of has ever tried it. But this is not enough, because the child also has to figure out how far to leap in the particular language being acquired, and languages vary: some allow many word orders, some only a few; some allow the causative rule to apply freely, others to only a few kinds of verb. Therefore a well-designed child, when faced with several choices in how far to generalize, should, in general, be conservative: start with the smallest hypothesis about the language that is consistent with what parents say, then expand it outward as the evidence requires. Studies of children's language show that by and large that is how they work. For example, children learning English never leap to the conclusion that it is a free-word-order language and speak in all orders like *give doggie paper; give paper doggie, paper doggie give; doggie paper give*, and so on. Logically speaking, though, that would be consistent with what they hear if they were willing to entertain the possibility that their parents were just taciturn speakers of Korean, Russian, or Swedish, where several orders are possible. But children learning Korean, Russian, and Swedish do sometimes err on the side of caution and use only one of the orders allowed in the language, pending further evidence.

Furthermore, in cases where children do make errors and recover, their grammars must have some internal checks and balances, so that hearing one kind of sentence can catapult another out of the grammar. For example, if the word-building system is organized so that an

irregular form listed in the mental dictionary blocks the application of the corresponding rule, hearing *held* enough times will eventually drive out *holded*.



These general conclusions about language learning are interesting, but we would understand them better if we could trace out what actually happens from moment to moment in children's minds as sentences come in and they try to distill rules from them. Viewed up close, the problem of learning rules is even harder than it appears from a distance. Imagine a hypothetical child trying to extract patterns from the following sentences, without any innate guidance as to how human grammar works:

Jane eats chicken.

Jane eats fish.

Jane likes fish.

At first glance, patterns jump out. Sentences, the child might conclude, consist of three words: the first must be *Jane*, the second either *eats* or *likes*, the third *chicken* or *fish*. With these micro-rules, the child can already generalize beyond the input, to the brand-new sentence *Jane likes chicken*. So far, so good. But let's say the next two sentences are

Jane eats slowly.

Jane might fish.

The word *might* gets added to the list of words that can appear in second position, and the word *slowly* is added to the list that can appear in third position. But look at the generalizations this would allow:

Jane might slowly.

Jane likes slowly.

Jane might chicken.

Bad start. The same ambiguity that bedevils language parsing in the adult bedevils language acquisition in the child. The moral is that the

child must couch rules in grammatical categories like noun, verb, and auxiliary, not in actual words. That way, *fish* as a noun and *fish* as a verb would be kept separate, and the child would not adulterate the noun rule with instances of verbs and vice versa.

How might a child assign words into categories like noun and verb? Clearly, their meanings help. In all languages, words for objects and people are nouns or noun phrases, words for actions and change of state are verbs. (As we saw in Chapter 4, the converse is not true—many nouns, like *destruction*, do not refer to objects and people, and many verbs, like *interest*, do not refer to actions or changes of state.) Similarly, words for kinds of paths and places are prepositions, and words for qualities tend to be adjectives. Recall that children's first words refer to objects, actions, directions, and qualities. This is convenient. If children are willing to guess that words for objects are nouns, words for actions are verbs, and so on, they would have a leg up on the rule-learning problem.

But words are not enough; they must be ordered. Imagine the child trying to figure out what kind of word can occur before the verb *bother*. It can't be done:

That dog bothers me. [*dog*, a noun]
 What she wears bothers me. [*wears*, a verb]
 Music that is too loud bothers me. [*loud*, an adjective]
 Cheering too loudly bothers me. [*loudly*, an adverb]
 The guy she hangs out with bothers me. [*with*, a preposition]

The problem is obvious. There is a certain something that must come before the verb *bother*, but that something is not a kind of word; it is a kind of *phrase*, a noun phrase. A noun phrase always contains a head noun, but that noun can be followed by all kinds of stuff. So it is hopeless to try to learn a language by analyzing sentences word by word. The child must look for phrases.

What does it mean to look for phrases? A phrase is a group of words. For a sentence of four words, there are eight possible ways to group the words into phrases: {That} {dog bothers me}; {That dog} {bothers me}; {That} {dog bothers} {me}, and so on. For a sentence of five words, there are sixteen possible ways; for a sentence of six words, thirty-two ways; for a sentence of n words, 2^{n-1} —a big num-

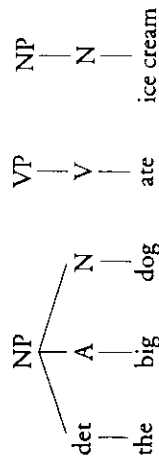
ber for long sentences. Most of these partitionings would give the child groups of words that would be useless in constructing new sentences, such as *wears bothers* and *cheering too*, but the child, unable to rely on parental feedback, has no way of knowing this. Once again, children cannot attack the language-learning task like a logician free of preconceptions; they need guidance.

This guidance could come from two sources. First, the child could assume that parents' speech respects the basic design of human phrase structure: phrases contain heads; role-players are grouped with heads in the mini-phrases called X-bars; X-bars are grouped with their modifiers inside X-phrases (noun phrase, verb phrase, and so on); X-phrases can have subjects. To put it crudely, the X-bar theory of phrase structure could be innate. Second, since the meanings of parents' sentences are usually guessable in context, the child could use the meanings to help set up the right phrase structure. Imagine that a parent says *The big dog ate ice cream*. If the child has previously learned the individual words *big*, *dog*, *ate*, and *ice cream*, he or she can guess their categories and grow the first twigs of a tree:

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      A   N   V   N
      |   |   |   |
      the big dog ate ice cream
  
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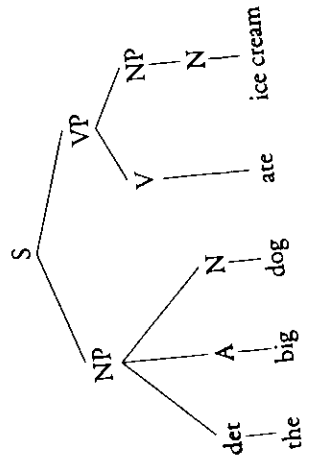
In turn, nouns and verbs must belong to noun phrases and verb phrases, so the child can posit one for each of these words. And if there is a big dog around, the child can guess that *the* and *big* modify *dog*, and connect them properly inside the noun phrase:



If the child knows that the dog just ate ice cream, he or she can also guess that *ice cream* and *dog* are role-players for the verb *eat*. *Dog* is a special kind of role-player, because it is the causal agent of the action and the topic of the sentence; hence it is likely to be the subject

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of the sentence and therefore attaches to the "S." A tree for the sentence has been completed:



The rules and dictionary entries can be peeled off the tree:

- S → NP VP
- NP → (det) (A) N
- VP → V (NP)
- dog: N
- ice cream: N
- ate: V; eater = subject, thing eaten = object
- the: det
- big: A

This hypothetical time-lapse photography of the mind of a child at work shows how a child, if suitably equipped, could learn three rules and five words from a single sentence in context.

The use of part-of-speech categories, X-bar phrase structure, and meaning guessed from context is amazingly powerful, but amazing power is what a real-life child needs to learn grammar so quickly, especially without parental feedback. There are many benefits to using a small number of innate categories like N and V to organize incoming speech. By calling both the subject and object phrases "NP," rather than, say, Phrase #1 and Phrase #2, the child automatically can apply hard-won knowledge about nouns in subject position to nouns in object position, and vice versa. For example, our model child can already generalize and use *dog* as an object without having heard an adult do so, and the child tacitly knows that adjectives precede nouns not just in subjects but in objects, again without direct evidence. The

child knows that if more than one *dog* is *dogs* in subject position, more than one *dog* is *dogs* in object position. I conservatively estimate that English allows about eight possible phrasemates of a head noun inside a noun phrase, such as *John's dog*; *dogs in the park*; *big dogs*; *dogs that I like*, and so on. In turn, there are about eight places in a sentence where the whole noun phrase can go, such as *Dog bites man*; *Man bites dog*; *A dog's life*; *Give the boy a dog*; *Talk to the dog*; and so on. There are three ways to inflect a noun: *dog, dogs, dog's*. And a typical child by the time he or she is in high school has learned something like twenty thousand nouns. If children had to learn all the combinations separately, they would need to listen to about 140 million different sentences. At a rate of a sentence every ten seconds, ten hours a day, it would take over a century. But by unconsciously labeling all nouns as "N" and all noun phrases as "NP," the child has only to hear about twenty-five different kinds of noun phrase and learn the nouns one by one, and the millions of possible combinations become available automatically.

Indeed, if children are blinkered to look for only a small number of phrase types, they automatically gain the ability to produce an infinite number of sentences, one of the quintessential properties of human grammar. Take the phrase *the tree in the park*. If the child mentally labels *the park* as an NP and also labels *the tree in the park* as an NP, the resulting rules generate an NP inside a PP inside an NP—a loop that can be iterated indefinitely, as in *the tree near the ledge by the lake in the park in the city in the east of the state . . .* In contrast, a child who was free to label in *the park* as one kind of phrase and *the tree in the park* as another kind would be deprived of the insight that the phrase contains an example of itself. The child would be limited to reproducing that phrase structure alone. Mental flexibility confines children; innate constraints set them free.

Once a rudimentary but roughly accurate analysis of sentence structure has been set up, the rest of the language can fall into place. Abstract words—nouns that do not refer to objects and people, for example—can be learned by paying attention to where they sit inside a sentence. Since *situation* in *The situation justifies drastic measures* occurs inside a phrase in NP position, it must be a noun. If the language allows phrases to be scrambled around the sentence, like Latin or Warlpiri, the child can discover this feature upon coming across a word that cannot be connected to a tree in the expected

place without crossing branches. The child, constrained by Universal Grammar, knows what to focus on in decoding case and agreement inflections: a noun's inflection might depend on whether it is in subject or object position; a verb's might depend on tense, aspect, and the number, person, and gender of its subject and object. If the hypotheses were not confined to this small set, the task of learning inflections would be intractable—logically speaking, an inflection *could* depend on whether the third word in the sentence referred to a reddish or a bluish object, whether the last word was long or short, whether the sentence was being uttered indoors or outdoors, and billions of other fruitless possibilities that a grammatically unfettered child would have to test for.



We can now return to the puzzle that opened the chapter: Why aren't babies born talking? We know that part of the answer is that babies have to listen to themselves to learn how to work their articulators, and have to listen to their elders to learn communal phonemes, words, and phrase orders. Some of these acquisitions depend on other ones, forcing development to proceed in a sequence: phonemes before words, words before sentences. But any mental mechanism powerful enough to learn these things could probably do so with a few weeks or months of input. Why does the sequence have to take three years? Could it be any faster?

Perhaps not. Complicated machines take time to assemble, and human infants may be expelled from the womb before their brains are complete. A human, after all, is an animal with a ludicrously large head, and a woman's pelvis, through which it must pass, can be only so big. If human beings stayed in the womb for the proportion of their life cycle that we would expect based on extrapolation from other primates, they would be born at the age of eighteen months. That is the age at which babies in fact begin to put words together. In one sense, then babies *are* born talking!

And we know that babies' brains do change considerably after birth. Before birth, virtually all the neurons (nerve cells) are formed, and they migrate into their proper locations in the brain. But head size, brain weight, and thickness of the cerebral cortex (gray matter), where the synapses (junctions) subserving mental computation are found, continue to increase rapidly in the year after birth. Long-

distance connections (white matter) are not complete until nine months, and they continue to grow their speed-inducing myelin insulation throughout childhood. Synapses continue to develop, peaking in number between nine months and two years (depending on the brain region), at which point the child has fifty percent more synapses than the adult! Metabolic activity in the brain reaches adult levels by nine to ten months, and soon exceeds it, peaking around the age of four. The brain is sculpted not only by adding neural material but by chipping it away. Massive numbers of neurons die in utero, and the dying continues during the first two years before leveling off at age seven. Synapses wither from the age of two through the rest of childhood and into adolescence, when the brain's metabolic rate falls back to adult levels. Language development, then, could be on a maturational timetable, like teeth. Perhaps linguistic accomplishments like babbling, first words, and grammar require minimum levels of brain size, long-distance connections, and extra synapses, particularly in the language centers of the brain (which we will explore in the next chapter).

So language seems to develop about as quickly as the growing brain can handle it. What's the rush? Why is language installed so quickly, while the rest of the child's mental development seems to proceed at a more leisurely pace? In a book on evolutionary theory often considered to be one of the most important since Darwin's, the biologist George Williams speculates:

We might imagine that Hans and Fritz Faustkeil are told on Monday, "Don't go near the water," and that both go wading and are spanked for it. On Tuesday they are told, "Don't play near the fire," and again they disobey and are spanked. On Wednesday they are told, "Don't tease the saber-tooth." This time Hans understands the message, and he bears firmly in mind the consequences of disobedience. He prudently avoids the saber-tooth and escapes the spanking. Poor Fritz escapes the spanking, too, but for a very different reason.

Even today accidental death is an important cause of mortality in early life, and parents who consistently spare the rod in other matters may be moved to violence when a child plays with electric wires or chases a ball into the street. Many of the accidental deaths of small children would probably have been avoided if the victims

had understood and remembered verbal instructions and had been capable of effectively substituting verbal symbols for real experience. This might well have been true also under primitive conditions.

Perhaps it is no coincidence that the vocabulary spurt and beginnings of grammar follow closely on the heels of the baby, quite literally—the ability to walk unaccompanied appears around fifteen months.



Let's complete our exploration of the linguistic life cycle. Everyone knows that it is much more difficult to learn a second language in adulthood than a first language in childhood. Most adults never master a foreign language, especially the phonology—hence the ubiquitous foreign accent. Their development often “fossilizes” into permanent error patterns that no teaching or correction can undo. Of course, there are great individual differences, which depend on effort, attitudes, amount of exposure, quality of teaching, and plain talent, but there seems to be a cap even for the best adults in the best circumstances. The actress Meryl Streep is renowned in the United States for her seemingly convincing accents, but I am told that in England, her British accent in *Plenty* was considered rather awful, and that her Australian accent in the movie about the dingo that ate the baby didn't go over too well down there, either.

Many explanations have been advanced for children's superiority: they exploit Motherese, make errors unself-consciously, are more motivated to communicate, like to conform, are not xenophobic or set in their ways, and have no first language to interfere. But some of these accounts are unlikely, based on what we know about how language acquisition works. For example, children can learn a language without standard Motherese, they make few errors, and they get no feedback for the errors they do make. In any case, recent evidence is calling these social and motivational explanations into doubt. Holding every other factor constant, a key factor stands out: sheer age.

People who immigrate after puberty provide some of the most compelling examples, even the apparent success stories. A few highly talented and motivated individuals master much of the grammar of a

foreign language, but not its sound pattern. Henry Kissinger, who immigrated to the United States as a teenager, retains a frequently satirized German accent; his brother, a few years younger, has no accent. Ukrainian-born Joseph Conrad, whose first language was Polish, is considered one of the best writers in English in this century, but his accent was so thick his friends could barely understand him. Even the adults who succeed at grammar often depend on the conscious exercise of their considerable intellects, unlike children, to whom language acquisition just happens. Vladimir Nabokov, another brilliant writer in English, refused to lecture or be interviewed extemporaneously, insisting on writing out every word beforehand with the help of dictionaries and grammars. As he modestly explained, “I think like a genius, I write like a distinguished author, and I speak like a child.” And he had had the benefit of being raised in part by an English-speaking nanny.

More systematic evidence comes from the psychologist Elissa Newport and her colleagues. They tested Korean- and Chinese-born students and faculty at the University of Illinois who had spent at least ten years in the United States. The immigrants were given a list of 276 simple English sentences, half of them containing some grammatical error like *The farmer bought two pig* or *The little boy is speak to a policeman*. (The errors were errors with respect to the spoken vernacular, not “proper” written prose.) The immigrants who came to the United States between the ages of three and seven performed identically to American-born students. Those who arrived between the ages of eight and fifteen did increasingly worse the later they arrived, and those who arrived between seventeen and thirty-nine did the worst of all, and showed huge variability unrelated to their age of arrival.

What about acquisition of the mother tongue? Cases in which people make it to puberty without having learned a language are rare, but they all point to the same conclusion. We saw in Chapter 2 that deaf people who are not exposed to sign language until adulthood never do as well as those who learned it as children. Among the wolf-children who are found in the woods or in the homes of psychotic parents after puberty, some develop words, and some, like “Genie,” discovered in 1970 at the age of thirteen and a half in a Los Angeles suburb, learn to produce immature, pidgin-like sentences:

Mike paint.
 Applesauce buy store.
 Neal come happy; Neal not come sad.
 Genie have Momma have baby grow up.
 I like elephant eat peanut.

But they are permanently incapable of mastering the full grammar of the language. In contrast, one child, Isabelle, was six and a half when she and her mute, brain-damaged mother escaped from the silent imprisonment of her grandfather's house. A year and a half later she had acquired fifteen hundred to two thousand words and produced complex grammatical sentences like

Why does the paste come out if one upsets the jar?
 What did Miss Mason say when you told her I cleaned my classroom?

Do you go to Miss Mason's school at the university?

Obviously she was well on her way to learning English as successfully as anyone else; the tender age at which she began made all the difference.

With unsuccessful learners like Genie, there is always a suspicion that the sensory deprivation and emotional scars sustained during the horrific confinement somehow interfered with their ability to learn. But recently a striking case of first language acquisition in a normal adult has surfaced. "Chelsea" was born deaf in a remote town in northern California. A series of inept doctors and clinicians diagnosed her as retarded or emotionally disturbed without recognizing her deafness (a common fate for many deaf children in the past). She grew up shy, dependent, and languageless but otherwise emotionally and neurologically normal, sheltered by a loving family who never believed she was retarded. At the age of thirty-one she was referred to an astonished neurologist, who had her fitted with hearing aids that improved her hearing to near-normal levels. Intensive therapy by a rehabilitative team has brought her to a point where she scores at a ten-year-old level on intelligence tests, knows two thousand words, holds a job in a veterinarian's office, reads, writes, communi-

cates, and has become social and independent. She has only one problem, which becomes apparent as soon as she opens her mouth:

The small a the hat.
 Richard eat peppers hot.
 Orange Tim car in.
 Banana the eat.
 I Wanda be drive come.
 The boat sits water on.
 Breakfast eating girl.
 Combing hair the boy.
 The woman is bus the going.
 The girl is cone the ice cream shopping buying the man.

Despite intensive training and impressive gains in other spheres, Chel-sea's syntax is bizarre.

In sum, acquisition of a normal language is guaranteed for children up to the age of six, is steadily compromised from then until shortly after puberty, and is rare thereafter. Maturation changes in the brain, such as the decline in metabolic rate and number of neurons during the early school-age years, and the bottoming out of the number of synapses and metabolic rate around puberty, are plausible causes. We do know that the language-learning circuitry of the brain is more plastic in childhood; children learn or recover language when the left hemisphere of the brain is damaged or even surgically removed (though not quite at normal levels), but comparable damage in an adult usually leads to permanent aphasia.

"Critical periods" for specific kinds of learning are common in the animal kingdom. There are windows in development in which ducklings learn to follow large moving objects, kittens' visual neurons become tuned to vertical, horizontal, and oblique lines, and white-crowned sparrows duplicate their fathers' songs. But why should learning ever decline and fall? Why throw away such a useful skill?

Critical periods seem paradoxical, but only because most of us have an incorrect understanding of the biology of organisms' life histories. We tend to think that genes are like the blueprints in a factory and organisms are like the appliances that the factory turns out. Our picture is that during gestation, when the organism is built,

it is permanently fitted with the parts it will carry throughout its lifetime. Children and teenagers and adults and old people have arms and legs and a heart because arms and legs and a heart were part of the infant's factory-installed equipment. When a part vanishes for no reason, we are puzzled.

But now try to think of the life cycle in a different way. Imagine that what the genes control is not a factory sending appliances into the world, but a machine shop in a thrifty theater company to which props and sets and materials periodically return to be dismantled and reassembled for the next production. At any point, different contraptions can come out of the shop, depending on current need. The most obvious biological illustration is metamorphosis. In insects, the genes build an eating machine, let it grow, build a container around it, dissolve it into a puddle of nutrients, and recycle them into a breeding machine. Even in humans, the sucking reflex disappears, teeth erupt twice, and a suite of secondary sexual characteristics emerge in a maturational schedule. Now complete the mental backflip. Think of metamorphosis and maturational emergence not as the exception but as the rule. The genes, shaped by natural selection, control bodies throughout the life span; designs hang around during the times of life that they are useful, not before or after. The reason that we have arms at age sixty is not because they have stuck around since birth, but because arms are as useful to a sixty-year-old as they were to a baby.

This inversion (an exaggeration, but a useful one) flips the critical period question with it. The question is no longer "Why does a learning ability disappear?" but "When is the learning ability needed?" We have already noted that the answer might be "As early as possible," to allow the benefits of language to be enjoyed for as much of life as possible. Now note that learning a language—as opposed to *using* a language—is perfectly useful as a one-shot skill. Once the details of the local language have been acquired from the surrounding adults, any further ability to learn (aside from vocabulary) is superfluous. It is like borrowing a floppy disk drive to load a new computer with the software you will need, or borrowing a turntable to copy your old collection of LP's onto tape; once you are done, the machines can be returned. So language-acquisition circuitry is not needed once it has been used; it should be dismantled if keeping it around incurs any costs. And it probably does incur costs. Metaboli-

cally, the brain is a pig. It consumes a fifth of the body's oxygen and similarly large portions of its calories and phospholipids. Greedy neural tissue lying around beyond its point of usefulness is a good candidate for the recycling bin. James Hurford, the world's only computational evolutionary linguist, has put these kinds of assumptions into a computer simulation of evolving humans, and finds that a critical period for language acquisition centered in early childhood is the inevitable outcome.

Even if there is some utility to our learning a second language as adults, the critical period for language acquisition may have evolved as part of a larger fact of life: the increasing feebleness and vulnerability with advancing age that biologists call "senescence." Common sense says that the body, like all machines, must wear out with use, but this is another misleading implication of the appliance metaphor. Organisms are self-replenishing, self-repairing systems, and there is no physical reason why we should not be biologically immortal, as in fact lineages of cancer cells used in laboratory research are. That would not mean that we would *actually* be immortal. Every day there is a certain probability that we will fall off a cliff, catch a virulent disease, be struck by lightning, or be murdered by a rival, and sooner or later one of those lightning bolts or bullets will have our name on it. The question is, is every day a lottery in which the odds of drawing a fatal ticket are the same, or do the odds get worse and worse the longer we play? Senescence is the bad news that the odds do change; elderly people are killed by falls and flus that their grandchildren easily survive. A major question in modern evolutionary biology is why this should be true, given that selection operates at every point of an organism's life history. Why aren't we built to be equally hale and hearty every day of our lives, so that we can pump out copies of ourselves indefinitely?

The solution, from George Williams and P. B. Medawar, is ingenious. As natural selection designed organisms, it must have been faced with countless choices among features that involved different tradeoffs of costs and benefits at different ages. Some materials might be strong and light but wear out quickly, whereas others might be heavier but more durable. Some biochemical processes might deliver excellent products but leave a legacy of accumulating pollution within the body. There might be a metabolically expensive cellular repair mechanism that comes in most useful late in life when wear and tear

have accumulated. What does natural selection do when faced with these tradeoffs? In general, it will favor an option with benefits to the young organism and costs to the old one over an option with the same average benefit spread out evenly over the life span. This asymmetry is rooted in the inherent asymmetry of death. If a lightning bolt kills a forty-year-old, there will be no fifty-year-old or sixty-year-old to worry about, but there will have been a twenty-year-old and a thirty-year-old. Any bodily feature designed for the benefit of the potential over-forty incarnations, at the expense of the under-forty incarnations, will have gone to waste. And the logic is the same for unforeseeable death at any age: the brute mathematical fact is that all things being equal, there is a better chance of being a young person than being an old person. So genes that strengthen young organisms at the expense of old organisms have the odds in their favor and will tend to accumulate over evolutionary timespans, whatever the bodily system, and the result is overall senescence.

Thus language acquisition might be like other biological functions. The linguistic clumsiness of tourists and students might be the price we pay for the linguistic genius we displayed as babies, just as the decrepitude of age is the price we pay for the vigor of youth.

10

Language Organs and Grammar Genes

“Ability to Learn Grammar Laid to Gene by Researcher.”

This 1992 headline appeared not in a supermarket tabloid but in an Associated Press news story, based on a report at the annual meeting of the principal scientific association in the United States. The report had summarized evidence that Specific Language Impairment runs in families, focusing on the British family we met in Chapter 2 in which the inheritance pattern is particularly clear. The syndicated columnists James J. Kilpatrick and Erma Bombeck were incredulous. Kilpatrick’s column began:

BETTER GRAMMAR THROUGH GENETICS

Researchers made a stunning announcement the other day at a meeting of the American Association for the Advancement of Science. Are you ready? Genetic biologists have identified the grammar gene.

Yes! It appears from a news account that Steven Pinker of MIT and Myrna Gopnik of McGill University have solved a puzzle that has baffled teachers of English for years. Some pupils master grammar with no more than a few moans of protest. Others, given the same instruction, persist in saying that Susie invited her and I to the party. It is all a matter of heredity. This we can handle.

A single dominant gene, the biologists believe, controls the ability to learn grammar. A child who says “them marbles is mine” is not necessarily stupid. He has all his marbles. The child is simply a little short on chromosomes.