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 combinational 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 I 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 cleverly 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 mere 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 splendor, 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 directors 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
defunctionalized
positivistic
predicative
multilateral
quantitative
divergent
synchronous
differentiated
inductive
integrated
distributive
participatory
degenerative
aggregating
appropriative

simulated

homogeneous

transfigurative

diversifying

cooperative

progressive

complementary

eliminative

interdependence

diffusion

periodicity

synthesis

sufficiency

equivalence

expectancy

plasticity

epigenesis

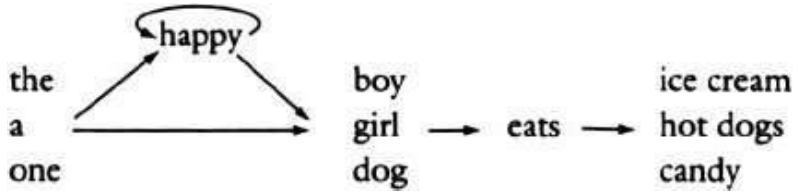
constructivism

deformation

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 out 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

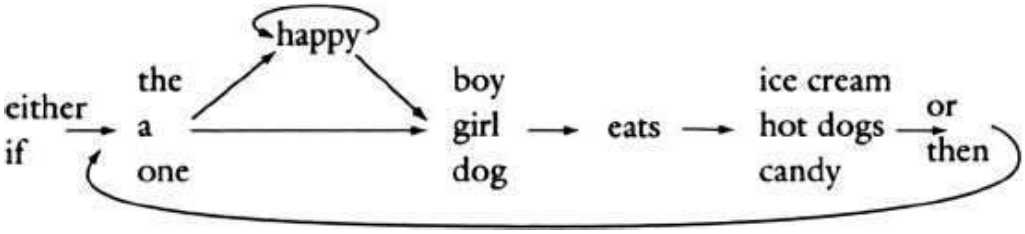
recording which word follows which other word. They do it by recording which word *category*—noun, verb, and so on—follows which other category. That is, we can recognize *colorless green ideas* because it has the same order of adjectives and nouns that we learned from more familiar sequences like *strapless 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 designated 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 eats 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.

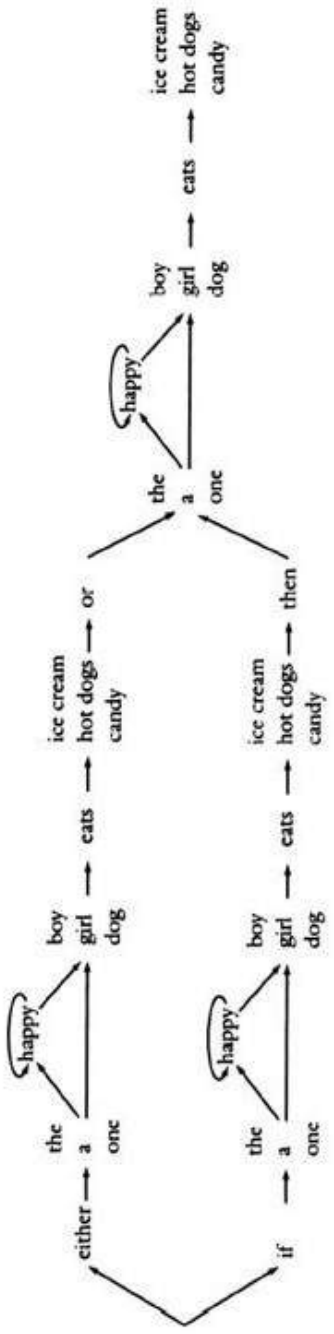
Now, you might think it would be a simple matter to redesign the device so that it does not have to remember early choices at late points in the sentence. For example, one could join up *either* and *or* and all the possible word sequences in between into one giant sequence, and *if* and *then* and all 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 ("Chapter 4"). 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.

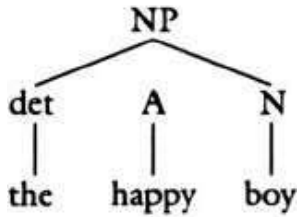
The difference between the artificial combinatorial system we see in word-chain devices and the natural one we see in the human brain is summed up in a line from the Joyce Kilmer poem: "Only God can make a tree." A sentence is not a chain but a tree. In a human grammar, words are grouped into phrases, 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 "determinator" (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 → VNP

"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*."

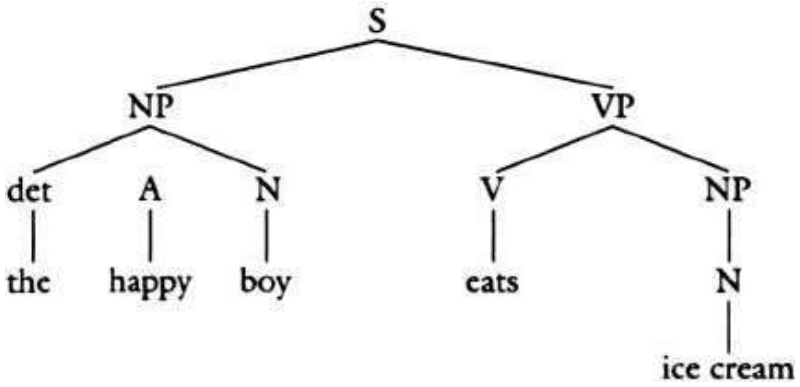
A → happy, lucky, tall

"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 bat*), 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:

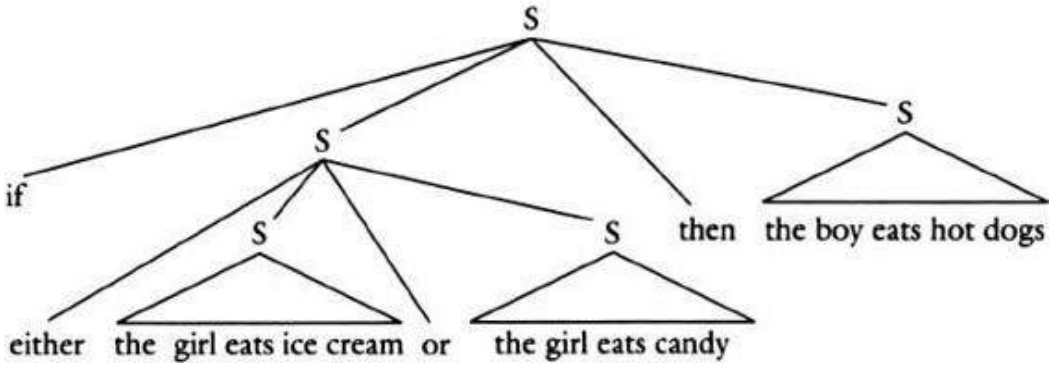
S → either S or S

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

S → then S

"A sentence can consist of the word *if*, followed by a sentence, followed by the word *then*, followed by another sentence."

These rules embed one instance of a symbol inside another instance of the same symbol (here, a sentence inside a sentence), a neat trick—logicians call it "recursion"—for generating an infinite number of structures. The pieces of the bigger sentence are held together, in order, as a set of branches growing out of a common node. That node holds together each *either* with its *or*, each *if* with its *then*, as in the following diagram (the triangles are abbreviations for lots of underbrush that would only entangle us if shown in full):



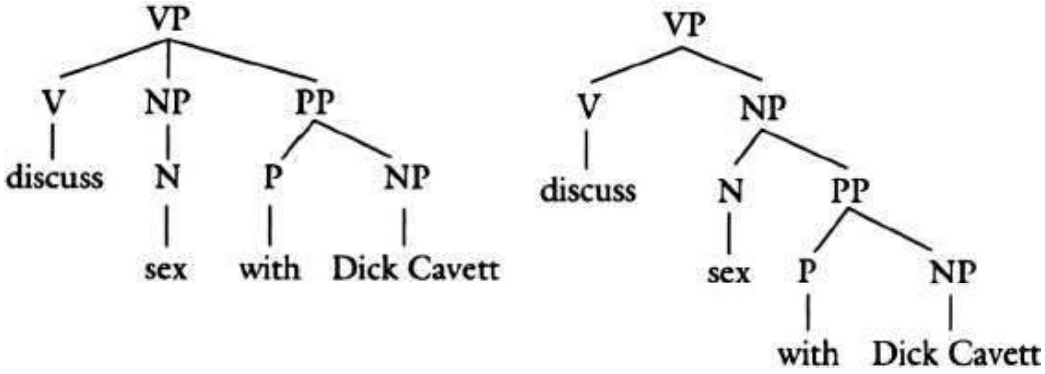
There is another reason to believe that a sentence is held together by a mental tree. So far I have been talking about stringing words into a grammatical order, ignoring what they mean. But grouping words into phrases is also necessary to connect grammatical sentences with their proper meanings, chunks of mentalese. We know that the sentence shown above is about a girl, not a boy, eating ice cream, and a boy, not a girl, eating hot dogs, and we know that the boy's snack is contingent on the girl's, not vice versa. That is because *girl* and *ice cream* are connected inside their own phrase, as are *boy* and *hot dogs*, as are the two sentences involving the girl. With a chaining device it's just one damn word after another, but with a phrase structure grammar the connectedness of words in the tree reflects the relatedness of ideas in mentalese. Phrase structure, then, is one solution to the engineering problem of taking an interconnected web of thoughts in the mind and encoding them as a string of words that must be uttered, one at a time, by the mouth.

One way to see how invisible phrase structure determines meaning is to recall one of the reasons mentioned in Chapter 3 that language and thought have to be different: a particular stretch of language can correspond to two distinct thoughts. I showed you examples like *Child's Stool Is Great for Use in Garden*, where the single word *stool* has two meanings, corresponding to two entries in the mental dictionary. But sometimes a whole sentence has two meanings, even if each individual word has only one meaning. In the movie *Animal Crackers*, Groucho Marx says, "I once shot an elephant in my pajamas. How he got into my pajamas I'll never know." Here

are some similar ambiguities that accidentally appeared in newspapers:

> Yoko Ono will talk about her husband John Lennon who was killed in an interview with Barbara Walkers.
>
> Two cars were reported stolen by the Groveton police yesterday.
>
> The license fee for altered dogs with a certificate will be $3 and for pets owned by senior citizens who have not been altered the fee will be $1.50.
>
> Tonight's program discusses stress, exercise, nutrition, and sex with Celtic forward Scott Wedman, Dr. Ruth Westheimer, and Dick Cavett.
>
> We will sell gasoline to anyone in a glass container.
>
> For sale: Mixing bowl set designed to please a cook with round bottom for efficient beating.

The two meanings in each sentence come from the different ways in which the words can be joined up in a tree. For example, in *discuss sex with Dick Cavett*, the writer put the words together according to the tree below ("PP" means prepositional phrase): sex is what is to be discussed, and it is to be discussed with Dick Cavett.



The alternative meaning comes from our analyzing the words according to the tree at the right: the words *sex with Dick Cavett* form a single branch of the tree, and sex with Dick Cavett is what is to be discussed.

Phrase structure, clearly, is the kind of stuff language is made of. But what I have shown you is just a toy. In the rest of this chapter I will try to explain the modern Chomskyan theory of how language works. Chomsky's writing are "classics" in Mark Twain's sense: something that everybody wants to have read and nobody wants to read. When I come across one of the countless popular books on mind, language, and human nature that refer to "Chomsky's deep structure of meaning common to all human languages" (wrong in two ways, we shall see), I know that Chomsky's books of the last twenty-five years are sitting on a high shelf in the author's study, their spines uncracked, their folios uncut. Many people want to have a go at speculating about the mind but have the same impatience about mastering the details of how language works that Eliza Doolittle showed to Henry Higgins in *Pygmalion* when she complained, "I don't want to talk grammar. I want to talk like a lady in a flower shop."

For nonspecialists the reaction is even more extreme. In Shakespeare's *The Second Part of King Henry VI*, the rebel Dick the Butcher speaks the well-known line "The first thing we do, let's kill all the lawyers." Less well known is the second thing Dick suggests they do: behead Lord Say. Why? Here is the indictment presented by the mob's leader, Jack Cade:

> Thou hast most traitorously corrupted the youth of the realm in erecting a grammar school…. It will be proved to thy face that thou hast men about thee that usually talk of a noun and a verb, and such abominable words as no Christian ear can endure to hear.

And who can blame the grammarphobe, when a typical passage from one of Chomsky's technical works reads as follows?

> To summarize, we have been led to the following conclusions, on the assumption that the trace of a zero-level category must be properly governed. 1. VP is α>-marked by I. 2. Only lexical categories are L-markers, so that VP is not L-marked by I. 3. α-government is restricted

to sisterhood without the qualification (35). 4. Only the terminus of an X^0-chain can α-mark or Case-mark. 5. Head-to-head movement forms an A-chain. 6. SPEC-head agreement and chains involve the same indexing. 7. Chain coindexing holds of the links of an extended chain. 8. There is no accidental coindexing of I. 9. I-V coindexing is a form of head-head agreement; if it is restricted to aspectual verbs, then base-generated structures of the form (174) count as adjunction structures. 10. Possibly, a verb does not properly govern its α-marked complement.

All this is unfortunate. People, especially those who hold forth on the nature of mind, should be just plain curious about the code that the human species uses to speak and understand. In return, the scholars who study language for a living should see that such curiosity can be satisfied. Chomsky's theory need not be treated by either group as a set of cabalistic incantations that only the initiated can mutter. It is a set of discoveries about the design of language that can be appreciated intuitively if one first understands the problems to which the theory provides solutions. In fact, grasping grammatical theory provides an intellectual pleasure that is rare in the social sciences. When I entered high school in the late 1960s and electives were chosen for their "relevance," Latin underwent a steep decline in popularity (thanks to students like me, I confess). Our Latin teacher Mrs. Rillie, whose merry birthday parties for Rome failed to slow the decline, tried to persuade us that Latin grammar honed the mind with its demands for precision, logic, and consistency. (Nowadays, such arguments are more likely to come from the computer programming teachers.) Mrs. Rillie had a point, but Latin declensional paradigms are not the best way to convey the inherent beauty of grammar. The insights behind Universal Grammar are much more interesting, not only because they are more general and elegant but because they are about living minds rather than dead tongues.

Let's start with nouns and verbs. Your grammar teacher may have had you memorize some formula that equated parts of speech with kinds of meanings, like

> A NOUN's the name of any thing;
>
> *As school or garden, hoop* or *swing*.
>
> VERBS tell of something being done;
>
> To *read, count, sing, laugh, jump*, or *run*.

But as in most matters about language, she did not get it quite right. It is true that most names for persons, places, and things arc nouns, but it is not true that most nouns are names for persons, places, or things. There are nouns with all kinds of meanings:

the *destruction* of the city [an action]

the *way* to San Jose [a path]

whiteness moves downward [a quality]

three *miles* along the path [a measurement in space]

It takes three *hours* to solve the problem. [a measurement in time]

Tell me the *answer*. ["what the answer is," a question]

She is a *fool*. [a category or kind]

a meeting [an event]

the *square root* of minus two [an abstract concept]

He finally kicked *the bucket*. [no meaning at all]

Likewise, though words for things being done, such as *count* and *jump*, are usually verbs, verbs can be other things, like mental states (*know, like*), possession (*own, have*), and abstract relations among ideas *(falsify, prove)*.

Conversely, a single concept, like "being interested," can be expressed by different parts of speech:

her *interest* in fungi [noun]

Fungi are starting to *interest* her more and more. [verb]

She seems interested in fungi. Fungi seem *interesting* to her. [adjective]

Interestingly, the fungi grew an inch in an hour. [adverb]

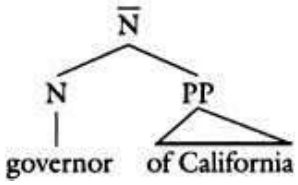
A part of speech, then, is not a kind of meaning; it is a kind of token that obeys certain formal rules, like a chess piece or a poker chip. A noun, for example, is simply a word that does nouny things; it is the kind of word that comes after an article, can have an '*s* stuck onto it, and so on. There is a connection between concepts and part-of-speech categories, but it is a subtle and abstract one. When we construe an aspect of the world as something that can be identified and counted or measured and that can play a role in events, language often allows us to express that aspect as a noun, whether or not it is a physical object. For example, when we say *I have three reasons for leaving*, we are counting reasons as if they were objects (though of course we do not literally think that a reason can sit on a table or be kicked across a room). Similarly, when we construe some aspect of the world as an event or state involving several participants that affect one other, language often allows us to express that aspect as a verb. For example, when we say *The situation justified drastic measures*, we are talking about justification as if it were something the situation did, though again we know that justification is not something we can watch happening at a particular time and place. Nouns are *often* used for names of things, and verbs for something being done, but because the human mind can construe reality in a variety of ways, nouns and verbs are not limited to those uses.

Now what about the phrases that group words into branches? One of the most intriguing discoveries of modem linguistics is that there appears to be a common anatomy in all phrases in all the world's languages.

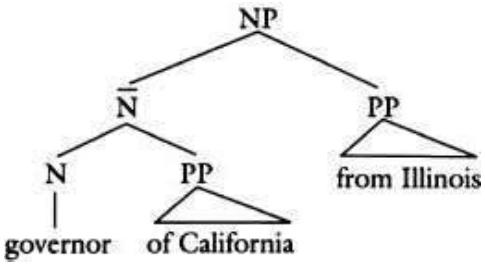
Take the English noun phrase. A noun phrase (NP) is named after one special word, a noun, that must be inside it. The noun

phrase owes most of its properties to that one noun. For example, the NP *the cat in the hat* refers to a kind of cat, not a kind of hat; the meaning of the word *cat* is the core of the meaning of the whole phrase. Similarly, the phrase *fox in socks* refers to a fox, not socks, and the entire phrase is singular in number (that is, we say that the fox in socks *is* or *was* here, not *are* or *were* here), because the word *fox* is singular in number. This special noun is called the "head" of the phrase, and the information filed with that word in memory "percolates up" to the topmost node, where it is interpreted as characterizing the phrase as a whole. The same goes for verb phrases: *flying to Rio before the police catch him* is an example of flying, not an example of catching, so the verb *flying* is called its head. Here we have the first principle of building the meaning of a phrase out of the meaning of the words inside the phrase. What the entire phrase is "about" is what its head word is about.

The second principle allows phrases to refer not just to single things or actions in the world but to sets of players that interact with each other in a particular way, each with a specific role. For example, the sentence *Sergey gave the documents to the spy* is not just about any old act of giving. It choreographs three entities: Sergey (the giver), documents (the gift), and a spy (the recipient). These role-players are usually called "arguments," which has nothing to do with bickering; it's the term used in logic and mathematics for a participant in a relationship. A noun phrase, too, can assign roles to one or more players, as in *picture of John, governor of California*, and *sex with Dick Cavett*, each defining one role. The head and its role-players—other than the subject role, which is special—are joined together in a subphrase, smaller than an NP or a VP, that has the kind of non-mnemonic label that has made generative linguistics so uninviting, "N-bar" and "V-bar," named after the way they are written, $\bar{N}$ and $\bar{V}$:



The third ingredient of a phrase is one or more modifiers (usually called "adjuncts"). A modifier is different from a role-player. Take the phrase *The man from Illinois*. Being a man from Illinois is not like being a governor of California. To be a governor, you have to be a governor of something; the Californianess plays a role in what it means for someone to be governor of California. In contrast, *from Illinois* is just a bit of information that we add on to help identify which man we are talking about; being from one state or another is not an inherent part of what it means to be a man. This distinction in meaning between role-players and modifiers ("arguments" and "adjuncts," in lingo) dictates the geometry of the phrase structure tree. The role-player stays next to the head noun inside the N-bar, but the modifier goes upstairs, though still inside the NP house:



This restriction of the geometry of phrase structure trees is not just playing with notation; it is a hypothesis about how the rules of language are set up in our brains, governing the way we talk. It dictates that if a phrase contains both a role-player *and* a modifier, the role-player has to be closer to the head than the modifier is—there's no way the modifier could get between the head noun and the role-player without crossing branches in the tree (that is, sticking extraneous words in among the bits of the N-bar), which is illegal. Consider Ronald Reagan. He used to be the governor of California, but he was born in Tampico, Illinois. When he was in office, he could have been referred to as *the governor of California from Illinois* (role-player, then modifier). It would have sounded odd to refer to him as *the governor from Illinois of California* (modifier, then role-player). More pointedly, in 1964 Robert F. Kennedy's senatorial ambitions ran up against the inconvenient fact that both Massachusetts seats were already occupied (one by his younger brother Edward). So

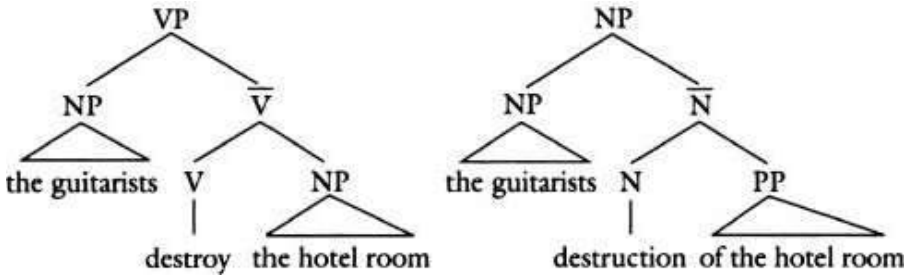
he simply took up residence in New York and ran for the U.S. Senate from there, soon becoming *the senator from New York from Massachusetts*. Not *the senator from Massachusetts from New York*—though that does come close to the joke that Bay Staters used to tell at the time, that they lived in the only state entitled to *three* senators.

Interestingly, what is true of N-bars and noun phrases is true of V-bars and verb phrases. Say that Sergey gave those documents to the spy in a hotel. The phrase *to the spy* is one of the role-players of the verb *give*—there is no such thing as giving without a getter. Therefore *to the spy* lives with the head verb inside the V-bar. But *in a hotel* is a modifier, a comment, an afterthought, and is kept outside the V-bar, in the VP. Thus the phrases are inherently ordered: we can say *gave the documents to the spy in a hotel*, but not *gave in a hotel the documents to the spy*. When a head is accompanied by just one phrase, however, that phrase can be either a role-player (inside the V-bar) or a modifier (outside the V-bar but inside the VP), and the actual order of the words is the same. Consider the following newspaper report:

> One witness told the commissioners that she had seen sexual intercourse taking place between two parked cars in front of her house.

The aggrieved woman had a modifier interpretation in mind for *between two parked cars*, but twisted readers give it a role-player interpretation.

The fourth and final component of a phrase is a special position reserved for subjects (which linguists call "SPEC," pronounced "speck," short for "specifier"; don't ask). The subject is a special role-player, usually the causal agent if there is one. For example, in the verb phrase *the guitarists destroy the hotel room*, the phrase *the guitarists* is the subject; it is the causal agent of the event consisting of the hotel room being destroyed. Actually, noun phrases can have subjects too, as in the parallel NP *the guitarists' destruction of the hotel room*. Here, then, is the full anatomy of a VP and of an NP:



Now the story begins to get interesting. You must have noticed that noun phrases and verb phrases have a lot in common: (1) a head, which gives the phrase its name and determines what it is about, (2) some role-players, which are grouped with the head inside a subphrase (the N-bar or V-bar), (3) modifiers, which appear outside the N- or V-bar, and (4) a subject. The orderings inside a noun phrase and inside a verb phrase are the same: the noun comes before its role-players *(the destruction of the hotel room*, not *the of the hotel room destruction)*, and the verb comes before *its* role-players *(to destroy the hotel room*, not *to the hotel room destroy)*. The modifiers go to the right in both cases, the subject to the left. It seems as if there is a standard design to the two phrases.

In fact, the design pops up all over the place. Take, for example, the prepositional phrase (PP) *in the hotel*. It has a head, the preposition *in*, which means something like "interior region," and then a role, the thing whose interior region is being picked out, in this case a hotel. And the same goes for the adjective phrase (AP): in *afraid of the wolf*, the head adjective, *afraid*, occurs before its role-player, the source of the fear.

With this common design, there is no need to write out a long list of rules to capture what is inside a speaker's head. There may be just one pair of super-rules for the entire language, where the distinctions among nouns, verbs, prepositions, and adjectives are collapsed and all four are specified with a variable like "X." Since a phrase just inherits the properties of its head (*a tall man* is a kind of *man*), it's redundant to call a phrase headed by a noun a "noun phrase"—we could just call it an "X phrase," since the nounhood of the head noun, like the manhood of the head noun and all the other information in the head noun, percolates up to characterize the

whole phrase. Here is what the super-rules look like (as before, focus on the summary of the rule, not the rule itself):

XP → (SPEC) X̄ YP*

"A phrase consists of an optional subject, followed by an X-bar, followed by any number of modifiers."

X̄ → X ZP*

"An X-bar consists of a head word, followed by any number of role-players."

Just plug in noun, verb, adjective, or preposition for X, Y, and Z, and you have the actual phrase structure rules that spell the phrases. This streamlined version of phrase structure is called "the X-bar theory."

This general blueprint for phrases extends even farther, to other languages. In English, the head of a phrase comes before its role-players. In many languages, it is the other way around—but it is the other way around across the board, across all the kinds of phrases in the language. For example, in Japanese, the verb comes *after* its object, not before: they say *Kenji sushi ate*, not *Kenji ate sushi*. The preposition comes after its noun phrase: *Kenji to*, not *to Kenji* (so they are actually called "postpositions"). The adjective comes after its complement: *Kenji than taller*, not *taller than Kenji*. Even the words marking questions are flipped: they say, roughly, *Kenji eat did?*, not *Did Kenji eat?* Japanese and English are looking-glass versions of each other. And such consistency has been found in scores of languages: if a language has the verb before the object, as in English, it will also have prepositions; if it has the verb after the object, as in Japanese, it will have postpositions.

This is a remarkable discovery. It means that the super-rules suffice not only for all phrases in English but for all phrases in all languages, with one modification: removing the left-to-right order from each super-rule. The trees become mobiles. One of the rules would say:

X̄ → {ZP*, X}

> "An X-bar is composed of a head X and any number of role-players, in either order."

To get English, one appends a single bit of information saying that the order within an X-bar is "head-first." To get Japanese, that bit of information would say that the order is "head-last." Similarly, the other super-rule (the one for phrases) can be distilled so that left-to-right order boils away, and an ordered phrase in a particular language can be reconstituted by adding back either "X-bar-first" or "X-bar-last." The piece of information that makes one language different from another is called a parameter.

In fact, the super-rule is beginning to look less like an exact blueprint for a particular phrase and more like a general guideline or principle for what phrases must look like. The principle is usable only after you combine it with a language's particular setting for the order parameter. This general conception of grammar, first proposed by Chomsky, is called the "principles and parameters" theory.

Chomsky suggests that the unordered super-rules (principles) are universal and innate, and that when children learn a particular language, they do not have to learn a long list of rules, because they were born knowing the super-rules. All they have to learn is whether their particular language has the parameter value head-first, as in English, or head-last, as in Japanese. They can do that merely by noticing whether a verb comes before or after its object in any sentence in their parents' speech. If the verb comes before the object, as in *Eat your spinach!*, the child concludes that the language is head-first; if it comes after, as in *Your spinach eat!*, the child concludes that the language is head-last. Huge chunks of grammar are then available to the child, all at once, as if the child were merely flipping a switch to one of two possible positions. If this theory of language learning is true, it would help solve the mystery of how children's grammar explodes into adultlike complexity in so short a time. They are not acquiring dozens or hundreds of rules; they are just setting a few mental switches.

The principles and parameters of phrase structure specify only what kinds of ingredients may go into a phrase in what order. They do not spell out any particular phrase. Left to themselves, they would run amok and produce all kinds of mischief. Take a look at the following sentences, which all conform to the principles or super-rules. The ones I have marked with an asterisk do not sound right.

Melvin dined.

* Melvin dined the pizza.

Melvin devoured the pizza.

*Melvin devoured.

Melvin put the car in the garage.

* Melvin put.

* Melvin put the car.

* Melvin put in the garage.

Sheila alleged that Bill is a liar.

* Sheila alleged the claim.

* Sheila alleged.

It must be the verb's fault. Some verbs, like *dine*, refuse to appear in the company of a direct object noun phrase. Others, like *devour*, won't appear without one. This is true even though *dine* and *devour* are very close in meaning, both being ways of eating. You may dimly recall from grammar lessons that verbs like *dine* are called "intransitive" and verbs like *devour* are called "transitive." But verbs come in many flavors, not just these two. The verb *put* is not content unless it has both an

object NP *(the car)* and a prepositional phrase *(in the garage)*. The verb *allege* requires an embedded sentence *(that Bill is a liar)* and nothing else.

Within a phrase, then, the verb is a little despot, dictating which of the slots made available by the super-rules are to be filled. These demands are stored in the verb's entry in the mental dictionary, more or less as follows:

dine:

verb

means "to eat a meal in a refined setting"

eater = subject

devour:

verb

means "to eat something ravenously"

eater = subject

thing eaten = object

put:

verb

means "to cause something to go to some place"

putter = subject

thing put = object

place = prepositional object

allege:

verb

means "to declare without proof"

declarer = subject

declaration = complement sentence

Each of these entries lists a definition (in mentalese) of some kind of event, followed by the players that have roles in the event. The entry indicates how each role-player may be plugged into the sentence—as a subject, an object, a prepositional object, an embedded sentence, and so on. For a sentence to feel grammatical, the verb's demands must be satisfied. *Melvin devoured* is bad because *devour*'s desire for a "thing eaten" role is left unfulfilled. *Melvin dined the pizza* is bad because *dine* didn't order *pizza* or any other object.

Because verbs have the power to dictate how a sentence conveys who did what to whom, one cannot sort out the roles in a sentence without looking up the verb. That is why your grammar teacher got it wrong when she told you that the subject of the sentence is the "doer of the action." The subject of the sentence is often the doer, but only when the verb says so; the verb can also assign it other roles:

The big bad wolf *frightened* the three little pigs. [The subject is doing the frightening.]

The three little pigs *feared* the big bad wolf. [The subject is being frightened.]

My true love *gave* me a partridge in a pear tree. [The subject is doing the giving.]

I *received* a partridge in a pear tree from my true love. [The subject is being given to.]

Dr. Nussbaum *performed* plastic surgery. [The subject is operating on someone.]

Cheryl *underwent* plastic surgery. [The subject is being operated on.]

In fact, many verbs have two distinct entries, each casting a different set of roles. This can give rise to a common kind of

ambiguity, as in the old joke: “Call me a taxi.” “OK, you’re a taxi.” In one of the Harlem Globetrotters’ routines, the referee tells Meadowlark Lemon to shoot the ball. Lemon points his finger at the ball and shouts, “Bang!” The comedian Dick Gregory tells of walking up to a lunch counter in Mississippi during the days of racial segregation. The waitress said to him, “We don’t serve colored people.” “That’s fine,” he replied, “I don’t eat colored people. I’d like a piece of chicken.”

So how do we actually distinguish *Man bites dog* from *Dog bites man?* The dictionary entry for *bite* says “The biter is the subject; the bitten thing is the object.” But how do we *find* subjects and objects in the tree? Grammar puts little tags on the noun phrases that can be matched up with the roles laid out in a verb’s dictionary entry. These tags are called *cases*. In many languages, cases appear as prefixes or suffixes on the nouns. For example, in Latin, the nouns for man and dog, *homo* and *canis*, change their endings depending on who is biting whom:

Canis hominem mordet. [not news]

Homo canem mordet. [news]

Julius Caesar knew who bit whom because the noun corresponding to the bitee appeared with **-*em*** at the end. Indeed, this allowed Caesar to find the biter and bitee even when the order of the two was flipped, which Latin allows: *Hominem canis mordet* means the same thing as *Canis hominem mordet*, and *Canem homo mordet* means the same thing as *Homo canem mordet*. Thanks to case markers, verbs’ dictionary entries can be relieved of the duty of keeping track of where their role-players actually appear in the sentence. A verb need only indicate that, say, the doer is a subject; whether the subject is in first or third or fourth position in the sentence is up to the rest of the grammar, and the interpretation is the same. Indeed, in what are called “scrambling” languages, case markers are exploited even further: the article, adjective, and noun inside a phrase are each tagged with a particular case marker, and the speaker can scramble the words of the phrase all over the sentence (say, put

the adjective at the end for emphasis), knowing that the listener can mentally join them back up. This process, called agreement or concord, is a second engineering solution (aside from phrase structure itself) to the problem of encoding a tangle of interconnected thoughts into strings of words that appear one after the other.

Centuries ago, English, like Latin, had suffixes that marked case overtly. But the suffixes have all eroded, and overt case survives only in the personal pronouns—*I, he, she, we, they* are used for the subject role; *my, his, her, our, their* are used for the possessor role; *me, him, her, us, them* are used for all other roles. (The *who/whom* distinction could be added to this list, but it is on the way out; in the United States, *whom* is used consistently only by careful writers and pretentious speakers.) Interestingly, since we all know to say *He saw us* but never *Him saw we*, the syntax of case must still be alive and well in English. Though nouns appear physically unchanged no matter what role they play, they are tagged with silent cases. Alice realized this after spotting a mouse swimming nearby in her pool of tears:

> "Would it be of any use, now," thought Alice, "to speak to this mouse? Everything is so out-of-the-way down here, that I should think very likely it can talk: at any rate, there's no harm in trying." So she began. "O Mouse, do you know the way out of this pool? I am very tired of swimming about here, O Mouse!" (Alice thought this must be the right way of speaking to a mouse: she had never done such a thing before, but she remembered having seen, in her brother's Latin Grammar, "A Mouse—of a mouse—to a mouse—a mouse—O mouse!")

English speakers tag a noun phrase with a case by seeing what the noun is adjacent to, generally a verb or preposition (but for Alice's mouse, the archaic "vocative" case marker *O*). They use these case tags to match up each noun phrase with its verb-decreed role.

The requirement that noun phrases must get case tags explains why certain sentences are impossible even though the super-rules admit them. For example, a direct object role-player

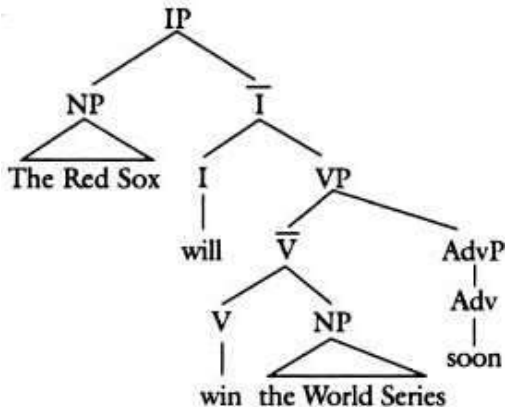
has to come right after the verb, before any other role-player: one says *Tell Mary that John is coming*, not *Tell that John is coming Mary*. The reason is that the NP *Mary* cannot just float around tagless but must be casemarked, by sitting adjacent to the verb. Curiously, while verbs and prepositions can mark case on their adjacent NP's, nouns and adjectives cannot: *governor California* and *afraid the wolf*, though interpretable, are ungrammatical. English demands that the meaningless preposition *of* precede the noun, as in *governor of California* and *afraid of the wolf*, for no reason other than to give it a case tag. The sentences we utter are kept under tight rein by verbs and prepositions—phrases cannot just show up anywhere they feel like in the VP but must have a job description and be wearing an identity badge at all times. Thus we cannot say things like *Last night I slept bad dreams a hangover snoring no pajamas sheets were wrinkled*, even though a listener could guess what that would mean. This marks a major difference between human languages and, for example, pidgins and the signing of chimpanzees, where any word can pretty much go anywhere.

Now, what about the most important phrase of all, the sentence? If a noun phrase is a phrase built around a noun, and a verb phrase is a phrase built around a verb, what is a sentence built around?

The critic Mary McCarthy once said of her rival Lillian Hellman, "Every word she writes is a lie, including 'and' and 'the.'" The insult relies on the fact that a sentence is the smallest thing that can be either true or false; a single word cannot be either (so McCarthy is alleging that Hellman's lying extends deeper than one would have thought possible). A sentence, then, must express some kind of meaning that does not clearly reside in its nouns and verbs but that embraces the entire combination and turns it into a proposition that can be true or false. Take, for example, the optimistic sentence *The Red Sox will win the World Series*. The word *will* does not apply to the Red Sox alone, nor to the World Series alone, nor to winning alone; it applies to an entire concept, the-Red-Sox-winning-the-World-Series. That

concept is timeless and therefore truthless. It can refer equally well to some past glory, a hypothetical future one, even to the mere logical possibility, bereft of any hope that it will ever happen. But the word *will* pins the concept down to temporal coordinates, namely the stretch of time subsequent to the moment the sentence is uttered. If I declare "The Red Sox will win the World Series," I can be right or wrong (probably wrong, alas).

The word *will* is an example of an auxiliary, a word that expresses layers of meaning having to do with the truth of a proposition as the speaker conceives it. These layers also include negation (as in *won't* and *doesn't*), necessity (*must*), and possibility (*might* and *can*). Auxiliaries typically occur at the periphery of sentence trees, mirroring the fact that they assert something about the rest of the sentence taken as a whole. The auxiliary is the head of the sentence in exactly the same way that a noun is the head of the noun phrase. Since the auxiliary is also called INFL (for "inflection"), we can call the sentence an IP (an INFL phrase or auxiliary phrase). Its subject position is reserved for the subject of the entire sentence, reflecting the fact that a sentence is an assertion that some predicate (the VP) is true of its subject. Here, more or less, is what a sentence looks like in the current version of Chomsky's theory:



An auxiliary is an example of a "function word," a different kind of word from nouns, verbs, and adjectives, the "content" words. Function words include articles (*the, a, some*), pronouns (*he, she*), the possessive marker '*s*, meaningless prepositions like *of*, words that introduce complements like *that* and *to*, and

conjunctions like *and* and *or*. Function words are bits of crystallized grammar; they delineate larger phrases into which NP's and VP's and AP's fit, thereby providing a scaffolding for the sentence. Accordingly, the mind treats function words differently from content words. People add new content words to the language all the time (like the noun *fax*, and the verb *to snarf*, meaning to retrieve a computer file), but the function words form a closed club that resists new members. That is why all the attempts to introduce gender-neutral pronouns like *hesh* and *than* have failed. Recall, too, that patients with damage to the language areas of the brain have more trouble with function words like *or* and *be* than with content words like *oar* and *bee*. When words are expensive, as in telegrams and headlines, writers tend to leave the function words out, hoping that the reader can reconstruct them from the order of the content words. But because function words are the most reliable clues to the phrase structure of the sentence, telegraphic language is always a gamble. A reporter once sent Cary Grant the telegram, "How old Cary Grant?" He replied, "Old Cary Grant fine." Here are some headlines from a collection called *Squad Helps Dog Bite Victim*, put together by the staff of the *Columbia Journalism Review:*

New Housing for Elderly Not Yet Dead

New Missouri U. Chancellor Expects Little Sex

12 on Their Way to Cruise Among Dead in Plane Crash

N.J. Judge to Rule on Nude Beach

Chou Remains Cremated

Chinese Apeman Dated

Hershey Bars Protest

Reagan Wins on Budget, But More Lies Ahead

Deer Kill 130,000

Complaints About NBA Referees Growing Ugly

Function words also capture much of what makes one language grammatically different from another. Though all

languages have function words, the properties of the words differ in ways that can have large effects on the structure of the sentences in the language. We have already seen one example: overt case and agreement markers in Latin allow noun phrases to be scrambled; silent ones in English force them to remain in place. Function words capture the grammatical look and feel of a language, as in these passages that use a language's function words but none of its content words:

DER JAMMERWOCH

Es brillig war. Die schlichte Toven
Wirrten und wimmelten in Waben.

LE JASEROQUE

Il brilgue: les tôves lubricilleux
Se gyrent en vrillant dans la guave.

The effect can also be seen in passages that take the function words from one language but the content words from another, like the following pseudo-German notice that used to be posted in many university computing centers in the English-speaking world:

ACHTUNG! ALLES LOOKENSPEEPERS!

> Das computermachine ist nicht fuer gefingerpoken und mittengrabben. 1st easy schnappen der springenwerk, blowenfusen und poppencorken mit spitzensparken. 1st nicht fuer gewerken bei das dumpkopfen. Das rubbernecken sightseeren keepen das cottenpickenen hans in das pockets muss; relaxen und watchen das blinkenlichten.

Turnabout being fair play, computer operators in Germany have posted a translation into pseudo-English:

ATTENTION

> This room is fulfilled mit special electronische equippment. Fingergrabbing and pressing the cnoeppkes from the computers is allowed for die experts only! So all the "lefthanders" stay away and do not disturben the brainstorming von here working intelligencies. Otherwise you will be out thrown and kicked andeswhere! Also: please keep still and only watchen astaunished the blinkenlights.

Anyone who goes to cocktail parties knows that one of Chomsky's main contributions to intellectual life is the concept of "deep structure," together with the "transformations" that map it onto "surface structure." When Chomsky introduced the terms in the behaviorist climate of the early 1960s, the reaction was sensational. Deep structure came to refer to everything that was hidden, profound, universal, or meaningful, and before long there was talk of the deep structure of visual perception, stories, myths, poems, paintings, musical compositions, and so on. Anticlimactically, I must now divulge that "deep structure" is a prosaic technical gadget in grammatical theory. It is not the meaning of a sentence, nor is it what is universal across all human languages. Though universal grammar and abstract phrase structures seem to be permanent features of grammatical theory, many linguists—including, in his most recent writings, Chomsky himself—think one can do without deep structure per se. To discourage all the hype incited by the word "deep," linguists now usually refer to it as "d-structure." The concept is actually quite simple.

Recall that for a sentence to be well formed, the verb must get what it wants: all the roles listed in the verb's dictionary entry must appear in their designated positions. But in many sentences, the verb does not seem to be getting what it wants. Remember that *put* requires a subject, an object, and a prepositional phrase; *He put the car* and *He put in the garage* sound incomplete. How, then, do we account for the following perfectly good sentences?

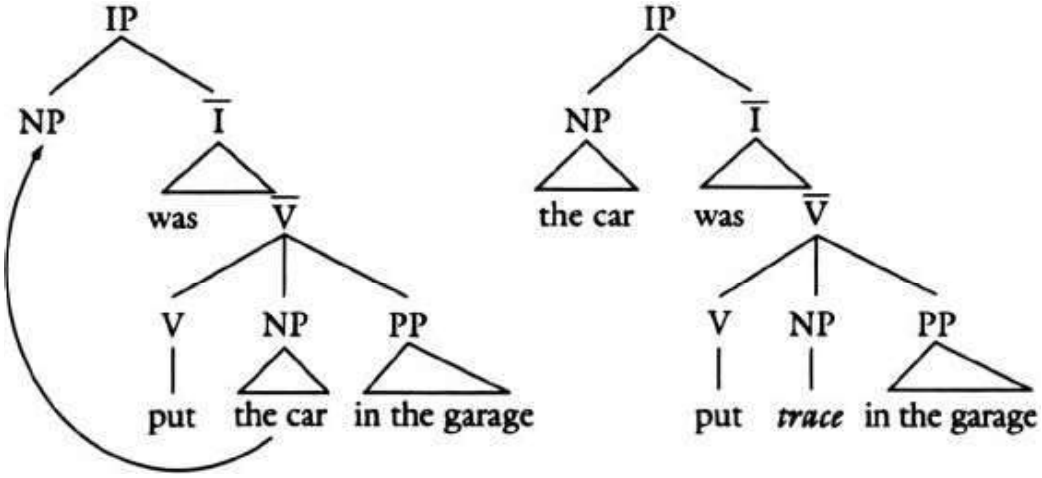
> The car was put in the garage.
>
> What did he put in the garage?

Where did he put the car?

In the first sentence, *put* seems to be doing fine without an object, which is out of character. Indeed, now it rejects one: *The car was put the Toyota in the garage* is awful. In the second sentence, *put* also appears in public objectless. In the third, its obligatory prepositional phrase is missing. Does this mean we need to add new dictionary entries for *put*, allowing it to appear in some places without its object or its prepositional phrase? Obviously not, or *He put the car* and *He put in the garage* would slip back in.

In some sense, of course, the required phrases really are there—they're just not where we expect them. In the first sentence, a passive construction, the NP *the car*, playing the role of "thing put" which ordinarily would be the object, shows up in the subject position instead. In the second sentence, a *wh*-question (that is, a question formed with *who, what, where, when*, or *why*), the "thing put" role is expressed by the word *what* and shows up at the beginning. In the third sentence, the "place" role also shows up at the beginning instead of after the object, where it ordinarily belongs.

A simple way to account for the entire pattern is to say that every sentence has two phrase structures. The phrase structure we have been talking about so far, the one defined by the super-rules, is the deep structure. Deep structure is the interface between the mental dictionary and phrase structure. In the deep structure, all the role-players for *put* appear in their expected places. Then a transformational operation can "move" a phrase to a previously unfilled slot elsewhere in the tree. That is where we find the phrase in the actual sentence. This new tree is the surface structure (now called "s-structure," because as a mere "surface" representation it never used to get proper respect). Here are the deep structure and surface structure of a passive sentence:



In the deep structure on the left, *the car* is where the verb wanted it; in the surface structure on the right, it is where we actually hear it. In the surface structure, the position from which the phrase was moved contains an inaudible symbol that was left behind by the movement transformation, called a "trace." The trace serves as a reminder of the role that the moved phrase is playing. It tells us that to find out what *the car* is doing in the putting event, we should look up the "object" slot in the entry for the verb *put*; that slot says "thing put." Thanks to the trace, the surface structure contains the information needed to recover the meaning of the sentence; the original deep structure, which was used only to plug in the right sets of words from the lexicon, plays no role.

Why do languages bother with separate deep structures and surface structures? Because it takes more than just keeping the verb happy—what deep structure does—to have a usable sentence. A given concept often has to play one kind of role, defined by the verb in the verb phrase, and simultaneously a separate role, independent of the verb, defined by some other layer of the tree. Consider the difference between *Beavers build dams* and its passive, *Dams are built by beavers*. Down in the verb phrase—the level of who did what to whom—the nouns are playing the same roles in both sentences. Beavers do the building, dams get built. But up at the sentence (IP) level—the level of subject-predicate relations, of what is being asserted to be true of what—they are playing different roles. The active sentence is saying something about beavers in general, and

happens to be true; the passive sentence is saying something about dams in general, and happens to be false (since some dams, like the Grand Coulee Dam, are not built by beavers). The surface structure, which puts *dams* in the sentence's subject position but links it to a trace of its original verb phrase position, allows the cake to be both eaten and had.

The ability to move phrases around while still retaining their roles also gives the speaker of a rigid-word-order language like English a bit of wiggle room. For example, phrases that are ordinarily buried deep in the tree can be moved to early in the sentence, where they can hook up with material fresh in the listener's mind. For example, if a play-by-play announcer has been describing Nevin Markwart's progression down the ice, he could say *Markwart spears Gretzky!!!* But if it was Wayne Gretzky the announcer had been describing, he would say *Gretzky is speared by Markwart!!!!* Moreover, because a passive participle has the option of leaving the doer role, ordinarily the subject, unfilled in deep structure, it is useful when one wants to avoid mentioning that role altogether, as in Ronald Reagan's evasive concession *Mistakes were made*.

Hooking up players with different roles in different scenarios is something that grammar excels at. In a *wh*-question like

What did he put [*trace*] in the garage?

the noun phrase *what* gets to live a double life. Down in the who-did-what-to-whom realm of the verb phrase, the position of the trace indicates that the entity has the role of the thing being put; up in the what-is-being-asserted-of-what realm of the sentence, the word *what* indicates that the point of the sentence is to ask the listener to provide the identity of something. If a logician were to express the meaning behind the sentence, it would be something like "For which *x*, John put *xin* the garage." When these movement operations are combined with other components of syntax, as in *She was told by Bob to be examined by a doctor* or *Who did he say that Barry tried to convince to leave?* or *Tex is fun for anyone to tease*, the components interact to determine the meaning of the sentence in chains of deduction as intricate and precise as the workings of a fine Swiss watch.

Now that I have dissected syntax in front of you, I hope your reaction is more favorable than Eliza Doolittle's or Jack Cade's. At the very least I hope you are impressed at how syntax is a Darwinian "organ of extreme perfection and complication." Syntax is complex, but the complexity is there for a reason. For our thoughts are surely even more complex, and we are limited by a mouth that can pronounce a single word at a time. Science has begun to crack the beautifully designed code that our brains use to convey complex thoughts as words and their orderings.

The workings of syntax are important for another reason. Grammar offers a clear refutation of the empiricist doctrine that there is nothing in the mind that was not first in the senses. Traces, cases, X-bars, and the other paraphernalia of syntax are colorless, odorless, and tasteless, but they, or something like them, must be a part of our unconscious mental life. This should not be surprising to a thoughtful computer scientist. There is no way one can write a halfway intelligent program without defining variables and data structures that do not directly correspond to anything in the input or output. For example, a graphics program that had to store an image of a triangle inside a circle would not store the actual keystrokes that the user typed to draw the shapes, because the same shapes could have been drawn in a different order or with a different device like a mouse or a light pen. Nor would it store the list of dots that have to be lit up to display the shapes on a video screen, because the user might later want to move the circle around and leave the triangle in place, or make the circle bigger or smaller, and one long list of dots would not allow the program to know which dots belong to the circle and which to the triangle. Instead, the shapes would be stored in some more abstract format (like the coordinates of a few defining points for each shape), a format that mirrors neither the inputs nor the outputs to the program but that can be translated to and from them when the need arises.

Grammar, a form of mental software, must have evolved under similar design specifications. Though psychologists under the influence of empiricism often suggest that grammar mirrors commands to the speech muscles, melodies in speech sounds, or

mental scripts for the ways that people and things tend to interact, I think all these suggestions miss the mark. Grammar is a protocol that has to interconnect the ear, the mouth, and the mind, three very different kinds of machine. It cannot be tailored to any of them but must have an abstract logic of its own.

The idea that the human mind is designed to use abstract variables and data structures used to be, and in some circles still is, a shocking and revolutionary claim, because the structures have no direct counterpart in the child's experience. Some of the organization of grammar would have to be there from the start, part of the language-learning mechanism that allows children to make sense out of the noises they hear from their parents. The details of syntax have figured prominently in the history of psychology, because they are a case where complexity in the mind is not caused by learning; learning is caused by complexity in the mind. And that was real news.