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JEREMY WOLFE: In the last lecture, I was talking about the fact that people-- kids go through roughly the stages of language development-- they go through the same set of language development stages. Ooh, did it stop? Doo-doo-doo. Nope.

[LAUGHTER]

A babbling sort of pre-verbal stage, one word, two word, and then more than two word stages. And the question we're left with at the moment is, well, what is it that they're actually learning when they're learning language? There's lots of stuff that they're-- that's got to be learned.

One of the things that I saw on the handout somewhere there, as I recall, is they've got to do a remarkable job of learning words and word meaning between about a year and a half and six years of age in order to explain what the-- in order to account for the vocabulary that a six-year-old has, you have to assume that children are learning 5 to 10 words a day, every day. So that's a rate approaching a word an hour or so. And they're not doing it in school, right? It's not that they're going to school and, every day, they're being handed long vocabulary lists. They're just picking this stuff up.

It's an amazing and not trivial feat for figuring out how you do that. Somebody says, oh, look, there's the chalk. And the kid not only has to learn this new word, "chalk," but has to figure out that it somehow refers to this box of stuff and not to the color yellow or to the letter C or to the small boxes when Bush is president or any of a vast number of other possibilities. It's a very daunting problem.

I'm going to focus, rather than on the word meaning problem, on a different problem, which is the problem of learning grammar. And that is-- there, there are two large-scale classes of theory that I have cartoon-- I cartooned them on the board and described them on the handout as the East Coast view and the West Coast view. This is-- the East Coast view could really be called the MIT view, originally.

It really starts with people like Chomsky here and is nicely wrapped up in Steve Pinker's book called *The Language Instinct*, which, if you turn out to be interested in the topic of language and language learning, I strongly recommend you read it. Among other things, Pinker is one of the better writers in our field. And it's a good read.

And the West Coast view was a view held by, oh, people like Mark Seidenberg at UCLA. Well, Mark Seidenberg's now at Minnesota. So this geographical thing doesn't work so well anymore.

But here's the distinction. The notion that the East Coast guys-- so let's start with the specific problem. Specific problem might be something like how do you-- well, as it says on the handout, how do you make the past tense in English? I mean, you'd obviously have to learn how to make the past tense in some other language if you were going to learn yourself some other language.

But I walk to the store. Yesterday, I did what?

AUDIENCE: Walked.

JEREMY WOLFE:I walked to the store. OK. Today, I plan to, I don't know, I plan to go to the airport, actually, right after this lecture. Yesterday, I did what?

AUDIENCE: [INAUDIBLE]

JEREMY WOLFE:All right. OK, so how do we go and make the past tense in English? Huh?

AUDIENCE: ED.

JEREMY WOLFE:Yeah, stick an -ed on things, most of the time. Except, today I'm going to sing. Yesterday, I--

AUDIENCE: Sang.

JEREMY WOLFE:I didn't "singed." And today, we ring the bell. Yesterday--

AUDIENCE: Rang.

JEREMY WOLFE:We rang the bell, or we rung the-- no, we didn't rung the bell yesterday. The bell was rung yesterday, but we rang it yesterday. Anyway, it gets complicated. And today, I bring you all this information about language. And yesterday, I--

AUDIENCE: Brought.

JEREMY WOLFE:Brought. It's not even "brang." So as a rule, there's a sort of sub, sing, sang kind of rule. There's a bring, brang, brang-- no, brang doesn't work-- brought. So you have to learn-- well, so kids behave as though they have learned a rule and a set of exceptions.

The East Coast view of this is that they really have learned a rule, that somewhere, deep in their little brains, you could hypothetically go in and find the rule, that it is written in there. One of the lines of evidence for this is that, at a certain point during development, as they're learning this, they start to overuse the rule. And a child will say things like I "goed" to the store yesterday, and-- or I "bringed" the ball home from school yesterday or something like that. They'll start to overgeneralize.

They don't do it all the time. But they start to behave as though they are saying, aha, got this verb here. I know I need to make it into the past tense. What's the rule for making the past tense? I got to stick an -ed on the end of it, even though, a few months earlier, they might have successfully said went.

It is as if they learn a rule and they learn a set of exceptions. The job-- and when you go in and look for what you're trying to say, past tense of go, if the past tense go-- I went-- doesn't get there fast enough, you default to the rule. And you say I "goed."

This assumes-- or-- this assumes a certain amount of stuff in the head ahead of time. That's what this cartoon is about. It doesn't need to be-- it doesn't need to be exactly this kind of stuff. But this is the stuff that you might have in the head.

Let's think, actually, going back to the lectures I was giving on cognitive development a couple-- last week. Remember, there's pretty good evidence that little kids have in their head an idea about objects. They know there are such things about objects. So-- oops, I didn't put objects in here. Let's assume that there are such things as objects.

Well, and also, we saw that little kids know something about number. They can do that Karen Wynn style baby math. They know that there's one, and more than one, certainly. And now let's assume that they've got some innate idea, some innate capability to learn language. Well, if I'm going to learn a language of any use, it's going to have to be able to talk about these object things.

So I'm going to have some sort of innate idea that there will be nouns. I don't know what the nouns are going to look like in this language. But I come into the world in this view, knowing that there have to be noun-like things.

Not only that, I know that there can be one thing, and there can be more than one thing. It therefore follows that I need to be able to talk about that too. And so my job as a little language learner is to figure out what do the nouns look like, and how do I make those into plurals in my language?

And what I will do-- so there's an infinite number of ways, in principle, that I could designate a plural. But I will learn that, for the most part, in English, it's going to be add S, right? Oh, look, there's the cat. Oh, look, there are the cats, and so on.

And I'm going to have to do the same thing as I was talking about in the past tense. I'm going to have to learn there are exceptions. Yeah, cat, cats, rat, rats, chair, chairs, mouse-- uh, mice. Fish-- for some reason, fish is fish. One fish, two fish, red fish, blue fish, all that kind of stuff. So again, I'll learn a rule. I'll overgeneralize that rule when I get to be three or four years old. And I'll learn a set of exceptions.

And I will find, when I become a literature professor later on and study the history of English literature, that things shift over time. Things that were exceptions or things that were ungrammatical once upon a time might become grammatical. It's a moving target, language. You have to figure out what the current state of your language might be.

The alternative is to say-- the West Coast view, which is really a neural net parallel distributed processing kind of view, is to say, we don't have to propose that there's all this stuff, these structures in the head, in quite the same way. What we can say is, look, there's this very powerful association learner in here and statistical-- a device out there looking for statistical regularity.

There's evidence I think I mentioned last time that little kids, long before they can speak a language, are already sensitive to the statistical regularities of what syllables can follow what other syllables in the noises that they are hearing. So you've got this very powerful statistical learning device in your head. And it ends up behaving as if it had a rule. But the rule is not explicitly-- is not written out anywhere in brainware. It's just the way the network behaves.

In the same way that this hunk of chalk-- where's somebody who looks reasonably alert? Do you look reasonably alert? No, now she's looking elsewhere to see if she can-- uh, no, no? All right. How about if I just throw it out there. There we go. Look at that. [WHISTLES] See that? Oh, very good. Send it back.

That's a smart hunk of chalk. It knew to fly on a parabolic path.

[LAUGHTER]

Right? Knew a whole bunch of 801-style physics. It didn't know it in any real sense, of course. It behaves as if because it's operating under simple physical forces in the world and ends up behaving as if it knows physics.

It's a somewhat stretched analogy. But the same sort of thing is going on here. You learn about the linguistic world you are in, and then you behave as if you knew these rules rather than having some mechanism by which you actually, in a sense, before, at birth, knew that there should be such rules and merely needed to figure out the particular form that the rule took in your language.

These are, in a sense modern and not hugely different views of initial positions that are radically different. So if this is a continuum here, way over here somewhere would be radical nativist views of language. And way over here somewhere would be radical empiricist views of language-- empiricist.

The most radical nativist views nobody particularly held, except, I think I mentioned, that little children are subject to this as an erroneous thought. And that's the view that you are not only born to have language, but you're born to have a specific language, so that, if you are a Saudi kid, that you are born to speak Arabic and that, all else being equal-- well, even all else not being equal. You're a Saudi kid, you get transplanted to Sweden, and at the right moment, Arabic appears.

That's not true. Nobody other than a small kid, I think, ever particularly believed this because it was clearly falsifiable. But what-- the earliest experiment I know in this area-- and I don't know if the experiment was ever done-- is something reported by Herodotus in his book about traveling in Egypt. And he says that King Psammetichus of Egypt, 2,500 years ago, believed that there was an original language of humankind. Were King Psammetichus grown up in the Judeo-Christian tradition, he might have called it the language of the Garden of Eden. What language did Adam and Eve speak in the garden? Well, it'd be the original language of humankind.

And Psammetichus figured he would go and figure out what that language was. He actually had a hypothesis about what it was. He was King of Egypt. It stood to reason that the original language of humanity was Egyptian. And so what he is alleged to have done is to take two children, give them to a shepherd, tell the shepherd to raise them with sheep and not talk to them and to report to the king what the first word was that these children spoke.

And the report is that, when the children first spoke, their first word was *bekós*, which sounds suspiciously like they were imitating the sheep, I think. But anyway, *bekós* turned out to mean bread. And that seemed like a pretty encouraging thing, except that it meant bread in Phrygian, the language of Phrygia, which is in modern-day Turkey. It didn't-- it wasn't word for bread in Egyptian at all. And so Psammetichus is reputed to have been disappointed by the results of the experiment.

Look, we don't know that the experiment was ever done. We do know, or we're pretty sure we know, how the experiment would have come out had it actually been done, which is that they wouldn't have spoken a language at all, that, in the absence of a linguistic environment, even if you come into the world with some native endowment to learn a language, which does seem to be the case, you do not speak a normal human language unless you are raised in a linguistic environment at some point.

We think we know this from an isolated set of cases over the course of historical record, where kids are somehow deprived of linguistic input. Now, that happens typically in odd and disturbing kinds of circumstances. And so it's nothing like a real experiment, because of course, you'd never do the real experiment. It wouldn't be even close to ethical.

This class of children are known as wolf children, a term that has always disturbed me personally.

[LAUGHTER]

But the illusion is not to Wolfe with an E, but to the legendary story of the founding of Rome, where the twins Romulus and Remus are abandoned. I can't remember why. But anyway, they get suckled by a she-wolf. And so if you look at Roman coins and things, you'll see this picture of a great big wolf and two little babies suckling underneath. This is-- and presumably, the wolf wasn't speaking good Latin, but presumably, Romulus and Remus managed to come up with good Latin somehow out of all of this.

There are-- occasionally, it happens that some kid gets abandoned in the woods and somehow survives. I think there's a case of an Indian child who's described in *Gleitman*. There was a very disturbing book-- interesting but disturbing book-- called *Genie*, written a few years ago, about a child of deeply disturbed parents who had taken her and basically locked her in a closet for all of her childhood.

And the bottom line is that this is not going to be good for any aspect of your development, but you don't develop a normal language. If you don't get exposed to language during a so-called critical period, which, for language, is certainly over by early adolescence and is getting pretty much over-- six seven, eight years old, you'd better get your language experience in there before that. You're just never going to speak a normal grammatical language. The door closes on it.

So Genie, this poor girl who was raised in the closet, you could be taught-- could be taught a certain amount of vocabulary and things like that. But could never somehow get a real grip on the grammar of a language. It also turns out to be easier to learn a second language during the critical period, but not impossible to learn one afterwards, as those of you who have just started learning French or something will be happy to know. The claim is that it's very difficult to become a truly fluent speaker of a second language later in life. But it's not impossible in the way it appears to be impossible to learn a first language after the end of a critical period.

The alternative, the radical alternative, to King Psammetichus on one side, if we're sticking with classical references, on this side would be somebody like Saint Augustine, who writes that he learned-- he knows how he learned language. He learned language by being explicitly taught, the same way you'd learn anything else, that people said, that's chalk. That's a chair. That's your TA. And you learned this sort of stuff, and that it was an act of learning not unlike other acts of learning.

Now, this gets developed-- Saint Augustine was not particularly working on learning theory. But by the time you get to the mid-20th century and the heyday of behaviorism and all that good Skinnerian pigeons-in-the-box kind of thing, you get theories of language learning that say, well, look, language learning is just a fancy variety of any other kind of learning. You want your kid to speak English, and so you reward him for speaking English. You shape the behavior.

And the same time you're trying to get the kid to do some complicated thing like being toilet trained, you're also trying to get him to do things like saying, I go to the store. Yesterday, I went to the store. And it's just the same thing, more or less.

One of the great efforts to make that into a single coherent story is BF Skinner's book called *Verbal Behavior*-- good name from a good behaviorist. It's just another kind of behavior. And the start of the East Coast story and the start of modern cognitive science, in some ways, is Noam Chomsky, then a young professor at MIT, writing a scathing review of that book, which still bears reading. It's still fun to read that. Or you can go read the summary of it or the recap of it in Pinker's book.

But you have to imagine this as a cultural event. Skinner is the leading American psychologist of the time, and this young Noam Chomsky guy is going after him with a bat and both barrels blazing and any other weaponry you can think of. It is not a temperate review. It is insulting in many ways. And it's an insulting piece written by a young guy about a very senior, established, important guy. And it started-- it starts a revolution.

Anyway, I'm not going to go through the whole argument. But the sorts of things that Chomsky points out is that-- Skinner's talking about schedules of reinforcement. The patterns of reinforcement for language just aren't there. This has been extensively developed since Chomsky's time.

But yeah, let me-- you can imagine this from-- just an example. Imagine yourself back home as a little kid, and you go up to your mother, and you say, Mommy, I "loves" you so much. What's the chance that she's going to say, bad child, bad child. It's I love you.

[LAUGHTER]

And by the same token, what's the chance that, if you go up and say, as a precocious three-year-old, Mother dear, I'm sorry to have to say this, but it turns out that I actually loathe you and despise the ground on which you walk.

[LAUGHTER]

Right? Your mother is not going to say, that's a very sophisticated utterance for a three-year-old. Good job.

[LAUGHTER]

Right? You're not going to get-- and look, that's a cartoon version. But when you go and look at substantial bodies of child language and their interaction with the grown-ups in their life, you don't find good evidence for systematic correction of language or systematic reinforcement for grammatical structure. You don't find any great sensitivity on the part of the kid to that correction when it's given.

The sorts of things that every parent has-- they show up in the child language literature, but any parent can tell you that the kid comes up to you and says, Mommy I "loves" you. And you say, oh, that's sweet, honey, but it's really Mommy, I love you. And the kid says, yeah, that's right, Mommy. I "loves" you.

They don't show an awful lot of sensitivity to what-- to this sort of negative-- the negative support for what they're saying. How they actually figure out, eventually, that it's wrong is an interesting and important problem. But what is pretty clearly the case is that a story that will explain how it is that I persuaded my pigeon in my intro psych class to do ballet. I think I told that story here.

But anyway, I shaped my pigeon to do ballet. That was great-- that such a story does not cash out well as a story for how you're trying to explain language. It does not seem to be possible to explain language in those terms. As noted, if you want to know more about this particular argument, I really would recommend Pinker's book. It's good stuff.

So what have we got? We got the notion that specific languages are learned. You didn't come into the world pre-wired for English, Arabic, Chinese, or whatever. Language, in the abstract-- it's not exactly clear what it is that's innate. But something is innate that allows you to learn language.

And that something could be as specific as having, in a sense, the grammar written out in some abstract form in your head, and you're filling in the blanks. It could be something as non-specific as having a device that's designed to look for regularities in linguistic input. But something is in there that predisposes you and any linguistically normal human to learn language.

And in fact, it doesn't have to be-- it's not just something that's predisposing you to learn a spoken language. One of the most interesting bits of work in recent years in this area is the development of what really boils down to a brand new language that we can-- growing up, as much as anything, out of whatever this innate endowment is. This is the story of Nicaraguan Sign Language.

Before the Sandinista revolution in the '70s, in Nicaragua, I gather that deaf kids were typically raised at home and treated as though they were not just deaf, but not bright. They weren't going to learn much. When the-- I don't know if this is universally true, but there was a population of such kids.

When the revolution happened, one of the things that happened was a school for the deaf was set up in Managua, in the capital. And a bunch of deaf kids were brought together for the first time. What happened was that-- deaf kids, even in the absence of other members of a deaf community, will produce signs, gestures, called home signs, that indicate certain things. It's sort of a basic vocabulary, not a language, but a sort of a core vocabulary that you can use to communicate with your hearing parents, for instance.

What happened was that all these deaf kids got together. And I don't know what was going on in school, but I think what was going on at night up in the dormitories was they were working something out so that they could communicate with each other. And they put together a sort of a proto language.

Then the next generation, the next cohort of kids come. And now there's a crude linguistic environment. And what has happened over the next few cohorts of kids is that the next round of language-learning kids have systematically developed a language that now has grammatical structures in it that look like the grammatical structures of other languages.

American Sign Language, which is the common language used in the deaf community, the signing deaf community, here is a language like French, English, Chinese, or whatever. It's not English translated into hand gestures. Nicaraguan Sign Language is not American Sign Language. It's a new sign language with its own set of vocabulary and its own grammatical structure. But that grammatical structure seems to reflect an underlying tendency for all languages to have certain structures to them.

Let me give you one example because, brand new, this year's discovery in this realm-- suppose you're telling the Jack and Jill story, right? Jack and Jill went up the hill, and then stuff happens, and they fall down the hill, right? In English, the fall down part and the hill part are separate. They are obligatorily separate. There's the verb part, and there's the object of that verb. You fell down, and you fell down the hill.

There's no reason that would need to be the case in a sign language, right? You could perfectly have a gesture that was [SPUTTERS] that designates the act of falling down a hill. And indeed, apparently, the first generations of signers in Nicaragua, in this Nicaraguan school, have signs like that. But the new kids, the kids who came in young and are learning, developing this new grammatical version of sign language, have now separated those signs out and have a falling sign and a hill sign. I'm not-- I don't know that the signs look like that at all.

The important piece of it, though-- that's another misconception about signs is that the signs necessarily need to be pictographic. There's no requirement that the hill sign look like a hill. But for those of us who are complete illiterates in anything like a sign language, it might as well be because it gives you the idea. So they have developed, instead of a [SPUTTERS] falling down the hill sign, a [THUMP] falling [WHISTLES] hill grammar that corresponds to the same sort of constraints that show up in other languages.

Strong evidence-- this whole project has been interesting evidence for the powerful sense in which the human brain is there to learn. And even, if necessary, to create language. Well, I-- that raises the interesting question of, well, what about non-human brains? Do animals have language? And this has been a question for a long, long time. It's been a scientific question for a reasonably long time.

We're going to talk about it it's important to distinguish between two different sorts of language. One would be the natural-- any natural language that the animals might have on their own. Do animals talk to each other in the absence of humans intervening? And the other question is, can we teach them our language? Can we teach them how to talk like us in some fashion?

Within this natural and trained language dichotomy, then it's important to break this, the question of language, down into smaller pieces because, otherwise, you end up in an endless sterile argument about, well, what exactly do you mean by language? You can-- if I write a question on the final exam-- because it won't be on the midterm because today's topic is not on the midterm-- if I write a question on the final exam that basically says, do animals have language, it would be perfectly possible to write a coherent answer for either the yes or no position. But that would depend on what it is that you mean by "language."

So let's break this down a little bit. For starters, do animals have something that we could call signals? Do they have sensory stimuli that are communicative in their intent? Well, the answer to that is clearly yes. There's no problem with that, with figuring that out at all.

A peacock's tail is a signal to the peahen. Tropical fish-- why are tropical fish-- do tropical fish have all these beautiful colors all over them? Well, the idea is that I'm a tropical fish with, oh, I guess with stripes on. And I got to look for another tropical fish with stripes on because, if I mate with one with spots on, nothing's going to happen. But if I mate with one with stripes on, we get more little stripy fish.

The peacock tail story is supposed to be slightly more complicated. The standard evolutionary story for peacock tails is that peacock tails are really stupid, right? They don't help you fly. They drag-- they make you more likely to get chomped on by a predator and stuff.

But they're a huge investment. And what this is the male peacock saying, I am so fit, my genes are so good, that I grew this whole [WHOOSH] thing just for you, honey. And you really ought to come and check this out. So it's a signal. And it's not-- an awful lot of animal signals seem to be about sex and mating issues-- not all of them.

So vervet monkeys, for instance, have three distinct alarm calls. How do there are distinct alarm calls? Well, you go off and record them, and then you get your-- no your iPod because they don't have the little-- you get your boombox or something, and you play them to a bunch of vervet monkeys.

If you play call number one, all the vervet monkeys jump up a tree. If you play call number two, all the vervet monkeys jump down a hole. And if you play number three, they all stand up and look all around. And apparently, what this is about is, if you give-- if you see-- if you're a vervet monkey, and you see a leopard, you give one scream, and everybody jumps up the tree because the leopard can't go up the tree.

If you see a hawk or whatever the big predator bird is who eats vervet monkeys, you give a different scream. You should jump down the hole because the bird ain't going down the hole. And snakes, you want to just keep an eye out for them. So if somebody thinks they see a snake, everybody else is just going to look around.

So you've got sort of a three word vocabulary there. It also gets on to the second issue on the handout I-- oh, yes. No, that's not the handout. This is the handout. Yes, it should say meaning. Do these signals have meaning? Well, sure. There's no point to having a signal of this sort if it doesn't have meaning.

Well, you could have a signal without meaning. Look, I've got a rock here. This crystal has a-- could be thought of as signaling its sapphire-ness or something like that. But no other sapphire gives a hoot about it. There's no meaning there from the point of view of the rock. It just is, whereas an animal's signals of the sort that we've been talking about clearly have communicative intent. There is a purpose here.

And it's not even confined just to animals, it turns out. There are trees who respond to predator attacks by releasing a chemical. And it's all quite a passive kind of thing. The bug chews on the leaves. That ruptures the cells, which causes a chemical to be released, which can then be picked up by the next tree over.

The next tree over, in response, now mobilizes a defense against that predator. So in a sense, the trees are talking to each other. There's a signal there, and it's being received.

So no doubt that the animal kingdom has signals. The equivalent in human language would be phonemes. And no doubt that these signals have meaning, at least in some cases. And that could be considered to be sort of the equivalent of morphemes.

What about human language? What about training an animal to use human language? Could be the case that the only reason that a chimp, who is a close relation of ours, hasn't talked to us is because nobody talked to him.

So back in the '30s, the Hayeses, a couple in Salt Lake City, as I recall, tried this out. What they did was they had a kid. Mara could try this. They had a kid. They got a chimp. They said, we'll raise the two of them identically. I don't know. The chimp might sleep through the night sooner. But they'll talk to the kid. They'll talk to the chimp.

And after how long-- [MUTTERS] oh, it doesn't say how long they were at it. You don't want to do this for too long, because after a while, raising your chimp with your-- just hanging around in the playroom with your kid is not going to be good for the kid, because the chimp may not talk a lot, but the chimp grows big and strong and will play with your kid in ways that your kid will not enjoy.

But the kid-- the chimp didn't talk. And this is important because any neurologically normal child raised in a linguistic environment will talk, will learn to talk or, if deaf, will communicate and, given appropriate input, will communicate in other ways. The chimp is reputed to have said, I think, "mama"-- what have we got here? "Mama," "papa," and "cup." And that was it.

Now, one of the problems here that was quickly identified is that the chimp's vocal apparatus is not like yours and mine and is poorly designed to make the range of human phonemes that are important in human language. So the-- it occurred to subsequent researchers to try using sign language with chimps because chimps are very good with their hands. There's no problem making the gestures.

There's no physical limitation on the sort of gestures that the chimps could make, or gorillas-- limited work with orangutans, who turn out to be big and lazy, I understand. But gorillas, chimps, bonobo chimps, and gorillas all make good signers. And so most of the effort to teach human language to primates has involved sign language or computer keyboard arrangements where you teach-- you're sort of teaching the animal to type, in a sense, rather than to sign.

Now, it's true that chimps don't have the vocal apparatus to talk the way you and I talk. But that couldn't be the whole story, because if you have a child born with some congenital malformation that makes it impossible for them to talk properly, that child will talk badly, but will talk and will learn a language. A chimp in the same situation will simply not talk. There is a fundamental difference in the way that the chimp and the child are responding to linguistic input.

So can you teach him to sign? Yeah, actually, you can teach him to sign. There's a whole string of chimps who do really quite well with vocabularies on the order of hundreds of signs that seem to have discrete meaning. And it's not limited even to chimps. Irene Pepperberg, who was here for a while, is now a fellow at Harvard this year, has made a career out of studying African gray parrots. It's a not terribly dramatic, nice-looking little parrot with a nice little bird brain.

And the nice thing, of course, about parrots is that they can form the sounds. They're pretty good with the phonemes-- (PARROT VOICE) Polly want a cracker?-- and all that sort of stuff. But they're also remarkably bright.

And Alex, her great African gray, has a vocabulary on the order of 50 to 100 words, I think, that it can use in-- I suppose he can use in various and reasonable ways. So if Irene says to Alex, pick up the blue thing or the blue one, Alex will toddle over and grab a blue thing. And if you say, get the truck, it'll go get the truck and stuff like that.

It clearly has a grasp of a vocabulary and an ability to use it in some fashion or other-- mostly trained. Almost all the examples of animal use of a human language, any aspects of a human language, are heavily trained. Again, that's different from a little kid, where a little kid will pick up a language just by being around speakers.

There are a couple of instances now in the literature where children, the offspring of signing apes, have picked up signing on their own. So it may in fact be the case that you don't need explicit training. But what does seem to be the case is that you can-- that chimps and parrots can use what you'd probably consider to be morphemes, signs with meaning of some sort.

There are issues about the data quality. So if you point to something-- if you point to this banana and ask one of the signing apes what it is, you'll probably get banana. But you might get something out like banana, banana, me, tickle, banana, you, tickle, me, banana, banana, or something. And you might wonder whether or not you should code that as banana.

I saw one description that said that chimps tend to run on at the hands-- the expression that somebody runs on at the mouth. Well, chimps sign a lot, these signing chimps, perhaps because they're playing the same guessing game that we're all playing with language. What does this guy want from me? What's he trying to-- pointing at that thing? Oh, yeah, if I make these banana signs, maybe a few other signs in there, good things will happen. He'll be happy with me, and maybe we'll get good stuff.

So in any case, we've got evidence for signals. We've got evidence that they have meaning. How about grammar? Is there any evidence for grammar in animals? Things get thinner there.

Recall that you can use grammatical information to get yourself into the meaning of an utterance, even if you don't really-- I think I-- did I put on the handout "colorless green ideas sleep furiously" which I think is a Chomsky-ism originally designed to point out that purely syntactic information tells you something even without much in the way of-- you know how that sentence put together. Actually, this goes back before that. How many of you are great *Alice in Wonderland* fans from your youth at some? Oh, very limited.

So most people cannot sit here and quote back to me, "'Twas brillig and the slithy toves did gyre and gimble in the wabe-- all mimsy were the borogoves, and the mome raths outgrabe"? You have no idea what that's about.

AUDIENCE: It's "Jabberwocky."

JEREMY WOLFE: Yeah, it's the "Jabberwocky" poem in-- is it *Through the Looking Glass* or-- I think it's *The Looking Glass*, rather than-- anyway, it's in one of the two *Alice* books. But the interesting thing about it is, even though you have no idea, "'Twas brillig and the slithy toves did gyre and gimble in the wabe," you wha? Well, but you know that now that there are some things called toves. They have the attribute of slithy-ness.

They can do things that are apparently gyre-ing and gimble-ing. You can say things like gyre-ing and gimble-ing, ING-ing these things, even though you've never-- I got no idea what this verb means. You just know it's a verb. So that's the power of the grammar, of the syntax of the language.

To what extent do animals have a grip on that? The answer seems to be a pretty limited grip. There is evidence for word order sensitivity in animal signing, for instance. So you can have-- the chimp equivalent of John hit Mary being different from Mary hit John. Those are two-- same words, different order, different meaning. And chimps will show a sensitivity to that.

In fact-- this was a hot issue, and people were arguing about it vociferously. Epstein up at Harvard, who was one of Skinner's last students, used to have a great time trying to do chimp-- these fancy chimp language demonstrations with pigeons. And he showed that, sure enough, you could get a pigeon to understand that I've got a bunch of colored keys in your Skinner box, that if I pick red, green, blue, I get food. But if I do blue, green, red, I get water. And the pigeon would respond appropriately to that.

So order information is there in chimp signing. And it's in there in other behaviors too. It's also-- there's order information, structural information, in natural animal language too. It's not just [SHRIEKS] means snake or something like that.

So for example, bees-- how many of you have been to the-- well, how many have you seen have seen the waggle dance of bees? No? All right, it's pretty thin stuff here. You get in free to the science museum here, I believe, as MIT students. Sometime, like Friday, when you're done with the midterm or something, you want to go over to the science museum. You go up to the third floor, fourth floor, where the library is. They've got a beehive there.

And if you look at this beehive-- it's a big glass plane, so you can look in on it-- what you will see-- not so much at this time of year, because they're all going to bed at this point, but anyway, what you'll see is a bee who will be marching up the hive with a characteristic waggle of her backside and then looping back down and repeating this while a whole bunch of other bees are gathered around.

It's easy to find because there's typically a sort of a circle of bees watching this. And this is a highly structured bit of communication about where to go to look for food. I didn't go off and review my waggle dance information, but I'm pretty sure that memory serves correctly to say that the length of the vector here gives information about how far you've got to go, that the direction of the vector is giving you orientation relative to the sun about which direction to fly. And I think amplitude of the waggle is telling you about the magnitude of the food source, how good is this stuff.

And I can't-- got any waggle dance experts?

AUDIENCE: The altitude.

JEREMY WOLFE: An altitude?

AUDIENCE: Yeah, the altitude. I don't know--

JEREMY WOLFE: How-- signaling how high you should fly?

AUDIENCE: Yeah.

JEREMY WOLFE: That's cool. I didn't know that. Why would they care? So they don't--

AUDIENCE: If you're on the ground--

JEREMY WOLFE: Oh, I suppose-- yes, of course, if the-- not all the flowers are just lying on the ground. It could-- particularly in Boston, it could be a roof garden. OK, in any case, that's cool. But you don't remember what the signal is. OK, you don't-- and you don't remember what-- the looping back piece contains information too, but I don't remember what that-- very clever research that people do on this. It's lovely, a lovely body of literature.

But in any case, very structured, and full of a sort of native grammar. But it's-- it's pretty limited stuff. Perhaps the-- well, the newest evidence for what the limitation might be that makes animal grammar fundamentally different from your grammar and my grammar comes from an experiment by-- that I think I put on the handout, yeah-- a new paper by Fitch and Hauser, where they basically were teaching grammatical structures to two primates, two non-human primates.

And they were pretty good. They were doing fine on the John hit Mary is different from the Mary hit John part. But it was nested constructions that they simply never managed to get. So Mary, who was engaged to Sam, hit John. That's perfectly fine for you, sticking one clause inside another. That was stuff that they could just never manage to get their primates to pick up on.

Now, this is not an argument-- Hauser, in particular, is not somebody who spends a lot of time arguing that apes are stupid or something like that. The great apes are remarkably clever beasts. And in studying them, you find cognitive abilities not unlike a lot of our cognitive abilities.

I don't think it's a Hauser experiment, but one of the ones that comes to mind is-- that I could have talked about in the context of egocentric behavior before, is that an important landmark in the development of-- in your mental development was when you learned how to lie. It's another one of these ones that didn't necessarily get a lot of positive reinforcement from your parents when you demonstrated it to them. But it is an important cognitive landmark because it says, I know that what's in here is not what's in there, in your head. I can tell you something that I know is bogus, and you'll believe it.

[LAUGHTER]

Monkeys can do that too. How do you know this? Well, I can't remember who did the experiment, but you set up this clever experiment with a good person and a bad person. The monkey knows both of these people. The good person-- so both of these people have access to these boxes of stuff. The monkey sometimes has access to the boxes of stuff. When the monkey gets access, he can look under the box, and he finds the banana. Oh, cool, great. Or the grapes, or there's nothing under there. That's boring.

OK, now, now the monkey's on the other side of the cage, and here's the stuff. And if the good guy comes in, he looks under one of these things, finds the banana, and he shares it with the monkey. If the bad guy comes in, he looks, finds the banana, he eats it, and doesn't give the monkey any. So now, do this a few times. Monkey's got this bit down.

Now a third party comes in and baits one of these two wells, puts the banana under one of them. And now, if the good guy comes in, what does the monkey do? The monkey basically says, (WHISPERING) look there. You only get the (WHISPERING) look there. That's where you want to look.

The bad guy comes in, what's the monkey do? He says, (WHISPERING) look there.

[LAUGHTER]

And monkeys will also do this to each other, apparently, in the wild. There's a version where you stash stuff around the field and-- how does it work that the monkey lies to his friends? But the monkey-- you arrange for monkey one to discover the good stash. And then this monkey, in some fashion, goes off and tells his buddies to go look over there. The good stuff's over here.

And the monkeys busy-- (WHISPERING) you guys go over there. And he goes and eats all the bananas. So they're clever animals. But there does seem to be-- there do seem to be fundamental differences that you don't get around, that at least nobody's figured out how to get around them yet. Nobody has figured out a way how to get monkeys to anything like the richness of the grammar that human language has.

The result of this is that, even if you want to concede-- this is why you can answer both ways to the do animals have language? Suppose you decide that all you want is some evidence for phonemes, morphemes, and an ability to be sensitive to structure. Well, yeah, there's some evidence that chimps can do that, for instance. But the hurdle of developing a productive language, a language where you can say new stuff, that does not seem to be something that-- that does not seem to be a hurdle that any non-human species gets over in either natural language or in trained language.

So bees, great, sophisticated stuff, but no evidence that the bee ever learns to talk about anything new with this, right? The bee doesn't get to-- they don't get to sit around and apparently muse about, remember last year? Remember that honey-- not the honey, remember that patch of flowers that was over there? At least nobody, to my knowledge, has ever found the past tense in waggle or anything like. It's there up to a limit, but not further.

Now what I will do is take a momentary break here, say a word about why does this matter. And then what I'll do is entertain in midterm questions for a few minutes before the end of the hour. So take a quick stretch, and then let's come back and finish things up here.

[SIDE CONVERSATION]

Why does this matter? This has been a very contentious topic, more so than many-- people argue about visual attention, but people don't get really agitated about it like it's a moral issue. People get agitated about animal language like it is a moral issue because, in some fashion, it is. Or it is not itself a moral issue, but it impinges on issues that have more to do with morality than with science.

Well, you could couch it in theological terms, if you like. In Psalms, the psalmist asks rhetorically, at some point, of God, "What is man that you are mindful of him?" What is it that makes us so special that we're different from all these animal things out there?

And that's a question that becomes difficult if there is not a nice, clean, qualitative difference between what an animal is and what us is. This was one of the reasons why the advent of the theory of revo-- revolution-- the theory of evolution was so problematic, because it suggested that species were not completely distinct and that we were somehow a completely separate creation, but that there was a continuity between all forms of animal life up to and including us.

If that's the case, who is it that gets the sort of and privileges that we would arrogate to ourselves? And who is it that we get to treat-- well, who we get to treat like animals? And the search for a nice clear-- I'm not going to give you the answer to this, because there is, at least in my view, there is no nice, sharp dividing line that gives you a nice clean answer to this. But the search for a nice clean answer could include, well, who can talk to us?

Maybe that's-- maybe the ability to speak or communicate in a linguistic way is the critical division, because-- I mean, look, think about it in terms of what you would eat. If it were the case that you walk out into the field, and the cow can talk to you and carry on a conversation, even a sort of a simple conversation, a childlike conversation-- good grass, like grass, nice grass-- what's the chance that you're going to eat him? It doesn't feel quite right anymore.

And it's not just language. We don't like to eat things that we get to know. Language is a good way to get to know something. But oh, third grade, at the moment, reading *Charlotte's Web*, right? How many of you read *Charlotte's Web* at some point? Oh, good. Still a classic out there. A lot of the-- it's an issue about language and who you're going to get to eat.

There's a great one in the little Jewish kid repertoire called *The Carp in the Bathtub*, where a big-- a carp is basically an overgrown goldfish-- thing comes home and is living in the bathtub. And the kids love it. But this thing is intended to be food. And sad things happen to the carp.

It's hard-- things that are close to you are not things that you want to kill, not things that you want necessarily want to hurt. And so how you draw that line is important. If you could argue that it is absolutely the case that there is human language ability, and animals just don't got it at all-- another realm where this was tried was humans are tool users, and animals just aren't. There's a sharp division there. We can see it. It makes these sorts of discussions somewhat easier.

It doesn't make them a lot easier, necessarily, because look, if you have a human child who has a congenital neurological problem that means that child will never speak, the kid's mentally retarded in some fashion, is never going to speak, that doesn't mean you can eat him--

[LAUGHTER]

--or anything of the sort. That's obvious, sick nonsense, right? So it's not a simple division. But the efforts to figure out what makes us distinctively human and, as a result, who do human rights extend to is a serious problem, one that I am not going to attempt to solve here, but one that is certainly worth your ongoing consideration.

What I will attempt to solve here, for the remaining 10, 15 minutes or so, is I will dutifully attempt to answer any questions about the midterm that you might have at the present moment. And somebody's asked-- a couple of people asked me, is it a hard midterm? And the answer is that the first two TAs who read it said, boy, this is easy, and the second two TAs who read it said, boy, this is hard. And sadly, the distinction between the first two TAs and the second two TAs, in this case, was the first two TAs had TA'ed the course last year and had been through this once before, and the other ones hadn't. So you may use that tidbit of information in any way you see fit.

What other tidbits of information can I provide for you? Oh, yeah, right.

AUDIENCE: The closed-class.

JEREMY WOLFE: Yeah, closed-class and open-class words-- it's on today's handout. I think I mentioned it last time, but let me reiterate that closed-class-- so it was on last time, so it's fair game for the midterm. Closed-class words are words that serve grammatical, syntactical roles and do not-- "the," "and," "uh"-- words that don't have a definition in any straightforward sense except to explain that "the" means noun is a-coming. "And" means I'm joining a couple of things together.

And open-class words are the other ones. Closed-class-- it's a much smaller set. The closed-class words are a very small set. And the open-class set is the set of all other words that fill up the dictionary and everything else. So I think that's what you need to know about that.

Oh, the other thing to know about it is the closed-class words are what shows up when you get beyond the two-word stage in language development. Little kids, two-word stage kids don't say, "the ball." They say, "go ball" or something like that. But when they start to say, "I see the cat," longer utterances, that's when you start getting these closed-class things coming in.

OK, what else do you need to know? Everybody knows everything. This is great. No? OK, what?

AUDIENCE: Do you give any more short answers or more longer--?

JEREMY WOLFE: If you look at the exam from years past, the mix is roughly comparable. I didn't actually check. There's an interesting push-pull here. The longer answers are worth 10 points. So if I write long answer questions, they-- I can get done writing the exam faster. I don't have to write as many questions.

The short answer questions, the multiple choice questions, are a lot easier to grade. So if I write a lot of those, it's an easier test to grade. And so the mix of those two pressures leads me to sort of the usual mix, I think. Does it-- didn't look weird, did it? Can any-- no, it's about the-- kind of the usual, some of each. Yes?

AUDIENCE: Are we all going to take it here?

JEREMY WOLFE: The ones of you who come here will.

AUDIENCE: Oh.

JEREMY WOLFE: The ones who sleep late-- well, actually, at least it's in the afternoon here. Mostly, people make it awake. It's-- when-- is the final in the morning or the afternoon?

AUDIENCE: Morning.

JEREMY WOLFE: It's morning?

AUDIENCE: Afternoon.

JEREMY WOLFE: Oh, good. Whenever it's in the morning, there's all these sad people who traipse in an hour and a half late with some great story about I woke up when my alarm clock woke me up, but then I went back to sleep, and I had a dream that I was awake taking the exam.

[LAUGHTER]

Can't I get credit for the answers I was writing?

[LAUGHTER]

But yeah, it's here. It's here. Everybody's taking it here. And look, do me a favor, do your best to put a seat between each of you. And if you're not putting a seat between each of you because we've run out-- because there are 300 of you and not 600 seats, it's considered good form not to take the exam like this--

[LAUGHTER]

--particularly since the guy sitting next to you is probably is just as clueless as you are.

And it's really, really embarrassing when your wrong answer is exactly the same as the wrong answer sitting next to you. That's-- I mean, it's OK on a multiple choice thing. But the-- this happened-- actually, this happened to me once upon a time in grade school. I was accused of plagiarizing a report. And they showed it to me and, (STERN VOICE) here's this kid's report. Here's your report. These are identical, which was true.

And arrogant, smart kid that I was, I said, do you think I'd plagiarize from him?

[LAUGHTER]

I mean, it was-- it didn't take much of a brain to figure out who had plagiarized from whom, because this was a kid who was still reading the books with the print that you could read across the room. And anyway.

[LAUGHTER]

It was-- I wasn't going to plagiarize his. I was sort of flattered that he took my paper, I guess. Anyway, does anybody actually have a question I should answer here? Yeah, all right.

AUDIENCE: Can you do over the logic of perception?

JEREMY WOLFE: Can I go over who?

AUDIENCE: Logic of perception.

JEREMY WOLFE: The logic of perception. Well, the logic of perception is Irvin Rock's jargon for what I was really talking about in lecture, for instance, as inference. And I think maybe in the book also is Helmholtz's idea of unconscious inference. It's this idea that you're continuously making the best guess you can from an impoverished stimulus, that you've got a set of rules built into you that say-- that help you to try to figure out what it is that you're looking at. There's more to Rock's argument than that, but not much more in the book, as I recall-- something about like that.

There was another hand over there a moment ago. Well, now there's one here.

AUDIENCE: Is the test-- I think you said this, but is the test more dependent upon lectures or the book?

JEREMY WOLFE: Oh, so lectures or book? This is the triage question. I haven't read the book. I wasn't at the lectures. Now what do I do? The answer is that the intersection of book and lecture is the best place to devote your energy.

So things that were covered in both are probably important enough that, well, they're important enough that Gleitman thought it was important, and I thought it was important. That sounds important. Beyond that, I used to say that, because I am as egocentric as the next person, that things that are in my lectures but not in the book are more likely to show up than things that are in the book but not in the lecture, but I'm not really sure that's true anymore.

And so I would say that, after that, if I was trying to figure out how to ration my precious time, I would look at the set of bullet questions that I put on most of the handouts until I ran out of time for the chapter readings because what you've got there is what I think is important in the chapters. And that's a pretty good bet on things that I might ask about. I got no particular stake in being arbitrarily evil and saying, can I find some really teeny little piece of the book that I can quiz you about, and (MOCKING VOICE) nah-hah, nobody got it.

[LAUGHTER]

The amusement of that wears off after the first 20 years of teaching the course, it turns out. So another way of looking at it is I tend to ask questions-- when I'm going for stuff that's just in the book, I tend to go for stuff that's covered in more than one sentence in the book. So if something is worth a page to Gleitman, you might as well pay more attention to that than a passing figure caption. You'll be-- all right, we'll take one more back there.

AUDIENCE: Is the exam an hour or an hour--

JEREMY WOLFE: Hour and a half. And you should know that it's no longer than it used to be when it was an hour long. [LAUGHS]
So you'll be fine.

AUDIENCE: What genre of book is it based on?

JEREMY WOLFE: What genre of book is it based on? Printed.

[LAUGHTER]

[SIDE CONVERSATION]

Good luck.

[SIDE CONVERSATION]