Lex Fridman Podcast #53 - Noam Chomsky: Language, Cognition, and Deep Learning

Published – November 29, 2019

Lex Fridman

The following is a conversation with Noam Chomsky. He's truly one of the great minds of our time and is one of the most cited scholars in the history of our civilization. He has spent over 60 years at MIT, and recently also joined the University of Arizona where we met for this conversation. But it was at MIT about four and a half years ago when I first met Noam. My first few days there I remember getting into an elevator at Stata Center, pressing the button for whatever floor, looking up and realizing it was just me and Noam Chomsky riding the elevator. Just me and one of the seminal figures of linguistics, cognitive science, philosophy, and political thought in the past century, if not ever. I tell that silly story because I think life is made up of funny little defining moments that you never forget for reasons that may be too poetic to try and explain. That was one of mine. Noam has been an inspiration to me and millions of others. It was truly an honor for me to sit down with him in Arizona. I traveled there just for this conversation, and in a rare, heartbreaking moment after everything was set up and tested the camera was moved, and accidentally the recording button was pressed stopping the recording. So, I have good audio of both of us but no video of Noam - just a video of me and my sleep deprived but excited face that I get to keep as a reminder of my failures. Most people just listen to this audio version for the podcast as opposed to watching it on YouTube, but still it's heartbreaking for me. I hope you understand and still enjoy this conversation as much as I did. The depth of intellect that Noam showed, and his willingness, to truly listen to me: a silly looking Russian in a suit was humbling, and something I'm deeply grateful for. As some of you know, this podcast is a side project for me, where my main journey and dream is to build AI systems that do some good for the world. This latter effort takes up most of my time but for the moment has been mostly private. But the former, the podcast, is something I put my heart and soul into, and I hope you feel, that even when I screw things up. I recently started doing ads at the end of the introduction. I'll do one or two minutes after introducing the episode, and never any ads in the middle that break the flow of the conversation. I hope that works for you and doesn't hurt the listening experience. This is the Artificial Intelligence podcast. If you enjoy it, subscribe on YouTube, give it five stars on Apple Podcast, support it on Patreon, or simply contact with me on Twitter @lexfridman.

This show is presented by Cash App, the #1 finance app on the App Store. I personally use Cash App to send money to friends, but you can also use it to buy, sell, and deposit Bitcoins in just seconds. Cash App also has a new investing feature. You can buy fractions of a stock, say $1 worth, no matter what the stock price is. Broker services are provided by Cash App Investing, a subsidiary of Square and member FDIC. I'm excited to be working with Cash App to support one of my favorite organizations called the FIRST, best known for their FIRST robotics and LEGO competitions. They educate and inspire hundreds of thousands of students in over 110 countries, and have a perfect rating on Charity Navigator, which means the donated money is used to maximum effectiveness. When you get Cash App in the App Store or Google Play, and use code 'LexPodcast', you'll get $10 and Cash App will also donate $10 to FIRST, which, again, is an organization that I've personally seen inspire girls and boys

to dream of engineering a better world. And now, here's my conversation with Noam Chomsky.

Lex Fridman
I apologize for the absurd philosophical question, but if an alien species were to visit Earth, do you think we would be able to find a common language or protocol of communication with them?

Noam Chomsky
There are arguments to the effect that we could. In fact, one of them was Marv Minsky's. Back about 20 or 30 years ago, he performed a brief experiment with a student of his, Daniel Bobrow. They essentially ran the simplest possible Turing machines, just free to see what would happen. And most of them crashed, either got into an infinite loop, or were stopped. The few that persisted essentially gave something like arithmetic. And his conclusion from that was, that if some alien species developed higher intelligence, they would at least have arithmetic. They would at least have what the simplest computer would do. And, in fact, he didn't know that at the time, but the core principles of natural language are based on operations, which yield something like arithmetic, in the limiting case, in the minimal case. So, it's conceivable that a mode of communication could be established based on the core properties of human language, and the core properties of arithmetic, which maybe are universally shared. So, it's conceivable.

Lex Fridman
What is the structure of that language, of language as an internal system inside our mind, versus an external system as it's expressed?

Noam Chomsky
It's not an alternative. It's two different concepts of language.

Lex Fridman
Different.

Noam Chomsky
It's a simple fact that there's something about you, a trait of yours, part of the organism you that determines that you're talking English and not Tagalog, let's say. So, there is an inner system. It determines the sound and meaning of the infinite number of expressions of your language. It's localized, it's not in your foot, obviously. It's in your brain. If you look more closely, it's in specific configurations of your brain. And that's, essentially, like the internal structure of your laptop - whatever programs it has, are in there. Now, one of the things you can do with language - it's a marginal thing in fact - is use it to externalize what's in your head. I think most of your use of language is thought, internal thought. But can do what you and I are now doing: we can externalize it. Well, the set of things that we're externalizing are

an external system. They're noises in the atmosphere, and you can call that language, in some other sense of the word, but it's not a set of alternatives. These are just different concepts.

Lex Fridman
So, how deep do the roots of language go in our brain, our mind? Is it yet another feature like vision? Or is it something more fundamental from which everything else springs in the human mind?

Noam Chomsky
Well, in a way it's like vision. There's something about our genetic endowment that determines that we have a mammalian rather than an insect visual system. And, there's something in our genetic endowment that determines that we have a human language faculty. No other organism has anything remotely similar. So, in that sense, it's internal. Now, there is a long tradition, which I think, is valid going back centuries to the early scientific revolution, at least, that holds that language is the sort of the core of human cognitive nature. It's the source. It's the mode for constructing thoughts, and expressing them, and that is what forms thought, and it's got fundamental creative capacities. It's free, independent, unbounded, and so on. And undoubtedly, I think the basis for our creative capacities, and the other remarkable human capacities that lead to the unique achievements, and not so great achievements of the species.

Lex Fridman
The capacity to think and reason, do you think that's deeply linked with language? Do you think the internal language system is essentially the mechanism by which we also reason internally?

Noam Chomsky
It is undoubtedly the mechanism by which we reason. There may also be other - there are undoubtedly other faculties involved in reasoning. We have a kind of scientific faculty. Nobody knows what it is, but whatever it is that enables us to pursue certain lines of endeavor, and inquiry, and to decide what makes sense, and doesn't make sense, and to achieve a certain degree of understanding in the world that uses language but goes beyond it. Just as using our capacity for arithmetic is not the same as having the capacity.

Lex Fridman
The idea of capacity, our biology, evolution. You've talked about it defining essentially our capacity, our limit, and our scope. Can you try to define what limit and scope are? And the bigger question, do you think it's possible to find the limit of human cognition?

Noam Chomsky

Well that's an interesting question. It's commonly believed, most scientists believe, that human intelligence can answer any question in principle. I think that's a very strange belief. If we're biological organisms, which are not angels, then our capacities ought to have scope and limits which are interrelated.

Lex Fridman

Can you define those two terms?

Noam Chomsky

Well, let's take a concrete example. Your genetic endowment, it determines that you can have a mammalian visual system, and arms, and legs, and so on. And, therefore, become a rich, complex organism. But if you look at that same genetic endowment, it prevents you from developing in other directions. There's no kind of experience which would yield the embryo to develop an insect visual system, or to develop wings instead of arms. So, the very endowment that confers richness and complexity also sets bounds on what can be attained. Now, I assume that our cognitive capacities are part of the organic world, therefore, they should have the same properties. If they had no built-in capacity to develop a rich and complex structure, we would have understand nothing. Just as if your genetic endowment did not compel you to develop arms and legs, you would just be some kind of a random ameboid creature with no structure at all. So, I think it's plausible to assume that there are limits, and I think, we even have some evidence as to what they are. So, for example, there's a classic moment in the history of science, at the time of Newton. There was from Galileo to Newton: modern science developed on a fundamental assumption, which Newton also accepted - namely, that the world, the entire universe, is a mechanical object. And by mechanical they meant something like the kinds of artifacts that were being developed by skilled artisans all over Europe: the gears, levers, and so on. And their belief was, "well, the world is just a more complex variant of this." Newton, to his astonishment and distress, proved that there are no machines - that there is interaction without contact. His contemporaries, like Leibniz and Huygens, just dismissed this as returning to the mysticism of the Neo-Scholastics, and Newton agreed. He said, "It is totally absurd. No person of any scientific intelligence could ever accept this for a moment." In fact, he spent the rest of his life trying to get around it somehow, as did many other scientists. That was the very criterion of intelligibility for, say, Galileo or Newton. Theory did not produce an intelligible world unless you could duplicate it in a machine, and he showed you can't. There are no machines, any. Finally, after a long struggle - took a long time - scientists just accepted this as common sense, but that's a significant moment. That means they abandoned the search for an intelligible world, and the great philosophers of the time understood that very well. So, for example, David Hume, in his encomium to Newton, wrote that, who was the greatest thinker ever, and so on. He said that he unveiled many of the secrets of nature, but by showing the imperfections of the mechanical philosophy, mechanical science, he left us with - he showed that - there are mysteries which ever will

remain. And science just changed its goals, it abandoned the mysteries. If it can't solve it, they'll put it aside. We only look for intelligible theories. Newton's theories were intelligible. It's just what they described wasn't. Well, Locke said the same thing. I think they're basically right, and if so that showed something about the limits of human cognition. We cannot attain the goal of understanding the world, of finding an intelligible world. This mechanical philosophy, Galileo to Newton, there's a good case that can be made that that's our instinctive conception of how things work. So, if say infants are tested with things that: if this moves, and then this moves. They kind of invent something that must be invisible, that's in between them, that's making them move, and so on.

Lex Fridman
Yeah, we like physical contact. Something about our brain seeks -

Noam Chomsky
Makes us want a world like then, just like it wants a world that has regular geometric figures. So, for example, Descartes pointed this out, that if you have an infant who's never seen a triangle before and you draw a triangle the infant will see a distorted triangle, not whatever crazy figure it actually is, you know. Three lines not coming quite together or one of them a little bit curved, and so on. We just impose a conception of the world in terms of perfect geometric objects. It's now been shown that it goes way beyond that. That if you show on a tachistoscope, let's say, a couple of lights shining, you do it three or four times in a row, what people actually see is a rigid object in motion not whatever is there. We all know that from a television set basically.

Lex Fridman
So that gives us hints of potential limits to our cognition?

Noam Chomsky
I think it does, but it's a very contested view. If you do a poll among scientists they'll say impossible, we can understand anything.

Lex Fridman
Let me ask and give me a chance with this. So I just spent a day at a company called Neuralink, and what they do is try to design what's called a brain machine, a brain-computer interface. So, they try to just do thousands of readings in the brain, be able to read what the neurons are firing and then stimulate back, so, two-way. Do you think their dream is to expand the capacity of the brain to attain information, sort of increase the bandwidth at which we can search Google, kind of thing? Do you think our cognitive capacity might be expanded, our linguistic capacity, our ability to reason might be expanded by adding a machine into the picture?

Noam Chomsky

It can be expanded in a certain sense, but a sense that was known thousands of years ago. A book expands your cognitive capacity, okay? So, this could expand it, too.

Lex Fridman

But it's not a fundamental expansion. It's not totally new things could be understood.

Noam Chomsky

Well, nothing that goes beyond our native cognitive capacities. Just like you can't turn the visual system into an insect system.

Lex Fridman

Well, I mean the thought is perhaps you can't directly but you can map –

Noam Chomsky

You could. But we already – we know that without this experiment, you could map what a bee sees and present it in a form so that we could follow it. In fact every bee scientist does that.

Lex Fridman

But you don't think there's something greater than bees that we can map, and then all of a sudden discover something, be able to understand a quantum world, quantum mechanics, be able to start to be able to make sense?

Noam Chomsky

You can, students at MIT study and understand quantum mechanics.

Lex Fridman

But they always reduce it to the infant, the physical, I mean they don't really understand –

Noam Chomsky

Not physical, that may be another area where there's just a limit to understanding. We understand the theories, but the world that it describes doesn't make any sense. So, you know the experiment, the Schrödinger's cat, for example, can understand the theory but as Schrodinger pointed out it's not an intelligible world. One of the reasons why Einstein was always very skeptical about quantum theory. He described himself as a classical realist, and wants intelligibility.

Lex Fridman

He has something in common with infants in that way. So, back to linguistics, if you could humor me, what are the most beautiful or fascinating aspects of language, or ideas, in

linguistics, or cognitive science, that you've seen in a lifetime of studying language and studying the human mind?

Noam Chomsky
Well, I think the deepest property of language and puzzling property that's been discovered is what is sometimes called structure dependence. We now understand it pretty well, but it was puzzling for a long time. I'll give you a concrete example. So, suppose you say "the guy who fixed the car carefully packed his tools." That's ambiguous. He could fix the car carefully or carefully pack his tools. Now suppose you put carefully in front: "Carefully the guy who fixed the car packed his tools." Then it's carefully packed, not carefully fixed. And in fact you do that even if it makes no sense. So, suppose you say, "carefully the guy who fixed the car is tall". You have to interpret it as carefully he's tall even though that doesn't make any sense. And notice that that's a very puzzling fact because you're relating carefully not to the linearly closest verb but to the linearly more remote verb. Linear closeness is a easy computation, but here you're doing a much more, what looks like a more complex computation. You're doing something that's taking you essentially to the more remote thing. Now, if you look at the actual structure of the sentence, where the phrases are and so on, turns out you're picking out the structurally closest thing, but the linearly more remote thing. But notice that what's linear is 100% of what you hear. You never hear structure. You can't. So, what you're doing is, and instantly, this is universal – all constructions, all languages – and what we're compelled to do is carry out what looks like the more complex computation on material that we never hear, and we ignore 100% of what we hear and the simplest computation. And by now, there's even a neural basis for this, that's somewhat understood, and there's good theories but none that explain why it's true. That's a deep insight into the surprising nature of language with many consequences.

Lex Fridman
Let me ask you about a field of machine learning and deep learning. There's been a lot of progress in neural network based machine learning in the recent decade. Of course, neural network research goes back many decades.

Noam Chomsky
Yeah.

Lex Fridman
What do you think are the limits of deep learning, of neural network based machine learning?

Noam Chomsky
Well, to give a real answer to that you'd have to understand the exact processes that are taking place, and those are pretty opaque, so it's pretty hard to prove a theorem about what can be done and what can't be done. But I think it's reasonably clear, I mean, putting

technicalities aside, what deep learning is doing is taking huge numbers of examples and finding some patterns. Okay, that could be interesting, and in some areas it is. But we have to ask here a certain question. Is it engineering, or is it science? Engineering, in the sense of just trying to build something that's useful, or science, in the sense that it's trying to understand something about elements of the world so it takes a Google parser. We can ask that question, is it useful? Yeah, it's pretty useful. I use Google Translator. So, on engineering grounds it's kinda worth having like a bulldozer. Does it tell you anything about human language? Zero, nothing. And in fact, it's very striking. From the very beginning it's just totally remote from science. So, what is a Google parser doing? It's taking an enormous text, let's say The Wall Street Journal corpus, and asking, how close can we come to getting the right description of every sentence in the corpus? Well, every sentence in the corpus is essentially an experiment. Each sentence that you produce is an experiment, which is, am I a grammatical sentence? Now, the answer is usually yes, so most of the stuff in the corpus is grammatical sentences. But now, ask yourself: is there any science which takes random experiments, which are carried out for no reason whatsoever, and tries to find out something from them? Like if you're, say, a chemistry PhD student you want to get a thesis, can you say, "well I'm just gonna do a lot of, mix a lot of things together, no purpose, and maybe I'll find something". You'd be laughed out of the department. Science tries to find critical experiments, ones that answer some theoretical question. Doesn't care about coverage of millions of experiments. So, it just begins by being very remote from science, and it continues like that, so the usual question, that's asked about, say, a Google parser is how well does it do?, or some parser, how well does it do on a corpus? But there's another question that's never asked: how well does it do on something that violates all the rules of language? So, for example, take the structure dependence case that I mentioned, suppose there was a language in which you used linear proximity as the mode of interpretation, these deep learning would work very easily on that. In fact, much more easily than on an actual language. Is that a success? No, that's a failure. From a scientific point of view that's a failure. It shows that we're not discovering the nature of the system at all because it does just as well, or even better on things that violate the structure of the system, and it goes on from there. It's not an argument against doing it. It is useful to have devices like this.

Lex Fridman
So yes, neural networks are kind of approximators that look – there's echoes of the behavioral debates, right? Behavioralism.

Noam Chomsky
More than echoes. Many of the people in deep learning say they're vindicated.

Lex Fridman
Yeah.

Noam Chomsky

Terry Sejnowski, for example, in his recent book says this vindicates Skinnerian behaviors, and it doesn't have anything to do with it.

Lex Fridman

Yes, but I think there's something actually fundamentally different when the dataset is huge, but your point is extremely well taken. But do you think we can learn, approximate that interesting, complex structure of language, with neural networks, that will somehow help us understand science?

Noam Chomsky

It's possible, I mean, you find patterns that you hadn't noticed, let's say. Could be, in fact it's very much like a kind of linguistics that's done, what's called corpus linguistics when you, suppose you have some language where all the speakers have died out but you have records. So, you just look at the records and see what you can figure out from that. It's much better to have actual speakers where you can do critical experiments, but if they're all dead you can't do them, so you have to try to see what you can find out from just looking at the data that's around. You can learn things. Anthropology is very much like that. You can't do a critical experiment on what happened two million years ago so you're kinda forced to take what data's around and see what you can figure out from it. Okay, it's a serious study.

Lex Fridman

So, let me venture into another whole body of work and philosophical question. You've said that evil in society arises from institutions, not inherently from our nature. Do you think most human beings are good, they have good intent, or do most have the capacity for intentional evil that depends on their upbringing, depends on their environment, on context?

Noam Chomsky

I wouldn't say that they don't arise from our nature. Anything we do arises from our nature. And the fact that we have certain institutions, and not others, is one mode in which human nature has expressed itself. But as far as we know, human nature could yield many different kinds of institutions. The particular ones that have developed have to do with historical contingency - who conquered whom, and that sort of thing. Then, they're not rooted in our nature in the sense that they're essential to our nature. So, it's commonly argued that these days, that something like market systems is just part of our nature, but we know from a huge amount of evidence that that's not true. There's all kinds of other structures. It's a particular fact of a moment of modern history. Others have argued that the roots of classical liberalism actually argue that what's called sometimes an instinct for freedom, an instinct to be free of domination by illegitimate authority is the core of our nature. That would be the opposite of this. And we don't know, we just know that human nature can accommodate both kinds.

Lex Fridman
If you look back at your life, is there a moment in your intellectual life - or life in general - that jumps from memory that brought you happiness that you would love to relive again?

Noam Chomsky
Sure, falling in love, having children.

Lex Fridman
What about - so you have put forward into the world a lot of incredible ideas in linguistics - in cognitive science. In terms of ideas that just excites you - when it first came to you - that - you love to relive those moments?

Noam Chomsky
Well, I mean, when you make a discovery about something it's exciting, like say even the observation of structure dependence, and on from that the explanation for it. But the major things just seem like common sense. So, if you go back to - take your question about external and internal language - you go back to, say, the 1950s, almost entirely language is regarded as an external object - something outside the mind. It just seemed obvious that that can't be true. Like I said, there's something about you that determines you're talking English not Swahili or something. But that's not really a discovery. That's just an observation of what's transparent. You might say it's kind of like the 17th century, the beginnings of modern science 17th century, they came from being willing to be puzzled about things that seemed obvious. So, it seems obvious that a heavy ball of lead will fall faster than a light ball of lead, but Galileo was not impressed by the fact that it seemed obvious, so he wanted to know if it's true. He carried out experiments - actually, thought experiments - never actually carried them out - which showed that it can't be true, you know. And out of things like that - observations of that kind - you know: Why does a ball fall to the ground instead of rising? - let's say. It seems obvious till you start thinking about it. 'Cause why does steam rise? - let's say. And I think the beginnings of modern linguistics roughly in the 50s are kind of like that - just being willing to be puzzled about phenomena that looked from some point of view obvious. And for example, a kind of doctrine, almost official doctrine of structural linguistics in the 50s, was that languages can differ from one another in arbitrary ways,and each one has to be studied on its own without any presuppositions. And in fact there were similar views among biologists about the nature of organisms, that each one's, they're so different when you look at them that you could be almost anything. Well, in both domains it's been learned that it's very far from true. There are very narrow constraints on what could be an organism or what could be a language. But these are, you know, that's just the nature of inquiry.

Lex Fridman

Science in general, yeah, inquiry. So, one of the peculiar things about us human beings is our mortality. Ernest Becker explored it. In general do you ponder the value of mortality? Do you think about your own mortality?

Noam Chomsky

I used to when I was about 12 years old. I wondered, I didn't care much about my own mortality, but I was worried about the fact that if my consciousness disappeared, would the entire universe disappear? That was frightening.

Lex Fridman

Did you ever find an answer to that question?

Noam Chomsky

No, nobody's ever found an answer, but I stopped being bothered by it. It's kind of like Woody Allen in one of his films. You may recall he goes to a shrink when he's a child, and the shrink asks him, "What's your problem?" He says, "I just learned that the universe is expanding. I can't handle that."

Lex Fridman

And another absurd question is, what do you think is the meaning of our existence here, our life on Earth, our brief little moment in time?

Noam Chomsky

That's something we answer by our own activities. There's no general answer. We determine what the meaning of it is.

Lex Fridman

The action determines the meaning.

Noam Chomsky

Meaning in the sense of significance, not meaning in the sense that chair means this, you know. But the significance of your life is something you create.

Lex Fridman

Noam, thank you so much for talking today. It was a huge honor, thank you so much. Thanks for listening to this conversation with Noam Chomsky, and thank you to our presenting sponsor Cash App. Download it, use code 'LexPodcast'. You'll get $10, and $10 will go to FIRST, a STEM education nonprofit that inspires hundreds of thousands of young minds to learn and to dream of engineering our future. If you enjoy this podcast subscribe on YouTube. Give us five stars on Apple Podcast, support on Patreon, or connect with me on Twitter. Thank you for listening and hope to see you next time.