The Neurobiology of Language

The Nature & Nurture Podcast

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Dr. Cedric Boeckx is a biolinguist and Research Professor at the Catalan Institute for Advanced Studies at the University of Barcelona. In this episode we discuss Cedric's research background, talk about what language is, from a scientific perspective, how it evolved in humans, and how it can be studied through cognitive psychology, computational modeling, and the human fossil record.

Adam Omary: Today I'm joined by Dr. Cedric Books. He is a research professor at the Catalan Institute for Advanced Studies of the University of Barcelona, where he studies the cognitive neurobiology of language. Cedric, welcome to the Nature and Nurture Podcast.

Cedric Boeckx: Thanks for having me.

Adam: Thanks for taking the time to be here. So how did you first get interested in this field? Were you more on the linguistics end and then the biology came later, or were you on the biology end and the linguistics came later?

Cedric: It's hard to know which came first. I think what came first is really the philosophy of it. So I was interested as an undergraduate in philosophy of mine and heard about Descartes and at some point also for, reading about politics, I heard about this guy called Noam Chomsky. that was famous also for linguistics and also for studying the mind, for studying cognition. So I got interested in this because Chomsky promised that studying language could actually tell us something deep and interesting about human cognition and ultimately human biology. So I've always thought that these three fields the language sciences, philosophy, and biology, at least can be brought together and can generate, an interesting intersection, as it were. And that would have been trying to do. Since then I focused primarily on on the linguistic side of things, but gradually realized that you know I had to get my hands dirty with biological details. If if I really wanted to to make good of the promise that ultimately we would get to the biology. Turns out that it's hard if you don't do biology.

Adam: Right. So Chomsky was one of the early advocates for language is innate, right, as opposed to something like humans are a blank slate and you learn it over time.

Cedric: That's right. He and a couple of his friends, like Eric Lennenberg and Maurice Halley in the 50s, were really trying to move away from the then dominant behaviorist, you know, I hesitate to say theory, say perspective or viewpoint that was certainly dominant in Cambridge, Massachusetts when they were students there. And I think that that's been a big theme since the 50s, pretty much. you have this very heated discussions about whether things are innate, things are learned. I think that there's actually a lot more agreement in between the lines. But yeah, he was certainly an early advocate of the need to recognize an important and significant contribution of biology.

Adam: Right. Yeah, because the innate thing seems really related to biology in the sense that if that is the case, then that's where it would come from.

Cedric: That's right. Eventually, that's where it would come from. Turns out it's very hard to figure out what the biological underpinnings are. But yeah, you expect to find something or some things that would help the learner. And then the big question, which perhaps we'll get into, is how specific that information is. And the linguists as it were, place their early bets on something being very specific to language in that innate component. I think that turned out not to be quite right, but it's certainly the bet that they made at the beginning.

Adam: So would the contrast to that be something like, it's not specific to language, it's just this general high intelligence that humans have in language is one way that we can use that?

Cedric: I don't like the word intelligence too much, but I think the contrast would be as opposed to something information specific, like dedicated to language and only to language. The contrast would be a learner that recruits cognitive biases, cognitive priors that are much more general in character. That means those that can be found in other cognitive systems, not specifically, in language, but also potentially, and this is particularly interesting to me, in other species, right? Because, first the philosophers and the linguists like to say that language, is something like a species-specific trait. And that, of course, makes it very hard for the biologists to study, because biologists love to compare, not contrast. And if you tell them, it's only us, then it makes their job much harder.

Adam: We should define what we mean by language, because I think most people think of spoken language and maybe syntax, but then in this more philosophical sense, language might be something like, abstract symbolic representation of information.

Cedric: I think that's right. How many hours do we have to define language? We have one hour. It's very hard, actually, you know, because, you know, this is such a term that's difficult to define. It's a term that so many people use in many different ways that it's very often these heated discussions arise from the fact that people don't quite mean the same thing or don't use the same definition, as it were. I think it's hard also to define language for another reason that we've come to appreciate, I think, over the past maybe decade or so. And it is that language is not one thing. It's really many different cognitive sub-components, if you want, that are brought together in specific tasks, for example, in communication, but also in thought. In, you know, it's really hard to find a definition that gets at all these components at once. And again, for the biologists, it's a good thing if language is sort of like a mosaic, consisting of bits and pieces that you can find in different animals, scattered as it were. But for the linguists or the philosophers, that's not a great definition when you say it's a bunch of very different things, right? And so you're right that for many people, very often, language is used as a term to refer specifically to things like syntax or thought or communication, and this is where the disagreements happen, as it were.

Adam: Seems like a paradox that you have to use language to define language.

Cedric: That's right, and I think that in part, you know, we all have at some level an idea of what language is, because we use it all the time. And that, in a certain sense, gives us the impression that we all know what it is. It's not like very complex concepts, like, I don't know, those that they use in physics or something. But at the same time, it leads to discussions that are often not very well informed because those definitions of language, I mean, our notion of language, our folk definition of language is very often not appropriate. Right.

Adam: And even things like physics, people can describe as a language. I mean, it's sort of a poetic term if you say the language of the universe. But then in the technical sense, something like an equation still contains information and it's written down. And that seems kind of similar to normal written language.

Cedric: In a certain sense, that's right. There is a technical notion. And of course, like all technical notions, they are hard to, as it were, export from one field to the next. And that makes certain issues about language very difficult to to convey. It's not that it's impossible to convey, but it just makes it harder for people in very different fields to abandon the sort of preconceived idea they have about language and then agree on a technical definition.

Adam: So in your own research, what does it look like when you're both studying language and when you're looking at the neurobiological aspect?

Cedric: Well, I think So I wouldn't be able to give you like a one sentence definition of it. But here are a couple of components of a, I think, a good definition of what language should be like. First of all, there should be some sort of notion of evolution in this. That is, it's a system of the mind. So it's an aspect of our cognition that evolved, like other things that evolved. That means that it probably has a very long history and consists of many different subparts, right? So that's certainly one thing. So it's not one component, but many. Another thing that I think must be part of a good definition of language is that it's not just about spoken language. It's now clear that, you know, language is a multimodal system. that very often relies on the spoken medium, but it can also make use of gestures. So we have sign languages that are perfectly as complex as spoken languages. And these modalities each contribute to making language what it is. So we shouldn't, in that definition, we shouldn't just collapse language and spoken language or speech. I think that this is a mistake that people often make. I think another component of that definition of language is that it's certainly a tool that creates meaning. So it's a tool that's used for thought and communication to convey some fairly complex thoughts to others. And so I'm opposed to this dichotomy of asking whether language is for thought or communication. I think it really contributes to both. It's certainly an important way in which we communicate, but I think it's also a system of cognition that enables us to combine ideas and thoughts in ways that are special in some sense.

Adam: And even thoughts seems kind of like communicating to yourself, maybe to your future or past self.

Cedric: Yeah, I think that there is certainly an internal aspect of language that Yeah, it's probably a way of communicating across different cognitive systems of the mind, as it were, so internal to oneself. I think that it certainly is not something that's an either or communication or thought. I think that these things are much more closely related and intertwined than many think.

Adam: Does your own work looking at the biological aspect of language, does it focus only on humans or do you also do comparative work with animals?

Cedric: So great question. I think at the beginning, I made a mistake of following the line of thought that was specific to humans. And so it was such a design, a defining feature of us that it's very easy to convince oneself it's just about us. And like I said, that makes the job of the biologist very hard. So if you If you stay away from the biology, I think it's sort of okay to think that it's only us. But if you really try to get closer to biological descriptions and components, then I think you really have to embrace a comparative method. And when I say embrace a comparative method, I don't just mean, looking at our closest living relatives, for example, chimpanzees and bonobos, and ask questions about them. But I mean a very broad spectrum that tries to learn about the cognitive capacities and systems of communications of birds, of bats, of whales, of tons of different species. Each of which, I think, contribute something to, tell us something about one aspect of human language.

Adam: Right, that seems to have the evolutionary component you mentioned.

Cedric: Yeah, that's the one. I mean, without that component, if you look at Darwin's big books, like Origins and Descents, they all start with the notion of comparison. So it starts with when we compare or by comparing. And linguists should do this a lot, a lot more than they're used to. That is, they should really think that one very good way of learning about us And what makes us human is actually to go beyond us and look at what other species are doing.

Adam: Right. So the next component you mentioned was that language isn't only spoken language, but from an evolutionary perspective, like every animal I can think of, like humans or birds or whales, they all seem to use auditory language. So why do you think that is, that it converged on using this mechanism of communication?

Cedric: I think the examples you meant are great examples of evolutionary convergence, not on speech because, again, speech is defined in so many ways that sometimes it's so human specific, but certainly convergence about this ability that's called vocal learning or sometimes vocal production learning of being able to essentially imitate conspecifics in their vocalization, right? But there are other animals that rely on other modalities and have very sophisticated systems of communications, like our closest relatives, the chimpanzees and the bonobos, don't seem to have such an elaborate way of imitating sounds among themselves, but they certainly deploy an interesting system of gestures that convey meaning. And it's precisely for this reason that quite a few linguists thought that the origin of human language was to be found not in the vocal modality, but in the gestural modality. Just because, our closest living relatives don't display the sort of abilities that, you're right, we find in other species like parrots,

songbirds, bats, and others. And I think the reason I insisted on saying that language is multimodal is because I think it's not going to be one or the other. I think we've managed somehow in the course of our evolution to recruit abilities from the gestural domain, but also from the vocal domain. That makes it particularly interesting.

Adam: I've heard some primates will have different vocalizations for predators, like they'll have different warning calls for different animals.

Cedric: Yes, it's not the case that, you know, other primates don't vocalize. They do. But for many of them, I think most of them really, The consensus is that these vocalizations are innate and that is there is very little learning from conspecifics. Unlike us, where it's clear that, you know, we learn the language of the community in which we are raised. And this is why when people have tried to understand this ability, we have to, you know, adopt the sounds of the community, as it were. They have had to move at least at first, away from primates. I say at first because the more we study this ability called vocal learning, the more we realize that it's a continuum. That is, it's not just black and white where some species have it and some species don't. It's probably the case that if you look hard enough, even among non-human primates, you will find some ability, some vocal learning ability that doesn't compare very well with what you find in parrots, say, but could nonetheless have played an interesting role in the course of our evolution, right? Because it provides a little substrate. And this is work, I think, that will become more and more prominent in the near future where people learn to look deeper into abilities that are not perhaps so obvious, but are nonetheless there.

Adam: Right. So at the two extremes, if it was all innate, you could have a human baby in absence of socialization. They clearly won't learn language. So it can't be all innate. And then also, if it's all learned, you can't stick like a chimp baby in with humans and it won't learn like we do. So it's somewhere in between. And it seems like it's something like, I don't know, something about our brains is more attuned for learning than other animals.

Cedric: Yeah, so the language instinct is really the language learning instinct, right? It's this instinct we have to learn. But I want to qualify a little bit what you said. I think it's nice to put it the way you did in terms of two extremes, like innate and learn, but I think it's also important to realize that the notion innate itself is not one thing. And Kevin Mitchell has written a wonderful book, actually entitled Innate, where he-
I

Adam: interviewed him a while ago.

Cedric: Okay, great. Where he stresses the fact that innate just doesn't mean, you know, inborn, as it were. There is an important developmental perspective on innate that I think is also extremely valuable for the linguists to take into account and inform this discussion of two extremes, you know, innate versus versus learn. It looks like a dichotomy, but it's really like a three-way distinction. There is development in between, right? It's what **** Clewanton called the triple helix, where you have the genes, you have the environment, and then you have noise or development in the middle, and that's a significant component as well, which I should say is not really well studied

by linguists. that these linguists have been extremely dichotomous in their vision of language. It must be either inborn or learned.

Adam: Right. It seems like the key to this whole understanding the biological aspect lies in that interaction, because whatever happens with our genes or our brain mixing with the environment differs from, in a way that allows us to learn language in a way that animals can't.

Cedric: That's correct. It's really an ability that emerges in the course of development. That is, it's not there from the beginning. It's not there in the environment alone, but it's in that middle ground created by both, actually, the biology and the environment. that the disability emerges. And that actually makes it very hard to find a term for this. So, you know, I, among others, have often used the term a language-ready brain to talk about disability that our brain has to, you know, to learn language. But even that, and I think that's a good term, but even that term suggests that there's a point where the brain is like ready for language before it gets into the environment where language is used. And that's not the case. It's really in the course of development and language use that the brain becomes ready for language as well.

Adam: There's also a certain critical period, right? Like if a child is raised up to a certain age outside of language, then it becomes much harder or maybe impossible to teach them?

Cedric: It's certainly much harder for me to learn anything now.

Adam: Right. So why do we go from language ready at the beginning? Because you would think that as you grow into an adult, you get smarter and it would be easier.

Cedric: Yes. So I think that's why in part I was reluctant to use the term intelligence. I think it's not about intelligence as such. It's not about learning tricks to learn language. It's really an ability that's very similar to other, as it were, physical abilities that we have that somehow are come with a certain developmental schedule and that must, you know, take place within a certain window of time. Afterwards, you are, as it were, stuck. And I think Eric Lennenberg was, I think, the first to really insist that this was a very important property of the language system, this sensitive or critical period. And there is debate as to, when exactly it closes, but what it does, but I don't think there is a meaningful debate to the fact that it exists. I mean, it's there. And I think that this is a property of language that we should try to capture and understand biologically, that is, how come the circuits we use to learn language have this schedule, as it were, attached to them. That's something we know there, but really don't quite understand, I think, deeply.

Adam: Do we have any hints as to why that might be the case, either biologically or maybe from an evolutionary perspective?

Cedric: It's nice you say why. I'm sure you've heard, maybe you've even read the famous paper by Tinbergen on the four why questions, you know, where he mentions that in order to understand the system, you want to understand the mechanism, the development, the function and the evolution. And I think your why question is really 4 why questions. Like what's the mechanism? What's the development of it? Like how

does it develop? Why did it evolve? And what's its function? Big questions. I tend to think, this is a research bias of mine. I admit that until we have a good handle on the mechanism, It's very hard to give good answers to the other why questions, like why it's there in terms of function or evolution. solution as it works. And given that we don't have a very good mechanism, I don't have a very good answer for you. It's, yeah, it's just something that we can only hopefully understand better later. But so far that notion has been with us for decades and it's still a very big puzzle.

Adam: So does ongoing research define this mechanism, is it something like learning at, looking at different areas of the brain and trying to see what they do and seeing how much that might relate to language or whatever particular function you're looking at?

Cedric: I wish it were more than this. I mean, it's certainly part of the general approach, namely. It makes a lot of sense to try to see which circuits are implicated and so which brain regions, like localizing those circuits and so on and so forth. But I think here I'd like to, as it were, quote David Popple, who likes to distinguish maps and mapping. He likes to say that just saying where in the brain something is happening, like where exactly, which region is more active, he's not going to tell you exactly the mechanism, mainly, you know, how it's happening, right? And so it's good to know where, but I think there's going to be tons of questions after the where. Like suppose I can give you like the top three regions, I don't have them, but suppose I give you the top three regions implicating it, I don't know, learning sounds or something like that, as you grow and learn the language, then the next question will be, well, why these regions as opposed to others? And what exactly do they do? I mean, what makes those regions fit for the task? I mean, how did evolution pick, as it were, those regions as opposed to others? All questions that, knowing where it's happening is just the beginning, right? And in a certain sense, the other questions are much harder.

Adam: So which questions does your own research attempt to tackle and what approaches you use for that?

Cedric: Good questions. I think they are two. I don't know if they are big, but they are certainly two questions and I find particularly intriguing. So I, I would like to understand a bit better, and certainly in the context of language, traits that have long been used to quote unquote define, say the anatomy or neural anatomy of our species, in, which is like the fact that it's not just our brain that we think is somehow a bit special in ways that, still remain to be understood, but also the fact that our head is configured in a certain way. we used to think that, for example, the configuration of the larynx is particularly important for speech. Now we understand that the brain is also playing a role, but it's certainly the case that our overall like craniofacial phenotype is specific. And I'd like to understand what this could tell us about cognition, because we know that certainly very early in development, say the parts of our anatomy that becomes the phase are very closely related to how the brain develops. So there is a question there that I'd love to understand better. And then we also know that our cranium has a particular shape that looks like a football as opposed to a rugby ball,

right? It's not elongated, it's round. And we now think we now know with reasonable confidence that this shape arises from the way the brain develops, and in particular, from the way certain parts of the brain develop, like the cerebellum, bit of the brain at the back of our skull, seems to expand at a particularly interesting point in our development and shapes our brain and then skull in particular ways. And I'd love to understand what this did to cognition in general and to language in particular. And I'm fascinated by the moment in time we're living in where we actually have access not just to a range of species that can tell us a lot by their behaviors, but also we have access to genomes of species that are extinct, like the Neanderthals or the Denisophans. And so I'd love to find a way to exploit that information, to try to see what we can learn about our own brain evolution, because those aspects that I mentioned, the face and the skull, seem to be quite, I mean, let's say fairly recent and specific. So I think we are at the stage where, to me, the direction of research is what can we learn, for sure, what can we learn about the brain that eventually forms the substrate for language and cognition? But also, what can we learn about the genome, about brain development, about cognition, that is, how much, so if I give you the genome, for example, of an extinct species or even a living species, how much can you then, I wouldn't say predict, but understand about brain development by just, you know, having that kind of information available? And then how do we translate that information all the way up to cognition, as it were? That's really the creating a linking hypotheses across these various levels of analysis from the genomes to the brain level to cognition is what I do. I'm trying to then understand the phase, the skull.

Adam: So when you're looking at variability in skull shapes or in genomes, What are the within group or between group differences bigger? Like if you would look at modern day humans with a large variability versus comparing averages of different species, which of those tends to be more useful?

Cedric: I think all sorts of informations are useful. What I think is the case is we certainly don't have enough yet data about the real amount of variation for many, many questions we are interested in. It's true that biology nowadays gets, you know, gives you a lot of information that we didn't have before. But I think we need a lot more. And that is, there's still lots of underrepresented groups, lots of understudied species in in all of these must somehow be aspects that we should focus on if we want to understand anything really, because the key, as it were, the key information will come from variation at all levels. So we should really have a very good handle of the variation and not and be aware that currently the information we have is biased in many ways. That is, it's not representative of the whole variation that we know exists. That's true in genetics. That's true for various aspects of cognitions. For example, we were mentioning how different species can inform, you know, us about language. I think it's the case that there's still lots of species that we haven't looked at carefully that could be extremely informative. I mean, we tend to stick to those species that give us a lot of information at first, and then somehow it becomes routine that we only

think of just a couple of them, as opposed to trying to really take advantage of the full spectrum of variation that we see.

Adam: So I'm sure this would be an oversimplification, but it's something like you'd be comparing, let's say, an extinct species or maybe even just another species like a chimp skull with a human skull, and then also compare the genome and see like, okay, the skull is different in these specific areas and the genes are different in these specific areas. So maybe these genes lead to these changes.

Cedric: Yeah, that's really a simplification. I think it can. So the beauty of biology, I think, is that it's complex. And so you can't really just infer shape or behavior from the genome. Of course, that doesn't mean that there is no information whatsoever, that it's hopeless, right? I think it's just a matter of learning that the distance between genotype and phenotype, whatever phenotype you're interested in being like in physical or cognitive or behavioral. The key is to understand that there is a link between genotype and phenotype, but that link and really goes through a very long and complicated route. And the beauty of our job is to try to figure out what that is, but also to learn that the answer won't be simple. So, yeah, we may have, for example, information about, you know, facial evolution in the facet record, for example, or, you know, variation in the current population. But we have to learn how, you know, information from the genome is indirectly related to what you can observe. And that indirectness is, of course, a source of of good work. I think that it's really very important to, once you realize the distance between genotype and phenotype, you realize there's really wonderful questions left to answer. But yeah, it would be nice if it were simple, but maybe, you know, it's better if it's complicated. That way we have things to do.

Adam: Yeah. Are there any specific findings that you have that you think would be simple enough to discuss?

Cedric: there are a couple that I think we have made progress on. And when I say we, I see it's really just a community, not just in particular. I think, for example, the importance of the cerebellum that I mentioned before as a region of the brain that matters for for cognition, but not just for like motor cognition where people have known this for a long time, but also for other aspects of cognition like language or, you know, what's sometimes called high level cognition, whatever that means. I think the recognition that it's not just the neocortex that does all the fancy bits of cognition and language, but it's also other parts of the brains that are just as important, maybe in fact, perhaps more important. I think it has really been an interesting development for me, like trying to find out how the textbook picture, for example, of how we understand you know, language in the brain. If you open a textbook, you're bound to find, you know, Broca's area, Wernicke's area, and then, you know, a link between the two. Turns out it's really massively more complex. There's lots more regions involved. I think that's been a super interesting development, that it's forced us to ask questions, but what do these understudied regions contribute to the neural aspects of language. That's been one thing. The other thing we've been working a fair amount on is the

evolution of the face and how it relates to the brain. So it turns out that there is, like I said, a stage in development very early on where the two systems, the cells that eventually will produce the face and then the brain, are entering into an interesting dialogue. And understanding this very early stage of development has been something that's given us a lot of, I think, interesting findings. So one of the things we've looked at a lot is the neural crest that is a population of cells that really develops very early and eventually gives rise to aspects of the phase, but also influences the brain. And it turns out that, you know, several conditions that we find in the populations that are called neurocristopathies are disorders related to the neural crest. And one perhaps you've heard of is Williams syndrome, a syndrome that gives rise to a characteristic cranial facial phenotype, but also a characteristic aspects of cognitions where language is preserved. But other aspects of cognition are are more damaged, let's say, and trying to see how we could understand the biological roots of that syndrome in terms of, for example, the neural crest has been particularly enlightening, at least to me.

Adam: So some of these some of these genetic differences that result in external changes also change the way you process internally.

Cedric: I think so. And that's cool to know. So, you know, when I talk about this, people try to think, oh, but wasn't this discarded, you know, theories that somehow you could predict cognition from the shape of the skull? And no, of course, that's not the point. The point is to realize that in the course of development and certainly very early in development, these systems interact closely with one another. That stage of development is worth looking into because you can understand how learning something about early facial development could also tell you something about the brain, not predict cognition. but I give you valuable information about brain development. Eventually, like I think we said early on, it's going to be key certainly for language, but also for other aspects of cognitions to really insist on brain development being the thing to try to understand much better because that's where the fun is.

Adam: How early in development are we talking?

Cedric: We are talking about, well before birth, there is a stage where, the body is taking shape, as it were, and the brains, some areas of the brains haven't developed really well enough. For example, the cerebellum develops much later in development, but very early in development, we have, series of cells like stem cells, like the neural crest that provide critical input to aspects of the body. And so any deficit that, address that, for example, affects the neural crest in terms of induction or migrations of these cells, will have long-term consequences that can be then studied at the level of cognition. So it's very, very early in development. And how do you see that?

Adam: When they're still in the womb.

Cedric: That's really great that you asked because over the past now, certainly five years, maybe a little bit earlier already, people have, I think, learned that there is a remarkable window of opportunity that can be, I think, that can be exploited for cognition as well, and certainly for neuroscience. And here I'm referring to the field of brain organoids, which I'm sure you've heard of, which is this enterprise of

trying to, as it were, recreate in a dish, in the lab, some aspects of very early brain development. right, by using the power of stem cells reprogramming to try to see if you can, yeah, like I said, reconstruct aspects of development in 3D. And so this has been something particularly useful because it gives you insights into a stage of development that otherwise wouldn't be accessible. Like you said, certainly in vivo you can, but there are now in vitro techniques that enable you to look into this, to ask questions and manipulate things experimentally to try to gain insight into those mechanisms of early development. So I think it's a very important new tool in our toolbox to study cognition eventually. And now I should say that, of course, like any new technique, there is always a lot of hype when there is a lot of hope. just like before, we're saying that there is no shortcut from genotype to phenotype. Likewise, looking at early brain development in a dish, like looking at the brain organoid, will not tell you immediately everything you want to know about cognition, but it will inform your understanding of the, as it were, the neural scaffolding that eventually produce a brain that's able to learn things in particular language. it's a bit like when you build a building, you have to rely on scaffolds to get there. And, the scaffolds are not the building, but they are very important for the building to eventually be there. And those early developmental stages are not cognition, not the building, but they are extremely important in understanding how the building eventually stands, as it were. And so in our case, how the brain does what it does.

Adam: So in that case, is the biggest gap between whatever stage that you're no longer allowed to continue growing the organelle and between birth?

Cedric: I think there are many gaps still. So there are like I said, regions of the brain that have a protracted development, like for example, the cerebellum that postnatally expands dramatically more than say the, other aspects of the brains. And that's still very difficult to reproduce, you know, in the lab. And so different regions have different developmental schedules and I don't think we have yet a very good handle on combining all of them. And as we know now, the brain It's pretty much all the parts of the brains that are involved. So you would like to have a holistic view of it, but you only have the bits and pieces that grow differently. So I think we are not there yet, but we can, I think, build on what we have and look forward to important discoveries in the future.

Adam: Right. So much of what we've discussed seems like it's not specific questions that are getting answered and then moving on. It's just large scale questions that we're slowly chipping way out.

Cedric: Yeah, I think that's right. But I think that's also progress. You know, when I was an early graduate student, I was told that one couldn't study things like the evolution of language, that it was impossible, that this was something that, yeah, one can do when, you know, after retirement, like some sort of science fiction bit. right? But we have come to learn that they are very indirect ways of approaching the questions. But I think even though they are very indirect, it's possible to do this. It's just that it's going to take a long time. But yeah, that's in part what makes it exciting.

Adam: Yeah, that is exciting. What do you think the field might look like in a couple years or decades. What do you think some of the next major realistic leaps forward will be?

Cedric: Well, I think, you know, future is really very hard to predict. But I think one thing I can say for sure is that the things that graduate students, say interested in language or cognition, will learn in the near future will look very different from what, say, I was learning as a graduate student. And I'm not saying in terms of content, but also, you know, methods and topics of study. So specifically for language, the curriculum of many, graduate programs was fairly fixed. You did a bit of syntax, semantics, and maybe, one course on language acquisition, maybe a bit of neuroscience, and that was it. But I think that in the near future, perhaps in some cases already now, but a cognitive scientist or linguist will have to learn about genetics, will have to learn about many more aspects of developmental neuroscience. We'll have to learn many things that don't look linguistically as it were, right? That, you know, will be part of the toolkit that, you know, we all these will not be familiar with. And I think we can only think that the study of language, I think, will largely not take place in linguistics department, in my opinion. I think that it will be really an aspect of biology and therefore will be studied in biology centers, as it were, because the techniques will be there for, not just for biologists to ask questions about, but they will need the linguist to also inform the experiments to learn those techniques. And, you can't really say something intelligent about experimental design if you don't know enough about what the experiment could tell you. So linguists will have to learn enough about the limitations and the objectives of a particular experiment in order for them to contribute to this. So I think that one thing we'll see is that the language sciences will turn out to be much broader than the linguistics programs we currently have.

Adam: Yeah, that's exciting. It seems like many areas of science are moving in that more interdisciplinary direction.

Cedric: Yes, the thing is not just to say it, the thing is to do it.

Adam: Right. Thank you very much for your time, Cedric.

Cedric: Thanks again for the invitation and thanks for the discussion.

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