Welcome to the Uberman Lab podcast where we discuss science and science-based tools for everyday life. I'm Andrew Uberman and I'm a professor of neurobiology and ophthalmology at Stanford School of Medicine. Today my guest is Dr. Eric Jarvis. Dr. Jarvis is a professor at the Rockefeller University in New York City and his laboratory studies the neurobiology of vocal learning, language, speech disorders, and remarkably the relationship between language, music, and movement in particular dance. His work spans from genomics, so the very genes that make up our genome and the genomes of other species that speak and have language, such as songbirds and parrots, all the way up to neural circuits, that is the connections in the brain and body that govern our ability to learn and generate specific sounds and movements coordinated with those sounds including hand movements, and all the way up to cognition, that is our ability to think in specific ways based on what we are saying and the way that we comprehend what other people are saying, singing and doing. As you'll soon see, I was immediately transfixed and absolutely enchanted by Dr. Jarvis' description of his work and the ways that it impacts all the various aspects of our lives. For instance, I learned from Dr. Jarvis that as we read, we are generating very low level of motor activity in our throat. That is, we are speaking the words that we are reading at a level below the perception of sound or our own perception of those words. But if one were to put an amplifier or to measure the firing of those muscles in our vocal cords, we'd find that as we're reading information, we are actually speaking that information. And as I learn and you'll soon learn, there's a direct link between those species in the world that have song and movement, which many of us would associate with dance, and our ability to learn and generate complex language. So for people with speech disorders like stutter or for people who are interested in multiple language learning, bilingual, trilingual, etc. And frankly, for anyone who is interested in how we communicate through words written or spoken, I'm certain today's episode is going to be an especially interesting and important one for you. Dr. Jarvis' work is so pioneering that he has been awarded truly countless awards. I'm not going to take our time to list off all the various important awards that he's received. But I should point out that in addition to being a decorated professor at the Rockefeller University, he is also an investigator with the Howard Hughes Medical Institute, the so-called HHMI. And for those of you that don't know, HHMI investigators are selected on an extremely competitive basis that they have to re-up, that is, they have to recompete every five years. They actually receive a grade every five years that dictates whether or not they are no longer a Howard Hughes investigator, whether or not they can advance to another five years of funding for their important research. And indeed, Howard Hughes investigators are selected not just for the rigor of their work, but for their pioneering spirit and their ability to take on high risk, high benefit work, which is exactly the kind of work that Dr. Jarvis has been providing for decades now. Again, I think today's episode is one of the more unique and special episodes that we've had on the HHMI lab podcast. I single it out because it really spans from the basic to the applied. And Dr. Jarvis' story is an especially unique one in terms of how he arrived at becoming a neurobiologist. So for those of you that are interested in personal journey and personal story, Dr. Jarvis' is truly a special and important one. I'm pleased to announce that the HHMI lab podcast is now partnered with Momentus Supplements. We partnered with Momentus for several important reasons. First of all, they ship internationally because we know that many of you are located outside of the United States. Second of all, and perhaps most important, the quality of their supplements is second to none, both in terms of purity and precision of the amounts of the ingredients. Third, we've really emphasized supplements that are single ingredient supplements and that are supplied in dosages that allow you to build a supplementation protocol that's optimized for cost, that's optimized for effectiveness, and that's optimized for effectiveness. And that you can add things and remove things from your protocol in a way that's really systematic and scientific. If you'd like to see the supplements that we partner with Momentus on, you can go to livemomentus.com slash Huberman. There you'll see those supplements and just keep in mind that we are constantly expanding the library of supplements available through Momentus on a regular basis. Again, that's livemomentus.com slash Huberman. Before we begin, I'd like to emphasize that this podcast is separate from my teaching and research roles at Stanford. It is, however, part of my desire and effort to bring zero cost to consumer information about science and science related tools to the general public. And now for my discussion with Dr. Eric Jarvis. Eric is so great to have you here. Thank you. Very interested in learning from you about speech and language. And even as I asked the question, I realized that a lot of people, including myself, probably don't fully appreciate the distinction between speech and language. I think of as the motor patterns, the production of sound that has meaning, hopefully, and language, of course, come in various languages and varieties of ways of communicating. But in terms of the study of speech and language and thinking about how the brain organizes speech and language, what are the similarities, what are the differences, how should we think about speech and language? Yeah, well, I'm glad you invited me here and I'm also glad to get that first question, which I couldn't consider a provocative one. The reason why I've been struggling, what is the difference with speech and language for many years? And realize why am I struggling? It's because there are behavioral terms, what's called psychologically psychology developed kind of terms, that don't actually align exactly with brain function. And the question is there is distinction between speech and language. And when I look at the brain of work that other people have done work, we have done also comparative with animal models, like those who can imitate sounds like parrots and songbirds. I started to see there really isn't such a sharp distinction. So to get at what I think is going on, let me tell you how some people think of it now, that there's a separate language module in the brain. That has all the algorithms and computations that influence the speech pathway on how to produce sound, and the auditory pathway on how to perceive and interpret it for speech or for sound that we call speech. And it turns out I don't think there is any good evidence for a separate language module. Instead, there is a speech production pathway that's controlling our learnings, controlling our job muscles that has built within it all the complex algorithms for spoken language. And there's the auditory pathway that has built within it all the complex algorithms for understanding speech, not separate from a language module. And this speech production pathway is specialized to humans and parrots and songbirds, whereas this auditory perception pathway is more ubiquitous amongst the animal kingdom. And this is why dogs can understand sit, see what they say, come here boy, get the ball and so forth. Dogs can understand several hundred human speech words, great aids, you can teach them for several thousand, but they can't say a word. Fascinating, because you've raised a number of animal species early on here, and because I have a basically an obsession with animals since the time I was very small, I have to ask which animals have language, which animals have modes of communication that are sort of like language. I've heard whale songs, I don't know what they're saying, they sound very beautiful, but they could be insulting each other for all I know. And then very well maybe dolphins, birds, I mean, what do we understand about modes of communication that are like language, but might not be what would classically be called language. So, so modes of communication that people would define as language, more in a very narrow definition they would say production of sound, so speech. But what about the hands, digesting with the hands, what about a bird who is doing aerial displays in the air, communicating information through body language, right. Well, I'm going to go back to the brain. So, what I think is going on is for spoken language, we're using the speech pathway in all the complex algorithms there. Next to the brain regions that are controlling spoken language are the brain regions for gesturing with the hands. And that hand parallel pathway has also complex algorithms that we can utilize. Some species are more advanced in these circuits, whether it's sound or gesturing with hands, in some or less advance. Now, we humans and a few others are the most advanced for the speech sounds or the spoken language, but a non human primary can produce gesturing in a more advanced form than they can produce sound. I'm not sure I got that across clearly, just to say that humans are the most advanced at spoken language, but not necessarily as big a difference at gestural language compared to some of the species. Very clear and very interesting and immediately prompts the question, have there been brain imaging or other sorts of studies evaluating neural activity in the context of your cultures and languages, at least that I associate with a lot of hand movement like Italian versus. I don't know, maybe you could give us some examples of cultures where language is not associated with as much overt hand movement. Yes. So as you and I are talking here today and people who are listening but can't see us, we're actually gesturing with our hands as we talk without knowing it or doing unconsciously. And if we were talking on a telephone, I would have one hand here and I would be gesturing with the other hand without even you seeing me. Right. And so why is that some have argued and I would agree with based upon what we've seen is that there is an evolutionary relationship between the brain pathways that control speech production and gesturing. And the brain regions I mentioned are directly adjacent to each other and why is that I think that the brain pathways that control speech evolved out of the brain pathways that control body movement. And that's when you talk about Italian, French, English and so forth, each one of those languages come with a learned set of gestures that you can communicate with. Now how is that related to other animals? Well, Coco, a gorilla who is raised with humans for 39 years or more, learned how to do gesture communication, learn how to sign language, so to speak. Right. But Coco couldn't produce those sounds. Coco could understand them as well. By by seeing somebody sign or hearing somebody produce speech, but Coco couldn't produce it with her voice. And so what's going on there is that a number of species, not all of them, a number of species have motor pathways in the brain where you can do learn gesturing rudimentary language if you want to say what your lens. Even if it's not as advanced as humans, but they don't have this extra brain pathways for the sound. So they can't gesture with their voice in the way that they gesture with their hands. I see. One thing that I've wondered about for a very long time is whether or not primitive emotions and primitive sounds are the early substrate of language and whether or not there's a bridge that we can draw between those in terms of just the basic respiration systems associated with different extreme feelings. Here's the way I'm imagining this might work. I smell something delicious. I typically inhale more and I might say or something like that. Whereas if I smell something cutrid, I typically turn away. I wince and I will exhale, you know, it's kind of like turn away trying to not ingest those molecules or inhale those molecules. I could imagine that these are the basic dark and light contrasts of the language system. And as I say that, I'm saying that from the orientation of a vision scientist who thinks of all visual images built up in a very basic way of a hierarchical model of the ability to see dark and light. Imagine this kind of primitive to more sophisticated pyramid of sound to language. Is this a crazy idea? Do we have any? Do we have any evidence? This is the way it works. No, it's not a crazy idea. And in fact, you hit upon one of the key distinctions in the field of research that I started out in, which is vocal learning research. So for vocal communication, you have most vertebrate species vocalize. But most of them are producing a Nate sounds that they're born with producing that is babies crying, for example, or dogs barking. And only a few species have learned vocal communication, the ability to imitate sounds. And that is what makes spoken language special. When people think of what's special about language, it's learn vocalizations. It's what that is what's rare. And so this distinction between the nateness and learned is more of a bigger dichotomy when it comes to vocalizations than for other behaviors in the animal kingdom. And when you go into brain, you see it there as well. And so all the things you talked about, the breathing, the grunting, and so forth, a lot of that is handled by the brainstem circuits, you know, right around the level of your neck and below. Like a reflex, anything. So, or even some emotional aspects of your behavior in the hypothalamus and so forth. But for a learned behavior, learning how to speak, learning how to play the piano, teaching a dog to learn how to do tricks is using the four brain circuits. And what has happened is that there's a lot of four brain circuits that are controlling learning how to move body parts in these species, but not for the vocalizations. But in humans and in parrots and some other species, somehow we acquired circuits where the four brain has taken over the brainstem. And now using that brainstem not only to produce the innate behaviors or vocal behaviors, but the learned ones as well. Do we have any sense of when modern or sophisticated language evolved, you know, thinking back to the species that we evolved from and even within homo sapiens. Has there been an evolution of language? Has there been a devolution of language? Yeah. Yeah. I would say, and to be able to answer that question, it does come with the caveat that I think we humans overrate ourselves when compared to other species. And so it makes even scientists go astray in trying to hypothesize when you've such you don't find fossil evidence of language that easily. In out there in terms of what happened in the past. We, amongst the primates, which we humans belong to, we are the only ones that have this advanced vocal learning ability. Now, when you, it was assumed that it was only homo sapiens, then you can go back in time now based upon genomic data, not only of us living humans, but of the fossils that have been found for homo sapiens, of Neanderthals, of Denisovan individuals, and discover that our ancestor, our human ancestors supposedly hybridized with these other hominid species. And it was assumed that these other hominid species don't learn how to imitate sounds. I don't know of any species today that's a vocal learner that can have children with a non vocal learning species. I don't see it. Doesn't mean it didn't exist. And when we look at the genetic data from these ancestral hominids that, you know, where we can look at genes that are involved in learn vocal communication, they have the same sequence as we humans do for genes that function in speech circuits. So I think Neanderthals had spoken language. I'm not going to say it's as advanced as what it is in humans, I don't know. But I think it's been there for at least between 500,000 to a million years that our ancestors had disability. And that we've been coming more and more advanced with it culturally and possibly genetically. But I think it's evolved sometime in the last 500,000 to a million years. Maybe we could talk a little bit more about the overlap between brain circuits that control language and speech and humans and other animals. I was weaned in the neuroscience era where bird song and the ability of birds to learn their tutors song was it was and still is a prominent field, subfield of neuroscience. And then of course, neuroimaging of humans speaking and learning, etc. And this notion of a critical period, a time in which languages learned more easily than it is later in life. And the names of the different brain areas were quite different. It one opens the textbooks we hear, Vernekes and Broca's for the humans and you look at the birds of it. I remember, you know, HBC, robust archstrait, I'm area X, right? Yes, etc. But for most of our listeners that those names won't mean a whole lot. But but in terms of homologies between areas in terms of function, what do we know? And how similar different are the brains of brain areas controlling speech and language and say a songbird and a young chat human child? So going back to the 1950s or even a little earlier and Peter Moller and others who got involved in neuro ethylogy, the study of neurobiology of behavior in a natural way. They start to find that behaviorally, there are these species of birds like sombers and parents and now we also know hummingbirds, just three of them out of the 40 something bird groups out there on the planet orders that they can imitate sounds like we do. And so that was a similarity. In other words, they had this kind of behavior that's more similar to us than chimpanzees have with us or then chickens have with them. And so they're closer relatives. And then they discovered even more similarities, these critical periods that if you remove a child, you know, this unfortunately happens where a child is feral and that is not raised with human and goes through their puberty phase of growth, becomes hard for them to learn a language as an adult. And so that's a critical period where you learn best and even later on when you're in regular society, it's hard to learn. Well, the set birds undergo these same thing. And then it was discovered that if they become deaf, we humans become deaf, our speed starts to deteriorate without any kind of therapy. And so that's a primate or, you know, or let's say a chicken becomes deaf, their vocalizations don't deteriorate very little at least. Well, this happens in the vocal learning birds. So there were all these behavioral parallels that came along in a package and then people looked into the brain for an animal not a bomb, my former PhD advisor and began to discover the area X you talked about, the robust nucleus of the arcopallion. And these brain pathways were not found in the species who couldn't imitate. So there was a parallel here. And then jumping many years later, you know, I started to dig down into these brain circuits to discover that these brain circuits have parallel functions with the brain circuits for humans, even though they're by a different name like Broca's and Larinja motor cortex. And most recently we discovered not only the actual circuitry and the connectivity are similar, but the underlying genes that are expressed in these brain regions in a specialized way different from the rest of the brain are also similar between humans and songbirds and parents. So all the way down to the genes and now we're finding the specific mutations are also similar, not always identical but similar, which indicates remarkable convergence for so called complex behavior in species separated by 300 million years from the common ancestor. And not only that, we are discovering that mutations in these genes that cause speech deficits in humans like in Fox P2, if you put those same mutations or similar type of deficits in these vocal learning birds, you get similar deficits. So convergence of the behavior is associated with similar genetic disorders of the behavior. Incredible. I have to ask, do hummingbirds sing or do they hum? Humming birds hum with their wings and sing with their Syrians in a coordinated way and a coordinated way. There's some species of hummingbirds that actually will Doug Ashwell showed this that will flap their wings and create a slapping sound with their wings that's in unison with their song and you would not know it but it sounds like a particular syllable in their songs. So it's their wings and their voice at the same time. Humming birds are clapping to their song clapping with their snapping their wings together in unison with a song to make it like if I'm going, I think that's not that. I think on the table, except they make it almost sound like their voice with their wings. Incredible. I guess as a kid you would say mind blown. Yes. Incredible. I love hummingbirds and I always feel like it's such a special thing to get a moment to see one because they move around so fast and they move around so fast and these ballistic trajectories that when you get to see one stationary for a moment or even just hovering there, you feel like you're extracting so much from their little microcosm of life but now I realize they're playing music. Exactly. And what's amazing about hummingbirds and I will say vocal learning species in general is that for whatever reason they seem to evolve multiple complex traits. You know, this idea that evolving language spoken language in particular comes along with a set of specializations. Incredible. When I was coming up in neuroscience, I learned that I think it was the work of Peter Marler that young birds learn songbirds learn their tutors song and learn it quite quite well. But that they could learn the song of another tutor. In other words, they could learn a different and for the listeners, I'm doing air quotes here, a different language, a different bird song different than their own species. And never as well as they could learn their own natural genetically linked song. Yes, genetically linked meaning that they would be like me being raised in a different culture and that I would learn the other language, but not as well as I would have learned English. This is the idea. Yes. Is that true? And that's and that's what I learned growing up as well and and talk to Peter Marler himself about before he passed. Yeah, this he used to call it the innate predisposition to learn. All right. So, which would be kind of the equivalent in the linguistic community of universal grammar. And so, there's this balance between the genetic control of speech or a song in these birds and the learned cultural control. And so, yes. If you were to take, you know, I mean, in this case, we actually tried this at Rockefeller later on take a zebra finch and raise it with a canary. And it would sing a song that was sort of like a hybrid in between we call it a conench. Right. And vice versa for the canary because there's something different about their vocal musculature or the gen or the circuitry in the brain. And with a zebra finch, even with a closely related species, if you would take a zebra finch, a young animal, and in one cage next to it, place its own species adult male. And in the other cage, place a Bengali finch next to it. It would preferably learn the song from its own species neighbor. But if you remove its neighbor, it would learn that Bengali finch very well. Fantastic. So, there's, it has something to do with also the social bonding with your own species. Incredible. That raises a question that I based on something I also heard, but I don't have any scientific pure-reviewed publication to point to. Which is this, this idea of pigeon, not the bird, but this idea of when multiple cultures and languages converge in a given geographic area that the children of all the different native languages will come up with their own language. I think this was in island culture, maybe in Hawaii called pigeon, which is sort of a hybrid of the various languages that their parents speak at home. And that they themselves speak. And that somehow pigeon, again, not the bird, but a language called pigeon for reasons I don't know. Harbors certain basic elements of all language. Is that true? Is that not true? I would, I haven't studied enough myself in terms of pigeon specifically, but in terms of cultural evolution of language and hybridization between different cultures and so forth, even amongst birds with different dialects. And you bring them together. You know, what is going on here is cultural evolution remarkably tracks genetic evolution. So if you bring people from two separate populations together that have been in their separate populations evolutionarily at least for hundreds of generations. So someone speaking Chinese, someone speaking English. And that child then is learning from both of them. Yes, that child is going to be able to pick up and merge phonemes and words together in a way that an adult would it. Because why they're experiencing both languages at the same time during their critical period years in a way that adults would not be able to experience. And so you get a hybrid and the lowest common denominator is going to be what they share. And so the phonemes that they've retained in each of their languages is what's going to be I imagine use the most. Interesting. So we've got brain circuits in songbirds and in humans that in many ways are similar perhaps not in their exact wiring but in their basic contour of wiring. And genes that are expressed in both sets of neural circuits in very distinct species that are responsible for these phenomena we're calling speech and language. What sorts of things are those genes controlling what I could imagine they were controlling the wiring of connections between brain areas you know essentially a map of you know of a circuit. Basically like an engineer with a circuit for speech and language make sure to sign this or search for speech and language but presumably other things too like the ability to connect motor patterns within the throat of muscles within the throat when the control of the tongue. I mean what are these genes doing you're pretty good. Yeah you've made some very good guesses there that makes sense. So so yes one of the things that differ in the speech pathways of us in the song pathways of birds is some of the connections are fundamentally different than the surrounding circuits like a direct cortical connection from the areas that control vocalizations in the cortex the motor neurons that control the larynx in humans or the serings and birds. And so we actually made a prediction that since some of these connections differ we're going to find genes that control neural connectivity and that specializing that function that differ and that's exactly what we found. And then we found genes that control what we call axon guidance and form and shouldn't connections and what was interesting it was sort of in the opposite direction that we expected that is some of these genes actually a number of them that control neural connectivity returned off in the speech circuit. And it didn't make sense to us at first and so we started to realize the function of these genes are to repelled connections from forming so repulsive molecules and so when you turn them off they allow certain connections to form that normally would have not formed so it's so by turning it off you got a gain of function for speech right. And other genes that surprised us were genes involved in calcium buffering neural protection like a parvalvement or a heat shock protein so when your brain gets hot these proteins turn on and we couldn't figure out for a long time why is that the case. And then the idea popped to me one day said ah when I heard the larynx is the fastest firing muscles in the body right in order to vibrate sound and and modulate sound in the way we do you have to control you have to move those muscles you know three to four to five times faster than just regular walking or running. And so when you stick electrodes in in the brain areas that control learn vocalizations in these birds and I think in humans as well of those neurons are firing at a higher rate to control these muscles and so what is that going to do you're going to have lots of toxicity in those neurons unless you up regulate molecules that take out the extra load that is needed to control the larynx. And then finally a third set of genes that are specializing the speed circuit are involved in neuroplasticity. Neuroplasticity meaning allowing the brain circuits to be more flexible so you can learn better and why is that I think learning how to produce speech is a more complex learning ability than say learning how to walk. Or learning how to do tricks and jumps and so forth that dogs do. It's interesting as you say that because I realized that many aspects of speech are sort of reflexive I'm not thinking about each word I'm going to say I just they just sort of roll out of my mouth hopefully with some thought we both know people that seem to speak. I think less fewer synapses between their brain and their mouth and others right a lot of examples out there and some people are very deliberate in their speech but nonetheless that much of speech is has to be precise and some of it less precise in terms of plasticity of speech and the ability to learn multiple languages but even just one language what's going on in the critical period the so called critical period why is it that so my niece speaks Spanish. She's got them all speak Spanish and English incredibly well she's 14 years old I've struggled with Spanish my whole life my father is bilingual my mother is not I've tried to learn Spanish as an adult it's really challenging I'm told that had I learned it when I was eight I would be better off that's right or it would be installed within me. So the first question is is it easier to learn multiple languages without an accent early in life and if so why and then the second question is if one can already speak more than one language as a consequence of childhood learning is it easier to acquire new languages later on. So so the answer to both of those questions is yes and that's but I but to explain this I need to let you know actually the entire brain is undergoing a critical period development not just the speech pathways and so it's easier to learn how to play a piano it's easier to learn how to write a bike for the first time and so forth as a young child than it is later in life what I mean easier in terms of when you start. You start from you start from first principles of learning something so the very first time if you're going to learn Chinese as a child versus the very first time you learn Chinese as an adult or learning play piano as a child versus an adult. But the speech pathways or let's say speech behavior I think has a stronger critical period change to it than other circuits and why what's going on there in general. If you why do you need a critical period to make you more stable to make you more stubborn so to speak the reason I believe is that the brain is not for brain can only hold so much information and if you are undergoing rapid learning to learn to acquire new knowledge you also have to. Dumb stuff put put in memory or information in the trash like in a computer you only have so many gigabases of memory and so therefore plus also for survival you don't want to keep forgetting things and so so the brain is designed I believe. So undergo this critical period and solidify the circuits with what you learned as a child and you use that for the rest of your life and we humans stay even more plastic in our brain functions control by a gene called SR gap to we have an extra copy of it that leads out speech circuit and other brain regions and a more immature state throughout life compared to other animals so we're more immature we're still juvenile light compared to other animals I knew it but we but we still go through the critical periods. So we're still going through the critical periods like they all do and now the question you asked about if you learned more languages as a child can you is it easier to learn as an adult and that's a common finding out there in the literature there's some that argue against it but for those that support it the idea there is. So we're born with a set of innate sounds you can produce a phonemes and you narrow that down because not all languages use all of them and so you narrow down the ones you use to string the phonemes together in words that you learn and you maintain those phonemes as an adult and here comes along another language that's using those phonemes or in different combinations you're not used to and therefore it's like starting from first principles but if you already have them in multiple languages that you're using. Then it makes it easier to use them in another third or fourth language. I see incredible. So it's not like your brain has under has maintained greater plasticity is your brain has maintained greater ability to produce different sounds that then allows you to learn another language faster got it. Are the hand gestures associated with sounds or with meanings of words I think the hand gestures associated with both the sounds and the meaning of when I say sound like if you are really angry right and you are making a loud screaming noise right you may make hand gestures that are look like you're going to beat the wall right because you're making loud sounds and loud gestures right. But if you want to explain something like come over here what I just do now to you for those who can't see me I swung my hand towards you and swung it here to me that has a meaning to it to come here so just like with the voice. The hand gestures are producing both you know both both qualities of sound and for people that speak multiple languages especially those that learn those multiple languages early in development. Do they switch their patterns of motor movements according to let's say going from Italian to Arabic or from Arabic to French in a way that matches the precision of language that they're speaking. You know what you just asked me a question I don't know the answer to I would imagine that would make sense because of of switching in terms of sometimes people might call this code switching even different dialects of the same language. Could you do that with your gestures I imagine so but I really don't know if that's true or not. I certainly don't know from my own experience because I only speak one language. Before we continue with today's discussion like to just briefly acknowledge our sponsor athletic greens now called AG one athletic greens aka AG one is an all in one vitamin mineral probiotic drink that also has adaptogens and digestive enzymes. I've been taking athletic greens since way back in 2012 so I'm delighted that they're sponsoring the podcast reason I started taking athletic greens and the reason I still drink athletic greens twice a day is that it supplies total foundational coverage of my vitamin mineral needs and it supplies important nutrients that I need to support my gut microbiome the gut microbiome as many of you know supports the immune system it also supports the so called gut brain access which is vital for mood for energy levels for regulating focus and many other features of our mental health and health. Physical health that impact our daily performance and high performance in any endeavors we might be involved in if you'd like to try athletic greens you can go to athletic greens dot com slash Huberman and claim a special offer they're giving away five free travel packs plus a year supply of vitamin D3 K2 with every order and of course vitamin D3 K2 vital for all sorts of things like hormone health and metabolic health and K2 for cardiovascular health and calcium regulation again you can go to athletic greens dot com slash Huberman to claim that special offer. To go a little bit into the abstract but not too far what about modes of speech and language that seem to have a depth of emotionality and meaning but for which it departs from structured language here's what I mean poetry. I think of musicians like there's some Bob Dylan songs that to me I understand the individual words I like to think there's an emotion associated with it at least I experienced some sort of emotion and I have a guess about what he was experiencing but if I were to just read it linearly without the music and without him singing it or somebody singing like him it wouldn't hold any meaning so in other words words that seem to have meaning but not associated with language but somehow tap into an emotionality. Yep absolutely so so we call this difference semantic communication communication with meaning and effective communication communication that has more of an emotional feeling content to it you know but not with you know the semantics and the two can be mixed up like with singing words that have meaning but also have this effective emotional you just love the sound of the singer that you're hearing and initially you know psychologist scientists in general thought that these were going to be controlled by different brain circuits and it is the case there are emotional brain centers and hypothalamus in the single cortex and so forth that do give tone to the sounds but I believe you know based upon imaging work and work we see in birds when when birds are communicating semantic information in their sounds which is not too often but it happens versus effective communication sing because I'm trying to attract the mate my courtship song or defend my territory it's the same brain circuits the same speech like or song circuits are being used in different ways. A friend of mine who's also a therapist said to me you know it's possible to say I love you with intense hatred and to say I hate you with intense love right and reminding me that's possible to hear both of those statements in either way so I guess it's not just limited to song or poetry it also there's something about the intention and the emotional context in which something spoken that it can heavily shape the way that we interpret what we hear that's right and and I consider all of that actually meaning even though I define that is a commonly do semantic and effective communication effective communication to say I hate you but meant love right is does have emotional meaning to it you know and so you know one's more like an object kind of meaning or an abstract there's several other points here I think it's important for those listening out there to hear is that when I say also this effective and semantic communication being used by similar brain circuits it also matters the side of the brain in birds and in humans there's there's left right dominance for learn communication learn sound communication so the left in us humans is more dominant for speech but the right has a more balanced for singing or processing musical sounds as opposed to processing speech both get used for both reasons and so when people say your right brain is your artistic and your left brain is your thinking brain this is what they're referring to and so that's another distinction the second thing that's useful to know is that all vocal learning species use their learn sounds for this emotional effective kind of communication but only a few of them like humans and some parades and dolphins use it for the semantic kind of communication calling speech and and that has led a number of people to hypothesize that the evolution of spoken language of speech evolved first for singing for this more like emotional kind of made attraction like the Jennifer Lopez the Ricky Martin kind of songs and so forth and then later on it became used for abstract communication like we're doing now interesting well that's a perfect segue for me to be able to ask you about your background and motor control not only of the hands but of the body so you have a number of important distinctions to your name but one of them is that you were a member of the Alvin Ali dance school school that's right that's right so you're you're an accomplished or and quite able dancer right tell us a little bit about your background in the world of dance and as how it informs your interest in neuroscience excuse me and perhaps even how it relates specifically to your work on speech and language yes well it's interesting and then this kind of history even goes before my time so in my family my mother and father side they both went to the high school of music and art here in New York City and particularly my mother's family going back multiple generations there were singers and I even did my family genealogy and found out not only you know we have some relationships to some well known singers disson relationships like loneliness monk but going back to the plantations in North Carolina and so forth my ancestors were singers in the church for the you know the towns and so for and this somehow got passed on multiple generations to my family and I thought I was going to grow up and be a famous singer right and my me my brothers and sister formed a band when we're kids and and so forth and but it turned out that I didn't inherit this singing talents of some of my other family members even though you know is you know okay you know but not like my brother or not like my mother my aunts and my cousin put a pay who's now a talent and Native American singer and so so what that then influence me to do other things and I started you know competing in dance contest you know actually just around the time of the satinite fever and I was as a teenager and I started when winning dance contest and I thought oh I can dance and I audition for the high school performing arts and I got in here in New York City and got into ballet dance and got in right and and and thought if I learned ballet I can learn everything else it was that idea if you learn something classical you can teach you for everything else and I was yeah at Alvin Ellie dance school Jaffa Valley dance school and at the end of my senior concert I was had this opportunity audition for the Alvin Ellie dance company and I had an opportunity to go to college and I also fell in love with another passion that my father had which was science and so I like science in high school and I found an overlap also between the arts and sciences you know both required creativity hard work discipline you know new discovery both weren't boring to me and the one decision I made at that at that senior dance concert was you know talking to the Alvin Ellie recruiter and thinking about it I have to make a decision and I thought something my mother taught me because she was grown up in the 1960s cultural revolution do something that has a positive impact on society and I thought I can do that better as a dancer than a scientist so now jump I get into college undergraduate school I major in molecular biology and mathematics I decide I want to be a biologist get into graduate school when it's a study the brain at you know the Rockefeller University so I went from hunter college to Rockefeller University and so now I got to the brain and I and why did I choose the brain is because it controls dancing but I didn't there was anybody studying dancing and I want to study the brain something that it does that's really interesting and complex and I thought oh languages what it does you couldn't study that in my she couldn't study non human primates but these birds do this wonderful thing that for now not about was studying at Rockefeller and so that's what got me into the birds and then jumping now 15 years later you know yeah that's right even after I'm into now having my own lab studying vocal learning in these birds as a model for language and humans it turns out that you know any hotel and you know others have discovered that only vocal learning species can learn how to dance is that right that's right yes I so I've seen these just scrolling through the files here in my mind I think about everyone so while someone was I love parents yeah everyone so while someone will send me one of these little Instagram or Twitter videos of a parrot doing what looks to me like dance typically it's a cockatoo that's right right that's right even foot stomping to the sound and famous one called snowball out there but there are no there are many snowballs out there they're all the dancing birds are named snowball that's interesting tactic so only animals with language dance yeah vocal learning in particular the ability to imitate sounds yes incredible yes and this now is bringing my life full circle right and I and and so when that was discovered in 2009 at that same time in my lab at Duke we discovered that vocal learning brain pathways in songbirds as well as in humans and in parrots right like snowball are embedded within circuit second control learning how to move and that led us to a theory called the brain pathway or motor theory of vocal learning origin where the brain pathways for vocal learning in speech evolved by a whole duplication of the surrounding motor circuits involving learning how to move now how does that explain dance right well when when snowball the cockatoo are dancing they're using the brain regions around their speech like circuits to do this dancing behavior and so what's going on there what we what we hypothesize and now like to test is that when this when when speech evolved in humans and the equivalent behavior in parrots and so on birds it required a very tight integration in the brain regions that can hear sound with the brain regions that control your muscles from moving your brain and tongue and so forth for producing sound and that's high auditory motor integration we argue then contaminate the surrounding brain regions and that contamination of the surrounding brain regions now allows us humans a particular way to coordinate our muscle movements of the rest of the body with sound in the same way we do for speech sounds well so we're speaking with our bodies when we dance incredible and I have to say that as poor as I am at speaking multiple languages I'm even worse at dancing so by guarantee you're better than a monkey but not snowball the cockatoo maybe not snowball on YouTube we have a video where there's some dancing with snowball and you'll see snowballs doing better than some of the scientists as long as I'm not the worst of all scientists and dancing there's always a real plasticity may it save me some day you said something incredible that I've I completely believe even though I have minimum to let's just say minimum dancing ability I can get by at a party or wedding without complete embarrassment but I don't have any structure training so the body clearly can communicate with movement as a trained dancer and knowing other trained dancers I always think of dance and bodily movement and communication body movement as a form of a wordlessness like a state of wordlessness in fact that the few times when I think that maybe I'm actually dancing modestly well for the context that I'm in or I see other people dancing they seem to just be very much in the movement it's almost like a state of non language non spoken language and and yet what you're telling me is that there's a direct bridge at some level between the movement of the body and language so is there a language of the body that is distinct from the language of speech and if so or if not how do those map on to one another was that Venn diagram look like yeah yeah so so let me define first dance in this context of vocal learning species this is the kind of dancing that we are specialized in doing and other the vocal learning species specialized in doing is synchronizing body movements of muscles to the rhythmic beat of music and for some reason we like doing it we like synchronizing to sound and doing it together as a group of people and that kind of communication amongst ourselves is more like the effective kind of communication I mentioned earlier unlike the semantic kind so we humans are using our practice is more for the semantic abstract communication but we're using learn dance for the effective emotional bonding kind of communication it doesn't mean we can't communicate semantic information in dance and we do it not as popular you know like a ballet that you know in the nutcracker it is popular you know where they are communicating you know the Arabian guy comes out which I was the Arabian guy in the ballet nutcracker that's how you remember yeah for the Westchester ballet company when I was a teenager you know we're trying to communicate meaning in our ballet dance and it can go on with a whole story and so forth and but people don't interpret that as clearly as speech you know they're seeing the ballet with semantic communication with a lot of emotional content where as you go out to a club you know yeah you're you're not coming communicating okay how you're feeling today tell me about your day and so forth you're trying to synchronize with other people in an effective way and I think that's because the dance brain circuit inherited the more ancient part of the speech circuit which was for singing I always had the feeling that with certain forms of music in particular opera but any kind of music where there are some long notes song that at some level there was a literal resonance created between the singer and the listener that or I think of like the deep voice of a Johnny Cash or where at some level you can almost feel the voice in your own body and in theory that could be the the vibration of the the or the firing of the frenic nerve controlling the diaphragm for all I know is there any evidence that there's a coordination between performer and audience at the at the level of mind and body I'm going to say possibly yes and the reason why is because I just came back from a conference on the neurobiology of dance that clearly I'm going to the wrong the college you know vision science by me so boring yes well one of my colleagues to come to pitch and Jonathan Fritz they organized a particular section on on this conference in Virginia and this is the first time I was in the room with so many neuroscientist studying the neurobiology of dance it's a new field now in the last five years and there was one a lab where they were putting eG electrodes on the dancers on two different dancers partnering with each other as well as the audience you know seeing the dance and and some you know argued okay if you're listening to the music as well how you respond because you're you're asking a question about music and I'm giving you an answer about dance and what they found is that you know the dancers when they resonate with each other during a dance or the audience listening to the dancers and the music there's some resonance going on there that they score as higher resonance the brain activity with these wireless eG signals are showing something different and so that's why say possibly it needs it needs more rigorous study and you know this is some stuff they published but it's not prime time yet but they're trying to figure this out love it so at least if I can't dance well maybe I can hear and feel what it is to dance in a certain way that that's right and and this will be some people will think that they even songs that they hear and they can almost sing to themselves in their own head and they know what they wanted to sound like and you know when it really sounds good what it sounds like but they can't get their voice to do it I'm raising for those listening I'm raising my hand no no musical ability others in my household have tremendous musical ability with instruments and with voice but not me yeah well and and so this is one of my one of my selfish goals of trying to find the genetics of wise can some people sing really well and some not is there some genetic predisposition to that and then can I modify my own muscles of brain circuits to sing better you're still after the thing I guess this is what happens when siblings are very in proficiency is that that competitiveness amongst brothers and sisters never goes away I've been trying to breathe good is my brother Mark and Victor you know for the rest of the hope my entire life watch out Mark and Victor he's coming for you with neuroscience right to back him earlier you said that you discovered that you could dance that that caught my ear it sounds like you didn't actually have to I'm not suggesting you didn't work hard at it but that at the moment where you discovered it it just sort of was a skill that you had that up until that point you didn't target a life in the world of dance but the fact that you quote unquote discovered that you could dance really well and then went to this incredible school of dance and did well tells me that perhaps there is a an ability that was built up in childhood and or that perhaps we do all have different genetic leanings for for different motor functions yeah well there for me there could be both explanations could be possible for the first yeah I grew up in its family listening to Motown songs you know dancing you know at parties and so forth family parties and you know an African American family basically and so so I grew up dancing from a young child but this discovery you know maybe dancing even more so in terms of a talent it could the genetic component if it really exists I don't know you know with my 23 me results you know it says I have the genetic substitutions that are associated with you know high intensity athletes and fast push muscles and who knows maybe that could have something to do with me being able to synchronize my body to rhythmic sounds maybe better than some others it turns out that my genetics also show that I have a genetic substitute that doesn't that makes it hard for me to sing on pitch and so that does correlate with my you know even though I can sing on this pitch specially if I hear a piano or you know kind of playing it but you know maybe that's why my siblings you know who didn't have that genetic predisposition in his 23 me results you know it could go along with the component as well I'm imagining family gatherings with 23 and me data and intense arguments about it and eight and learn ability yes fun love to be an attendant I'm not inviting myself to your Thanksgiving dinner by the way I suppose I am you're welcome to thank you I'll bring my 23 and me data I'd love to chat a moment about facial expression because that's a form of motor pattern that you know I think for most people out there just think about smiling and frowning but there of course you know thousands if not millions of micro expressions and things of that sort many which are subconscious and we're we are all familiar with the fact that when what somebody says doesn't match some specific feature of their facial expression that it can call up you know that you know that match can cue our attention especially among people that know each other very well yeah like you somebody will say we said that but you you're right I twitch to the you know a little bit in a way that tells me that you didn't really mean that this these kinds of things or when the opposite example when the emotionality and the content of our speech is matched to a facial expression so wonderful about that because it seems like everything is aligned yeah so how does the motor circuitry that controls facial expression map on to the the brain circuits that control language speech and even bodily and hand movements yeah you you ask a great question because we both know some colleagues like Winwick five all that Rockefeller University who study facial expression and the neurology behind it and now we both share some students that were co mentoring and talk about this same question that you brought up and what I'm learning a lot is that non human primates have a lot of diversity in their facial expression like we humans do and what we know about the neurobiology of brain regions controlling those these is that these non human primates and some other species that don't learn how to imitate vocalizations they have strong connections from the cortical regions to the motor neurons that control facial expressions but absent connections or weak connections to the motor neurons that control the voice so I think our diverse facial expression even though it's more personal and non human primates there was already a pre existing diversity of communication whether it's intentional or unconscious through facial expression in our ancestors and on top of that we humans now add the voice along with those facial expressions I see the and in terms of language learning when we're kids I mean children unfortunately are not told to fake their expressions or to smile when they say I'm happy so at some point everybody learns for better for worse how to untangle these different components of hand movement body posture speech and facial expression yes but in it in their best form I am assuming that the best form is always I guess there are instances where you know for safety reasons one might need to feign some of these some of these aspects of language but in most cases when those are aligned it seems like that could reflect that all the different circuitries are operating in parallel but that the the ability to misalign these is also a powerful aspect to our maturation I didn't think of theater for instance where deliberate disentangling of these areas is important but also we know when an actor when it feels real yeah and when it looks like when bad acting is oftentimes when the facial expression or body posture just doesn't quite match what we're hearing yeah so are these skills that that people that learn and acquire according to the ability and profession or do you think that all children and all adults eventually learn how to couple and uncouple these circuits a little bit yeah I think it's this similar argument I mentioned earlier about the innate and the learned for the vocalizations and by the way when I say we humans have facial expressions associated with our vocalizations in a different way than non human primates it's the learn vocalizations I'm talking about so there is a common view out there that facial expressions and non human species like non human primates or you can have them in birds too are innate all right and so they're they're they're reflexive control I don't believe that I think there's some learned component to it and I think we have more learning component to it as well but we also have an innate component and so if you try to put your hands behind your back and hold your face or even just not and try to speak and try to communicate it's actually harder to do you have to force yourself or put it by by your side this comes naturally facial expressions comes naturally because there is an innate component and yes you have to learn how to dissociate the two communicate something angry with your hands over your face but you know politely with your voice it's very hard to this thing to separate at this to because there is that innate component that brings them together so it's like an email too you're you're emailing and someone says something by email someone can interpret that angrily or or gently and it becomes ambiguous the facial expressions get rid of that ambiguity so glad you brought that out because my next question was and is about written language the first question I'll ask is when you write either type or write things out by hand do you hear the content of what you want to write in your head you just you personally yes I do yeah I and I know that I do because I was trying to figure out a debate about this issue and trying to resolve the debate with my own self experimentation on me I asked that because a quite well known colleague of ours Carl Dicerat at Stanford who's been on this podcast and it's you know of optogenetics fame and psychiatry fame etc. and I know him yeah he sends his regards I told me that his practice for writing and for thinking involves a quite painful process of forcing himself to sit completely still and think in complete sentences to force thinking in complete sentences and when you told me that I decided to try this exercise and it's quite difficult first of all it's difficult for the reason that you mentioned which is that with many thoughts I want to look around and I start to gesticulate with my hands and so there it is again the connection between language and hand movement even if one isn't speaking and the other part is that I that's challenging is I realize that while we write in complete sentences most of the time we'll talk about how that's changing now and texting etc. that we don't often think in complete sentences and specifically in simple declarative sentences that a lot of our thoughts would be if they were written out onto a page would look pretty much like passive language that a good copy editor or a good editor would say oh like we need to cross this out make this simple and declarative so what I'm getting at here is what is the process of going from a thought to language to written word and I also wanted to touch on hand written versus typed but thought to language to written word what's going on there what do we know about the neural circuitry and I was going to ask why is it so hard but now I want to ask why is this even possible it seems like a very challenging neural computational problem yeah and from coming from the linguistic world and even just the regular neurobiology world going back to something I said before is about a separate language module in the brain you know there was a thought or hypothesis that this language module has all these complex algorithms to them and they're signaling to the speech circuit how to produce the sounds the hand circuit how to write them or gesture the visual pathway on how to interpret them from reading and the auditory pathway for listening I don't think that's the case all right and you know that this thinking where there's this internal speech going on what I think is going on is to explain what you're asking is about that I'm going to take it from the perspective reading something you read something on a paper the signal from the paper goes through your eyes it goes to the back of your brain to your visual cortical regions eventually and then you now got to interpret that signal in your visual pathway of what you're reading how are you going to do that in terms of speech that visual signal then goes to your speech pathway in the motor cortex in front here in Broca's area and you silently speak what you read in your brain without moving your muscles and sometimes actually if you put electrodes EEG MG electrodes on your look Lorenzo muscles even on birds you can do this you'll see activity there while reading or or trying to speak silently even though no sounds coming out and so your speech pathway is now speaking what you're reading now to finish it off that signal is sent to your auditory pathways so you can hear what you're speaking in your own head that's incredible and this is why it's complicated because you're using like three different pathways the visual the speaking motor one in the auditory to read oh and then you got to write right OK here comes the fourth one now the hand area's next to your speech pathway is got to take that auditory signal or even the adjacent motor signals for speaking and translated into a visual signal on paper so you're using at least four brain circuits which includes the speech production and the speech perception pathways to write incredible and finally explains me why when I so I was weaned teaching undergraduates graduate graduate students and medical students and I've observed that when I'm teaching I have to stop speaking if I'm going to write something on the board I just have to stop all speaking completely right turns out this is an advantage to catch because it allows me to catch my voice it allows me to slow down a bit you know breathe and inhale some oxygen and so on because I tend to speak quickly if I'm not writing something out so there's a break in the circuitry for me or at least they are distinct enough that I have to stop and then write something yes that that that does imply competing brain circuits for your conscious attention we have colleagues up at Columbia med who are known at least in our circles for dictate voice dictating their papers not writing them out but just speaking into a voice recorder I've written papers that way it doesn't feel quite as natural for me as writing things out but not because I can go quickly and then I'm taught to language to typing I type reasonably fast I can touch type now I don't think I ever taught my I think I taught myself I never took a touch type of course just sort of happened now I think my motor system seems to know where the keys are with enough enough accuracy that it works This is remarkable to me that any of us can do this, but When it comes to writing what I've found is that if my rate of thought and my rate of writing are aligned nicely things go well and however if I'm thinking much faster than I can write that's a problem and Certainly if I'm thinking more slowly than I want to write that's also a problem and the solution for me has been to write with a pen I'm in love with these and I have no relationship to the company at least not now Although if they want to come if they want to work with us I love these pilot v5 v7s because not necessarily because of the ink or the the feel although I like that as well But because of the rate that it allows me to write they write very well slowly and they write very well quickly and so I have this theory Supported only by my own anach data no pure reviewed study that Hitting writing by hand is fundamentally different than typing out information Mm-hmm. Is there any evidence that this motor pathway for writing is better or somehow different than the motor pathway for for typing? Yeah, that's interesting And I don't know of any studies. I have my own personal experience as well But trying to put this into the context if I had to You know design and experiment to test the hypothesis here that you know to explain your Experience in mind is that writing by hand I would argue requires a different set of less skills with the fingers Than typing so you have you have to coordinate your fingers more in opposite directions and so forth but typing but also writing by hand requires more arm movement And so therefore I would argue that the The the difficulty there could be in the types of muscles and the fine motor control you need of those muscles Along with speaking in your brain at the same time. So basically I'm a course. I'm a brute And so it makes sense that I would have a more primitive writing device would work That's right. Yes, but but let me let me add to this in terms of the I in my own personal experience, right what I find is I Can write I can write something faster by hand For a short period of time compared to typing and that is because I think I run out of the energy in my arm movements faster than I run out of muscle energy in my finger movements and I think it takes a longer time for us to write words without fingers Because and in terms of the speech so I think you're writing whether it's by hand or typing and in your speech They only will align very well if you can type as fast as you can speak or write as fast as you can speak in your head I love it So what you've done if I understand correctly is created a bridge between thought and writing and that bridge is speech that Bridge is speech that's right That's right when you're writing something out you're speaking it to yourself and if you're speaking faster than you can type you got a problem I I do a number of podcast episodes that are not with guest but solo episodes and as listeners know these are very long episodes often two or more hours and We joke around the podcast studio that I will get locked into a mode of speech where some of it is more elaborate and An anecdotal and then I'll and then I'll punch out simple declarative sentences I find it very hard to switch from one module to the next the thing that I have done in order to Make that transition more fluid and prep for those podcast episodes is actually to read the lyrics of songs and to sing them in my head As a way of warming up my vocal cords, but luckily for those around me when I do that. I'm not actually singing out loud and so This what you're telling me Supports this idea that even when we are imagining Singing or writing in our mind. We are exercising our vocal cords You're actually getting a little low Potentials of electrical currents reaching your muscles there, which also means you're exercising your speech brain circuits too without actually You know going with the full volume activity in the muscles Incredible. Yeah, and this this idea of singing helps you as well Even with Parkinson's patients and so forth when they want to say something singing or listening to music helps them move better and the idea there is that The brain circuits for singing or let's say the function of the brain circuits for speech being used for singing first is the more ancestral Trade and that's why it's easier to do things with singing sometimes and it is with speaking. I love it Stutter is a particularly Interesting case and and one that every once in a while I'll get questions about this from our audience Stutter is is complicated in a number of ways, but culturally am I understanding from these emails that I receive is that stutter can often Cause people to hide and speak less Because it can be embarrassing and we're we are often not patient with with stutter We also have the assumption that if somebody's stuttering that they're thinking is slow, but it turns out there are many examples Historically of people who could not speak well, but who were brilliant thinkers I don't know how well they could write, but they found other modes of communication I realize that you're not a speech pathologist or therapist, but what is the current Neurobiological understanding of stutter and are what's being developed in terms of treatments for stutter? Yeah, so we actually Accidentally came across stuttering in somberds and we've published several papers on this So try to figure out the neurobiological basis the first study we had was a brain area called the basal ganglia What's the the stryanum part of the basal ganglia involved in coordinating movements learning how to make movements? when it was damaged in these in this in a speech like pathway in these birds what we found is that they started to stutter as the brain region recovered and unlike humans they actually recovered after three or four months and Why is that the case because bird brains undergoes new neurogenesis in a way that human or mammal brains don't and It was the new neurons that were coming in into the circuit But not quite you know with the right proper activity was resulting in this stuttering in these birds and And after it was repaired not exactly the old song came back as after the repair But still it recovered a lot better and it's now known they call this neurogenic Stuttering in humans would be damaged to the brazo ganglia or some type of Disruption to the basal ganglia at a young age also causes stuttering in humans and even those who are born with stuttering It's often the basal ganglia that's disrupted than some of the brain circuit and we think the speech part of the basal ganglia Ken adults who maintain a stutter from childhood Repair that stutter they can repair it with a therapy with learning how to speak slower Learning how to tap out a rhythm during stuttering and yeah, I'm not a speech pathologist but I started reading this literature and Talking to others that you know colleagues who actually study study stuttering. So yes There there are ways to overcome the stuttering through through you know behavioral therapy And I think all of the the tools out there Have something to do with sensory motor integration controlling what you hear with what you output in a Foughtful controlled way helps reduce the stuttering there are a couple examples from real life that I want to touch on and One is somewhat facetious, but But now I realize is it is a serious neurobiological issue serious meaning I think Interesting which is that every once in a while I will have a conversation with somebody who says the last word of the sentence along with me Mm-hmm, and it seems annoying in some instances But I'm guessing this is just a breakthrough of the motor pattern that they're hearing what I'm saying very well So I'm gonna interpret this it kindly and think they're hearing what I'm saying they're literally hearing it in their mind and They're getting that low level electrical activity to their throat and they're just joining me in the In the Annunciation of what I'm saying Probably without realizing it. Can we assume that that might be the case? Well, I wouldn't be surprised so that you know the motor theory of speech perception where this idea originally came what you hear is Going through your speech circuit and then also activating those muscles slightly So yes So one might argue Okay, is that speech circuit now interpreting what that person is speaking now you listening to me and is going to finish it off because it's already Going through their brain and they can predict it that would be one one theory on I don't think the verdict out there is known But that's one the other is synchronizing turn taking in in the the Conversation where you're acknowledging that we understand each other by finishing off what I say And it's almost like a social bonding kind of thing the other could be I want the person to shut out So I can speak as well and take that turn and and each pair of people have a rhythm to their conversation And if you have somebody who's over-talkative versus under-talkative of vice versa That rhythm can be lost and then finishing ideas and going back and forth But I I think Having something to do with turn taking as well makes a lot of sense. I have a colleague at Stanford who says That interruption is a sign of interest I'm not sure that everyone agrees. I think it's highly contextual. Yes, but there is this form of a verbal nod I was saying or things of that sort and there many of these and I'm often told by my audience You know that I interrupt my guests and things of that sort oftentimes. I'll just get caught in the natural flow of the conversation But I think we've had pretty good turn taking here I hope that's so far so good. I feel glad. I'm glad you feel that way because especially in the context of a discussion about language It seems important Texting is a very very interesting evolution of language because What you've told us is that we have a thought it's translated into language It might not be complete sentences, but texting I have to imagine this is the first time in human evolution where we've written with our thumbs So I want to you know, it seems more primitive to me than typing with fingers or hands But hey who whom who might have judged the evolution of our species in one direction or the other but the short-hand Grammatically often grammatically deficient incomplete sentence form of texting is an incredible thing to see Early in relationships romantic relationships people often evaluate the others text and their ability to use proper grammar and spelling etc This often quickly degrades and there's an acceptance that we're just trying to communicate through short-hand almost Military likes short-hand but with internally consistent between people, but there's no general consensus of what things mean but you know WTFs and like in omgs and all sorts of things I Wonder sometimes whether or not we are getting less proficient at speech because we are not required to To write and think in complete sentences I'm not being judgmental here. I see this in my colleagues. I see this in myself This is not a judgment of the younger generation I also know that slang has existed for Decades if not hundreds of years, but I also know that I don't speak the same way that I did when I was a teenager Because I've suppressed a lot of that slang not because it's inappropriate Or offensive although some of it was frankly But because it's out of context So what do you think's happening to language? Are we getting better at speaking? We're set speaking and what do you think the role of things like texting and tweeting and short-hand communication? Hash tagging what's that doing to the way that our brains work? Yeah, I think that the one in terms of you know Measuring your level of sophistication intelligence and you say OMG Right, I think that also could be a cultural thing that you belong to the next generation if you're in you know Or you're being cool if you're an older person you know using OMG and other things that the you know younger generation would use but Really think about it clearly a Texting actually has allowed for more rapid communication amongst people I I think without the invention of the phone before then or you know a texting back and forth you had to wait days for a letter to show up You couldn't call somebody in the phone and talk as well, you know, so this rapid communication but in terms of the rapid communication of writing in this case so I think actually It's it's more like a use it or lose it kind of a Thing with the brain the more you use a particular brain region or circuit the more enhanced. It's like a muscle The more you exercise it the more healthier it is the bigger it becomes and the more space it takes and the more you lose something else so I think texting I my is not decreasing The the the the speech prowess of the intellectual prowess of speech it's converting it and using it a lot in a different way In a way that may not be as rich and in regular writing because You can only communicate so much nuance in short term writing But whatever that it whatever is being done you got people texting hours and hours and hours on the phone So whatever your thumb circuit is gonna get pretty big actually I do wonder whether you know many people have lost their jobs based on tweets the short latency between thought and action and Distribution of one's thoughts is is incredible. Yes, and I'm not just talking about people who have Who apparently would have poor prefrontal top-down control? This is geek speak by the way for people that lack impulse control, but high-level academics I'm not gonna point fingers at anyone, but examples of in where you see these tweets You what were they thinking yep, so Presumably there's an optimal Strategy between the the thought speech motor at motor pathway Especially when the motor pathway engages communication with Hundreds of thousands of people and retweets in particular and the cut and paste function and the screenshot function Are often the reason why speech propagates. Yep, so to me it's it's a little eerie that the Just that the neural circuitry can do this and that we are catching up A little bit more slowly to the technology and you've got these casualties of of that mismatch I think I think that's a good Adjectives to use the casualties, you know, what's going on because Yes, it is the case with texting what you're really losing there is not less so the ability to write But more of the ability to interpret what is being written and you can over underterpent something That somebody means On the flip side of that, you know when if somebody's writing something very quick They could be writing Instinctually more instinctually they're in true meaning and they don't have time to modify and color code What they're trying to say and that's what they really feel And as opposed to saying a more nuanced way so I think both sides of that casualty are Present and that's a downturn, you know unintended negative consequence of Short-term I mean short word communication Yeah, I agree that this whole phenomenon could be netting people that Normally would only say these things out loud once inside the door of their own home or not at all right It's a it's an interesting time that we're in these of these speech and language and murder and motor patterns So part of the human evolution for language. I think this is all part of our evolution. That's right So for those of you thinking terrible thoughts, please put them in the world and be a casualty and for those of you that are not Please be very careful with how proficient your thought to language to motor action. Yes Maybe it's the technology companies should install some buffers some AI based buffers Right that's taking some eG signals from your brain while you're texting to say okay, this this is you know This is not a great thought slow down right or this doesn't reflect your best state That brings me to the what was going to be the next question anyway, which is we are quickly moving toward a time where There will be a even faster transition from thought to speech To motor output and maybe won't require motor output what I'm referring to here is some of the incredible work of our colleagues Eddie Chang at UCSF and others who are taking paralyzed human beings And learning to translate the electrical signals of neurons in various areas including speech and language areas to Computer screens that type out what these people are thinking in other words paralyzed people can put their thoughts on Interwriting that's a pretty extreme and Wonderful example of recovery of function. Mm-hmm. That is sure to continue to evolve But I think we are headed toward a time not too long from now where My thoughts can be translated into words on a page if I allow that to happen. Yeah, so and Eddie Chang's work I which I admire quite a bit and sight in my papers I think he's really one of those at the leading edge of trying to understand within humans the neuroviralgia speech and He may not say it directly, but I know I talked about this that supports this idea that the speech circuit in a separate language module I don't really think that there's a separation there. So with with that knowledge Yes, and putting electrodes in the human brain and then translating those electrical signals to speech Currents. Yeah, we can start to tell what is that person thinking? Why because we often think in terms of speech and Without saying words and that's a scary thought and now imagine if you can now Translate those into a signal that transmits something wirelessly and someone from some distant part of the planet is hearing your speech from a wireless signal without you speaking so Probably that won't be done ethical way who knows, you know, but the I mean the ethics of doing that probably you know Might not happen, but who knows we have these songbirds You know we apply the same technique to them we can start to hear what they're singing in their dreams or whatever Even though they don't produce sound so we can find out by testing on them. It's coming That's another it's coming For those listening who are interested in getting better at speaking and understanding languages Are there any tools that you recommend and here again? I let I realize you're not a speech therapist But here I'm not thinking about emeliorating any kind of Speech deficiency. I'm thinking for instance do you recommend that people read different types of writing? Would you recommend that people learn how to dance in order to become better at expressing themselves verbally? You know, and feel free to have some some degrees of freedom in this answer This these are obviously not peer-reviewed studies that we're referring to over all though there may be But I'm struck by the number of things that you do exceedingly well, and I can't help but ask Well that the singing that which I realize it may your brother didn't pay me and say this may not be quite as good as your brother's yet But is getting you'll surpass him. I'm guessing at some point They're getting exactly there you go You know Should kids learn how to dance and read hard books and simple books? What do you recommend should adults learn how to do that? Yeah, everyone wants to know how to keep their brain working better So to speak but also I think people want to be able to speak well and people want to be able to understand well. Yeah So what I've discovered personally, right is that so when I switch from pursuing a career in science from a career in dance I Thought one day I would stop dancing But I haven't because it I find it fulfilling for me You know just as a life experience So ever since I want started college, you know my late teens in early 20s I I kept dancing even till this day and they've been period of time like during the pandemic where I slowed down on dancing and so forth And and when you do that you realize okay there are parts of your body where your muscle tone decreases a little bit in Somewhat and or you could start to gain weight or I somehow don't gain weight that easily and I think it's related to my dance If that's that that's meaningful to your audience but what I found is you know in in science We'd like to think of a separation between movement and action and cognition and there is a separation for you between perception and production cognition being perception Production being moving right but if the speech pathways is next to the movement pathways what I discover is by dancing it is helping me Think it is helping keeping my brain fresh. It's not just moving my muscles I'm moving or using the the circuitry in my brain to do control a whole big body You need a lot of brain tissue to do that and so I argue if you want to stay cognitively Intact into your old age you better be moving and you better be doing it consistently whether it's dancing walking running and also practicing speech Oratory speech and so forth or singing is controlling the brain circuits that are moving your facial musculature And it's going to keep your cognitive circuits also in tune and I'm convinced of that from my own personal experience for me Long slow runs are a wonderful way to kind of loosen the joints for long podcasts Well, especially the solo podcast which can take many hours to record and Without those long slow runs at least the day before or even the morning of I don't think I could do it At least not as well. All right. Well, you're you're experiencing something similar. So that's an NF2. Yeah, I'm I'm tempted to learn how to dance because There are a lot of reasons to learn how to dance. Yeah, people can use their imagination. I Definitely want to get the opportunity to talk about some of the newer work that you're into right now about genomes of animals As you perhaps can tell from my quite authentic facial expressions. I adore the animal kingdom I just find it amazing and it's what the reason I went into neurobiology in part So many animals so many different patterns of movement so many body plans so many specializations What is the value of learning the genomes of all these animals? It you know, I can think of Conservation based you know schemes of trying to preserve these precious critters But what are you doing with the genomes of these animals? What do you want to understand about their brain circuits? And how does this relate to some of the discussion we've been having open? Yeah, I've gotten very heavily involved in genomes You know, not just to get at an individual gene involved in the trait of interest like spoken language but I realized that You know nature has done natural experiments for us But all these species out there with these various traits and the one that I'm studying like vocal learning has evolved multiple times among the animal kingdom even if it's rare it's multiple times and The similar genetic changes occurred in those species but to find out what those genetic changes that are associated with the trait of interest and not some other trait like flying In birds as opposed to singing You have to do what's called comparative genomics even in the context of studying the brain and you need their genomes to compare The genomes and do like a GWAS the genome-wide association study not just within a species like humans but across species and so you need a good genomes to do that Plus I've discovered I'm also interested in evolution in origins. How did these species come about a similar trait? And in last you know 300 million years or 60 million years depending who you're talking about and you need a good phylogenetic tree to do that and to get a good phylogenetic tree You also need their genomes and so because of this I got involved in large-scale consortiums to produce genomes of many different species including my vocal learners and my their closest relatives that I'm fans of But I couldn't convince the funding agencies to give me the money to do that just for my own project But when you get a whole bunch of people together who want to study various traits, you know heart disease or what or loss and gain a flight and so forth suddenly we all need lots of genomes to do this and So now that got me into a project to lead something called a vertebra genomes project to eventually sequence all 70,000 species on the planet and Earth bio genome project all new carry out species all 2 million of them and and to no longer Being a situation where I wish I had this genome now we have the genetic code of all life on the planet Created database of all their traits and find the genetic association with everything Out there that makes a difference from one species to another One more piece of The equation to add to this story is what I didn't realize as a neuroscientist where that these genomes are not only incomplete But there have lots of errors in them False gene duplications where mother and father chromosomes were so different from each other that the genome algorithm Assembly algorithms treated them as two different genes in this part of the chromosome So there are a lot of these false duplicated genes that people were thought were real but were not or missing parts of the genome Because the enzymes used to sequence the DNA couldn't get through this regulatory region that folded up on itself And made it hard to sequence and so I end up and in these consortiums Pulling in the genome sequencing companies developing the technology to work with us to improve it further And the computer science guys who then take that data and that technology and try to make the complete genomes And make the algorithms better to produce What we now just did recently and led by an effort by Ed and philope is the first human telomerative telomer genome with no errors All complete No missing sequence and now we're trying to do the same thing with vertebrates And other species actually we improved that but even before we got to the what we call telomerative telomer from one end of the chromosome to another And what we're discovering Is in this dark matter of the genome that was missing before Turns out to be some regulatory regions that are specialized in vocal learning species and we think are involved in developing speed circuits credible Well so much to learn and that we're going to learn from this information Early on in these genome projects and connect-dome projects I confess I was a little bit cynical This would be about 10-15 years ago I I thought okay necessary but not sufficient for anything We need it but it's not clear what's going to happen But you just gave a very clear example of what we stand to learn from this kind of information and And I know from the conservation side there's a huge interest in this because even though we would prefer to keep all these species alive rather than clone them there These sorts of projects do offer the possibility of potentially recreating species that were lost due to our own ignorance or missteps or what have you yes and along those lines Because you know we got involved in genomics some of the first species that we start working on are critically endangered species and I'm doing that not only for For perspective so understand their brains and the genes involved in their brain function But I feel like it's a moral duty So the fact that now I become more involved in genome biology and have helped develop these tools for more complete genomes Let's capture their genetic code now before they're gone And could we use that information To resurrect the species at some future time if not in my lifetime in In some time in the future and generations ahead of us and so In due in anticipation of that we created database we call the genome arc Uh and no pun intended like Noah's arc A meant to store the genetic code as complete genome assemblies as possible for all species on the planet Uh to be used for basic signs, but also some point in the future Uh and because of that uh funding agencies or private foundations that are in-strogen and conservation Have been reaching out to me now a neuroscientist Uh to help them out In producing high quality genome data of endangered species that they can use like revive and restore Who want to resurrect the passenger pigeon or colossal who wants to resurrect the woolly mammoth And so we're producing high quality genomes for these groups for their conservation projects What a terrific and important initiative and I think for those listening today they now certainly understand the value of under of deeply understanding the brain structures and genomes of different species Because I can fast even though I knew the a bit of the songbird literature and I certainly understand that humans have speech in language I had no idea that there was so much convergence of function structure and genomes and to me you know I feel a lot more like a an ape than I do a songbird and and yet here we are with the understanding that There's a lot more similarity between songbirds and humans than I certainly ever thought before Something very close to home for us humans I can give you an example of is evolution of skin color Uh and on the skin color reuse it unfortunately for racism and so forth We use it also for good things to let in more light or let out less light Depending on the part of the planet, you know our population evolved in And most people think dark skin people all evolve from the same dark skin person and light skin people all evolve in the same light skin person But that's not the case Dark skin and light skin amongst humans has evolved independently Multiple times like in you know the Pacific Islands versus Africa and it and it it's just depending on the angle of light Hitting the earth as to whether you need more protection from the sun or less protection To that's also associated with vitamin D synthesis in the skin and so um and each time um Where darker or lighter skin evolved independently hit the same gene, you know You know the melaton Melon and melon in receptors. That's right. Yes. Yeah. A genes that are involved in melon and formation Uh and so um those genes evolved some of the same mutations even in different species It's not just humans In equatorial regions. They're darker skinned animals and going away from the equator All right, I think of an Arctic foxes. That's right. That's right polar bears, you know and so uh And so some of the same genes are used in an evolutionary perspective to evolve in a similar way within and across species Incredible. Yeah, and that's the same thing happening in the brain too. The language is no exception Well, I have to say as somebody who is a you know career neuroscientist But as I mentioned several times that who also adores the animal kingdom but is I've also obsessed with speech and language and um at a distance not as a as a practitioner of music and dance This has been an incredible Conversation and opportunity for me to learn and I know I speak for a tremendous number of people when I just really want to say thank you for Joining us today. You are incredibly busy. It's clear from your description of your science and your knowledge base that you are involved in a huge number of things Um it very busy so thank you for taking the time to speak to all of us Thank you for the work that you're doing both on speech and language but also this important work on genomes and um The conservation of endangered species and far more and I have to say If you would agree to come back and speak to us again sometime I'm certain that if we were to sit down even six months or a year from now there's gonna be a lot more to come Yeah, we have some things cooking and uh and thank you for inviting me here to get the word out to the community Uh of what's going on in the science world? Well, we're honored and very grateful to Eric. Thank you Thank you for joining me today for my discussion with Dr. Eric Jarvis If you'd like to learn more about his laboratory's work You can go to Jarvis lab spell J-A-R-V-I-S lab all one word Jarvis lab.net and there you can learn about all the various studies taking place in his laboratory as well as some of the larger overarching themes that are driving those studies including studies on human genomics and animal genomics That surely are going to lead to the next stage discoveries of how we learn and think about and indeed use language If you're learning from and are enjoying this podcast, please subscribe to our YouTube channel That's a simple zero-cost way to support us Please also subscribe to the podcast on Spotify and Apple and on both Spotify and Apple You have the opportunity to leave us up to a five-star review If you have questions or comments or suggestions about topics you'd like us to cover or guess you'd like us to interview on the Heuberman lab podcast Please put those in the comment section on YouTube We do read all those comments and we do take them to heart Please also check out the sponsors mentioned at the beginning of today's podcast and check out momentous supplements Our new partners in the supplement space and check out athletic greens That's the best way to support this podcast if you're not already following us on social media Please do so we are Heuberman lab on Twitter and we are also Heuberman lab on Instagram and both places I cover science and science related tools some of which overlap with the content of the Heuberman lab podcast But much of which is unique from the content covered on the Heuberman lab podcast again That's Heuberman lab on Instagram and Heuberman lab on Twitter Please also check out our neural network monthly newsletter This is a newsletter that has summaries of podcast episodes It also includes a lot of actionable protocols It's very easy to sign up for the newsletter You go to Heuberman lab.com click on the menu go to newsletter You supply your email, but we do not share your email with anybody We have a very clear and rigorous privacy policy which is we do not share your email with anybody and The newsletter comes out once a month And it is completely zero cost again. Just go to heuberman lab.com and go to the neural network newsletter I'd also like to point out that the Heuberman lab podcast has a clips channel So these are brief clips anywhere from three to 10 minutes That encompass single concepts and actionable protocols related to sleep to focus Interviews with various guests we talk about things like caffeine when to drink caffeine relative to sleep alcohol when and how and if anyone should ingest it relative to sleep Doppamine serotonin mental health physical health and on and on all the things that relate to the topics most of interest to you You can find that easily by going to YouTube look for Heuberman lab clips in the search area And it will take you there subscribe and we are constantly updating those with new clips This is especially useful I believe for people that have missed some of the earlier episodes or you're still working through the back catalog of Heuberman lab podcasts Which admittedly can be rather long and last but certainly not least Thank you for your interest on science