[SQUEAKING]

[RUSTLING]

[CLICKING]

NORVIN RICHARDS: Here, I'm going to try to answer that. That's a really good question. And in some cases, we just kind have to guess. But in some cases, we have-- especially for languages like Greek and Latin, we have descriptions by people who attempted to describe their own sounds. That's a kind of thing that happens.

We can infer things from mistakes that people made at various points. So people who were learning how to spell, or say children, or people who weren't highly educated, when they misspelled words in, say, Greek or Latin, you can infer things. So if you're making-- if a certain kind of misspelling is common, you get to infer that those sounds were kind of common.

So in the case of ancient Greek, we think that there was an "Y" [high front rounded vowel] partly because there was a period where people were-- when people misspelled it. They either misspelled it as "u" or as "i". And then later, there was a period where people reliably misspelled it as "i," leading us to think that it had shifted to what it is in modern Greek, which is an "i." That's one of the kinds of things people do.

You also get to look at what happens to these words when they get borrowed into other languages, so languages that have richer or poorer systems. There's one classic example from Greek and from Latin. We know that Greek-- I see, I'm sorry, Raquel, you were right. This is going to be a long-- a long answer.

We know that the Greek letter, this Greek letter, used to be pronounced as a "p" with an extra puff of air. It used to be pi or pea [pronounced with aspiration], so just an especially emphatic "p." They also had another letter, which was a "p" without the extra puff of air, "p." And then this one shifted to-- well, actually, the modern-- this is the symbol for it in IPA, the bilabial fricative, a "fuh," a "fuh."

And the way that we know-- we can actually date pretty precisely when this shift happened. And that's because Greek was loaning lots of words into Latin. Latin was borrowing words from Greek, including a word that they spelled like this. And the fact that they spelled it like that, first of all, suggests that it was a "p" with an-- a "p" with an "h" sound and not something more like an "f" because Latin had an "F."

And they would have used an F if they had thought that this was an "f." Also, because people who were bad at spelling-- children, and people writing graffiti, and stuff like that-- when they misspelled this word, when they were writing graffiti about philosophy, they would misspell it by leaving out the H. So they would spell it just with a P. And then later, there was a period where people who were misspelling this word would misspell it by writing it with an F. And that's how you know that the word had changed its pronunciation right then at that point from an aspirated "p," a "p" with an "h" sound, to an "f."

AUDIENCE: So when I misspell things, that's actually benefiting the future.

NORVIN RICHARDS: You're being-- providing valuable data for future historical linguists, absolutely. That's absolutely true. Now, please engrave your misspellings in stone. That will make them a lot easier for people to handle. Any other questions about this?

OK, where was I going with all that? Oh, right, so I was saying-- I was telling you some things about typology. There are languages that have poorer and richer vowel systems. English has a particularly rich system of vowels. We have a fairly large number of vowels. There are plenty of languages out there that have-- languages that have fewer, that have five. There are plenty of languages that have three.

If you have three vowels, your three vowels are pretty invariably "a," "i," and "u" That is, they're the vowels that are kind of in the corners of this system. They're at the bottom right, and the top right, and the top left, yeah. There aren't languages out there that have three vowels and the three vowels are "eh," "ih," and "ah." That's not a kind of language that we find.

And there's some work on this, including classic work by my colleague Edward Fleming, talking about optimal distributions of vowels and vowel space, where the idea is have this space in your mouth. You want your vowels to be maximally contrastive. So you want people to always be able to hear the difference between different vowels. And the best way to do that is to have your vowels as far apart from each other as possible, as a theory about why we get the kinds of vowel systems that we get and not others.

OK. Oh, right, and then there are languages, like French, that have nasalized vowels. So French has words like "main," [with nasalized vowel] which is hand, and "met," which is dish. So that's another option that some languages take. You can lower your velum and allow some air to flow through your nasal cavity as you're making sounds. French, Portuguese, lots of languages do this.

OK, so I said we're classifying vowels. Why are we classifying vowels? Partly because it's fun, but also because it enables us to realize that we wonder about kinds of vowel spaces. Why are all the English vowels in the upper right-hand corner? Do they have to be? If you had a rounded vowel that was somewhere else, what would it sound like? All that good stuff.

Another thing that it does is help us to develop theories of phonologically natural sound changes. So here are some Turkish nouns. I'm sorry, I'm going to use your native language. And I'll just ask you to be quiet for the next little while. Here are some Turkish nouns. Some of you, if you've ever read CS Lewis, you might recognize the first one.

And here are the plurals of these nouns. What's the plural suffix in Turkish? Yeah?

AUDIENCE: L-A-R.

NORVIN RICHARDS: So it's L-A-R, [TURKISH] like in the word for lions, and the word for arms, and the word for slaves, and the word for daughters. Oh, but not in the words for winds, teeth, and roses, where we seem to get a [TURKISH]. So we get L-E-R for those three. I'll write them down-- [TURKISH]. And we get [TURKISH] for these-- [TURKISH].

Having done that, I'm now going to go back to the last slide. What do you think? Why are we getting [TURKISH] with these and [TURKISH] with those? Joseph, what do you think is happening?

AUDIENCE: I think this is an example of vowel harmony.

NORVIN RICHARDS: I think this is an example of what's called vowel harmony. What do you mean?

AUDIENCE: So a lot of languages will have a certain suffix or a prefix, affix without a morpheme. And when you attach to another word, the vowel, the primary vowel in that found morpheme will change to-- will harmonize with whatever-- with some vowel in the other [? word ?] [INAUDIBLE].

NORVIN RICHARDS: So that's well said. So what does this vowel have in common with these vowels? And what does this vowel have in common with these vowels? Bear in mind that "oo" is a front high grounded vowel and "uh" is a back high unrounded vowel. What do these vowels, "ay," "ee," and "oo" all have in common? Yes?

AUDIENCE: They're front.

NORVIN RICHARDS: They're all front. And what do these vowels-- "ah," "oh," "oo," and "uh"-- have in common? Well, they're all back, right? And the vowel in "lar" is back and the vowel in "ler" is front. So just as Joseph said, this is vowel harmony. The vowel of this suffix is having its properties determined by the vowel of the thing it's being attached to, the noun it's being attached to. Whether it's front or back is determined by the vowel of the noun it's attached to.

So this is front-back harmony. There's also rounding harmony-- so cases where you have a suffix whose roundedness is determined by the roundedness of the vowel that it's attaching to. There are other kinds of harmony. But those are things that happen.

And categorizing vowels, looking at vowels and thinking, ah yes, some of these are front and others are back, it's not just a fun thing to do that allows us to think about the insides of our mouths. It allows us to understand Turkish better, right? What the heck is going on in Turkish? Well, it's harmony for front versus back.

OK, I think when I was first introducing you to consonants, I said, consonants, they involve disturbing the flow of air. And the flow of air is usually going outward from your lungs. But there are some other options, I said, and chuckled mysteriously. And so I want to just show you why I was doing that.

There are other kinds of sounds out there. So the first kind of sound that I wanted to talk about are what are called ejectives. And I have some sound files that I'll play for you. These were all compiled and put online by the great phoneticist Peter Ladefoged, who used to teach at UCLA. He's no longer with us. I'll put a link on the website both to the particular classes of sounds that I'm going to show you and to the larger UCLA website, which has all kinds of cool sound files on it that you can listen to and amaze and annoy your friends with.

So the first type of sound that I want to talk about are what are called ejectives. There aren't languages of Europe that have ejectives. But they're quite popular in the languages of North and South America. And so it's worth learning how to do them. Let's start by making an ejective "t." This is how you make an ejective "t."

So first, we'll practice like this, you'll hold your breath. Don't do it now because I have other things to talk about. But what you're going to do is you're going to hold your breath and try to make an audible "t." sound. So go t, t, t.

AUDIENCE: t, t, t.

NORVIN RICHARDS: OK, good. And then if you were actually doing this in speech, you're not allowed to stop and hold your breath. The idea is to get-- well, so hold your breath, make your ejective "t," and then release into a vowel, so go ah, ta, ah, ta.

AUDIENCE: Ah, ta, ah, ta.

NORVIN RICHARDS: Cool, you guys sound very ejective. And similarly, you can do this with bilabial. There are bilabial ejective-- ah, pa, ah, pa-- or velar ejective stops like ah, ca, ah, ca. Cool, excellent. So we're all amateurs at this, but the Lakota are professionals. So let's listen to a Lakota speaker do this.

[AUDIO PLAYBACK]

NORVIN RICHARDS: That's an ejective velar.

[END PLAYBACK]

NORVIN RICHARDS: As opposed to, here's her regular velar stop.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Here's a bilabial one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: So that's what ejectives sound like in the wild. This is Lakota. It's a language still spoken, well, near North and South Dakota. So there are the Lakotas, and the Nakotas, and the Dakotas. They all live in that area. They're Siouan languages. Yeah? Oh, Raquel?

AUDIENCE: What's the difference between that and just the normal "k" sound followed by the glottal stop?

NORVIN RICHARDS: So it's very similar. You're engaging your-- so what you're doing when you make these sounds is you are making a velar closure. And then, you are also making a glottal stop. And then, you are pushing with your glottis to make the velar closure open. So you make your-- you move your larynx in order to get the closure to open. And that's what gives it this unique burst. So you're right. There is a glottal stop involved when you're doing that.

We're at-- yeah, so when I said that the flow of air is usually from your lungs, here's the place where it isn't exactly. The air originally came from your lungs. Well, it originally came from the world. It spent some time in your lungs.

And then, it got trapped between this glottal stop at your larynx and the closure that you're making in your mouth. And the flow of air that causes-- that's present as you're opening the stop-- is actually from your larynx. It's not from your lungs. It's not originally from your lungs, if that makes sense. So those are ejectives.

Clicks. I have some recordings of clicks in here somewhere. Yeah, there they are. These are Zulu clicks. There are three main kinds of clicks to think about. And clicks, again, involve a strange and cross-- typologically unusual, kind of, airflow. So clicks are found in-- so the languages with the richest click inventories are the Khoisan languages of places like Namibia. And then, there are a bunch of Bantu languages that also have clicks, also in Africa, in theory because they've been in contact with the Khoisan languages.

So clicks are really cross-linguistically not terribly popular. They're only found in that area and in one culturally restricted language spoken by the Lardil. So the Lardil have-- it's almost a language game. It's called Damin, which is used after a certain initiation ceremony.

So there's a period where you're not supposed to speak normal Lardil. And so you speak this other thing instead, which has all kinds of strange sounds in it, including clicks. It's called Damin. We may get a chance to talk more about it later.

But for languages that are not spoken under special cultural circumstances, these African languages, the Khoisan languages and the Bantu languages that have been in contact with them, are the only ones that have clicks. And I'm talking about clicks now because they do involve an unusual airflow.

They involve making a stop, a velar stop, and then using your tongue to sharply draw air into your mouth for a moment. So what's a click? One click is the dental click. It's the, kind of, sound you make to criticize someone, to [TSK-ING] thing that you sometimes--

[LAUGHTER]

--see spelled tsk. T-S-K. T-S-K. Yeah, there is a lateral click. Whenever I read about lateral clicks, the description of them is always that it's the sound you make to encourage a horse. I have never had to encourage a horse--

[LAUGHTER]

--or discourage a-- I've never-- I haven't interacted much with horses. So I'm not-- that description doesn't help me a whole lot. I gather it involves sucking the sides of your tongue in from the sides of your mouth. So you're going [CLICKING].

AUDIENCE: [CLICKING]

NORVIN RICHARDS: Yes, I think I hear some lateral clicks.

[LAUGHTER]

And then, there's another click, which is sometimes called a palatal click, which goes [CLUCKING].

AUDIENCE: [CLUCKING]

NORVIN RICHARDS: So you're-- oh, you guys are really good at that one.

[LAUGHING]

Yeah, so all three of these clicks are present, for example, in Zulu and in Xhosa, which is the native language of Nelson Mandela. And here are some Zulu ones that you can listen to. So we've got the dental one first.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: And here's the lateral one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: And the alveopalatal one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: And as you can see from this, Zulu draws distinctions depending on, basically, how you release the stave. So there are clicks-- those clicks, the ones I just played for you, involve a voiceless stop that's not aspirated, that doesn't have this puff of air that I was talking about and that we will talk about more. I was talking about when I was talking about "philosophy" and Greek. But you can also build them on aspirated stops, or on voiced stops, or even on nasals. So maybe I'll just run through all of the dental clicks. Here's the voiceless one again.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: But here, it is aspirated.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Ta ga. So there's air coming out as you do this. And here it is voiced.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: And here, it is nasal.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Whoa, that hardly sounded like a click at all. Here, let me try to find another nasal one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yep, that was clicky.

[LAUGHTER]

And here it is as a lateral.

[AUDIO PLAYBACK]

NORVIN RICHARDS: [CHUCKLING]

[END PLAYBACK]

NORVIN RICHARDS: Zulu really does sound like that.

[LAUGHING]

We did a field methods class on Zulu. And it has this beautiful-- because it's tonal. So it has all of this-- the intonation is just really pretty to listen to. So clicks is another kind of thing, not all that popular cross-linguistically. But it happens. And they're magnificent. The Khoisan languages have even richer arrays of click inventories than this. In particular, they also have bilabial clicks. So they have [CLICKING] as a sound. [CLICKING], that kind of a sound.

And they make all of these distinctions among their clicks. The result ends up being that the Khoisan languages, if you count all of these clicks as different consonants, the Khoisan languages have just huge inventories of consonants because they have all these different clicks. Yes?

AUDIENCE: Are the accents above the vowels indicative of what direction the tone is?

NORVIN RICHARDS: Yeah, those are tone marks. Yeah, so the accents that points down to the right are low-tones. And the accents the point up to the right are high-tones. And that's all Zulu's got. It's got high-tones and low-tones. And then, you can have long vowels that transition from a high-tone to a low-tone or vice versa. Yeah, yep. Clicks.

Implosives. Let me find you some implosives. They're around here somewhere. Where were they? These are implosives. Implosives, what implosives are, are sounds where-- so what you should do if you want to make an implosive, ah...

"b," for example, is you should make your bilabial closure. And then, you should try to inhale. So it's like, "bah, bah, bah, bah" [pronounced with implosive "b"]. And similarly, so don't hurt yourself. But that's what you're trying to do.

[LAUGHTER]

And there are also velar implosives, which you should really be careful with. They're "ag ba, ag ba" [pronounced with implosive "g"].

AUDIENCE: [INAUDIBLE]

NORVIN RICHARDS: Or "ah dah, ah dah" [pronounced with implosive "d"

AUDIENCE: [INAUDIBLE]

NORVIN RICHARDS: Yeah, [INAUDIBLE]. So here's a native speaker. So these are not all that uncommon in languages of India. There are a bunch of them in Indonesia. Here are some.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: That's a bilabial one. Here's a retroflex one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: "Dinu" [pronounced with voiced retroflex implosive "d"]. All right. So we can compare his implosive one with the regular voiced one. So here's the implosive one again.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, and then, here it is not implosive.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, and here's what it sounds like when it's velar.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: As opposed to the regular one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, so again, I'll put these files up. You can play with them at home, amaze and annoy your friends. No questions about any of that? So again, this has all been about interesting air flows. So here's one where the flow of air is not outward at all. It's going inward for just a millisecond, yeah, trying to suck air into your body instead of getting it out as you speak.

There are-- so I don't know of any languages that have, for example, a class of vowels that you must make while inhaling. So these are consonants that you make while attempting to inhale. That's the sense in which the flow of air is different. You could imagine a language that had the vowel "a" and also the vowel [GASP].

I've never heard of a language like that. There are languages that will inhale for particular words or classes of words. So I'm told that in Finland, there's an expression that basically means "yes." But it's used only by middle-aged women. And it involves inhaling. You say, [GASP]. And that marks you as a middle-aged Finnish woman.

[LAUGHTER]

So if you're ever attempting to sound like a middle-aged Finnish woman, you should use that a lot, yeah. But I've never heard of a language that had-- there are languages that have a series of nasal vowels, for example. But there aren't languages that have a series of inhaled vowels. That doesn't happen, no, as far as I know. And then trills, these don't involve a special airflow. But I wanted to talk about them partly because they came up in class.

AUDIENCE: [TRILLING]

NORVIN RICHARDS: Yeah, like that. So trills involve getting some type of-- some part of your vocal tract to flutter. And there are ones that are comparatively famous, like the so-called rolled "r." These are some examples that are going to sound like that. This is a language. This is a Dravidian language called Toda that has dental trills and also postalveolar trills. So you can listen to those.

Sure we can. Come on. Wake up, website. I take it back. We can't listen to those. Why can't we listen to those? I was listening to them just now. What is your deal? Never mind. We'll go to this other one. So the rolled "r" the [PURRING] sound, that's the alveolar trill, where you're holding your tongue fairly close to your alveolar ridge, and getting the air to flow, and holding your tongue in such a way that your tongue flutters in the breeze as it goes by.

English doesn't have that. But if you want to learn to speak Italian, or Spanish, or a variety of languages of Australia, you need to learn how to roll your "r"s. It's possible to be physically incapable of doing that. In fact, so for example, there are Italians who cannot roll their "r"s. But it's not all that common.

Yeah, it's the kind of thing that is a speech impediment if your native language has rolled "r"s. If your native language is English then you're off the hook. There are also languages that have uvular trills. That's one possible pronunciation of the French "r'' or the German "r." [PURRING IN BACK OF MOUTH]. I can only do a uvular trill with my head tilted back slightly. So yeah, that's, again, getting your uvula to move in the breeze.

AUDIENCE: Gargling.

NORVIN RICHARDS: I'm sorry.

AUDIENCE: Like gargling.

NORVIN RICHARDS: Like gargling. And then, there are languages that have bilabial trills, which was what Raquel was doing for us. Let me see if I can get these to come out. Ah, come on. All right. The UCLA website.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: There we go.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: So that's the sound that begins with a bilabial trill. [BLOWING]

AUDIENCE: [BLOWING]

NORVIN RICHARDS: [BLOWING] Yeah, you're better at it than me.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Oh, here's another one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, so this is Kele, it's a language spoken in Gabon, and Titan, which is, I believe, a Polynesian language. These are languages that have bilabial trills. Is that a question?

AUDIENCE: Question. Remind me why rolled "r"s are called "rolled 'r's" again.

NORVIN RICHARDS: That's the-- so in linguistics, they aren't usually called that. They're called alveolar trills. We call them rolled "r"s, I think, because they sound a little bit like a drum roll. It's like there's a repetitive sound. [PURRING] You're repeatedly striking the roof of your mouth. That's what I always thought that term referred to. But as I say. It's not a linguistic term.

AUDIENCE: Remind me why drums rolls [INAUDIBLE].

NORVIN RICHARDS: Oh, that's a good question. Well, because they sound like rolled "r"s.

[LAUGHTER]

I guess they sound like something is rolling and repeatedly-- so they involve a repeated strike of something. So if you have something rolling, bumping down a staircase or something, then it might sound a little bit like that. I don't know. I am now making things up. I will try to flag it when I'm making things up.

But yes, I don't know. That's a good question. You should go look it up in the OED or something. Maybe they'll have a theory. Yeah, other questions?

All right. So enough of the bilabial trills. And so yeah, as I say, I'll put the UCLA sound files up there so that you can play around with them. Oh, sorry. I spoke too soon. So we've been talking about sounds for a little while. And I've been encouraging you to try to make the strange sounds. You've all been clicking at me and trilling at me. It's been great.

But there is another way to study speech sounds. And I just wanted to show you how it works. I hope this works. We'll see. It's possible to make what are called spectrograms. And maybe what I'll do is just show you one. And that'll make it easier to talk about what they are. Let's see if I can get this to work.

You. Let's see if we can see that. There. That's a spectrogram. Let me Zoom in on it. Yeah, there we go. And I can zoom in on it a little further.

It isn't all vowels, is it? So this is a program called Praat. It's a freeware program. I'll put it up online. It's something that allows you to make spectrograms. As you can see, it's very easy.

It's a pretty easy program to use. I'll put up-- it's a program that's been around for a long time. It was developed by linguists and not by software engineers. And you can tell.

So it's a little bit-- the interface is a little bit clunky. But I'll put up some suggestions about how to use it. And I encourage you to download it and play around with it. It's fun. What's going on here, the thing on the bottom of this window is the spectrogram. And it's a spectrogram showing me making those vowel sounds, "a," "i," and "u," transitioning between them. I think I might be able to play what we're looking at here.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, so I didn't keep very much of the "u." That we can think just about the "a" and the "i." What you're doing when you are making vowels especially, but actually when you're speaking generally, is your vocal cords, in this case, my vocal chords were vibrating. They were making the air vibrate. There's this column of air that comes up through my vocal tract. They're making that air vibrate.

And then, those vibrations are interacting with other things I'm doing with my vocal tract. They're bouncing off the sides of my vocal tract. And as I change the shape of my vocal tract, I change what those vibrations are doing. Yeah, it's a complicated phenomenon. You end up creating this complicated waveform, which you can do Fourier analysis of and analyze it as a waveform that has a bunch of regular sine waves of various frequencies and amplitudes that are contributing to it. Yeah, and this is what you do when you do a Fourier analysis, yeah.

And what the spectrogram does is mark for you the frequencies that are making the greatest contribution to the general complicated air waveform. There are the darker parts. So these dark bands that you're seeing are what are called formants. And they are the things that are contributing the most to the sound.

As you can see, they're shifting as I shift from "ah" to "ee." So this formant down-- no, let's see. Can we see my cursor on this? Yes, this formant right here, you can see as I shift from "ah" to "ee," it goes up. Yeah? And this formant up here, as I shift from "ah" to "ee," it dips. So how far apart the formants are from each other is what distinguishes the vowels from each other.

You're hearing this difference in formants. You can do this for yourself. Here, I'm going to do another one. Hang on. "Wah."

Yeah, so here's another one. I didn't get a very good recording of that one. Try that again. "Wah." Well.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Hmm. Hmm. That's not doing what I'm expecting it to. Oh. Oh, I think I see what it's doing. It has to do with the fact that the microphone in my computer is lousy.

You can see the formant shifting for this one. Actually, you can't see them shifting all that much. But you can hear a formant shifting.

If you do the shift-- oh, no, wait. I think I can think of something that will show this better. Hang on just a sec. One more thing.

Stop. Stop. Stop. Let's try "ee-oo." There we go. That's better. So here, you can clearly see a formant going from up here to down here as I transition from "ee" to "oo." Is everybody seeing that? I'll play it again.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: I sound like a dolphin or something.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: Yeah, but as I switch from the "ee" to the "oo," you can see a formant descending, yeah. And you can hear that. If you do the-- so this is something that we were doing back when I was trying to convince you that vowels were worth categorizing, that the switch from "ee" to "oo" involves your tongue going from being front to being back, and also your lips going from being not rounded to being rounded, yeah.

And if you whisper that to yourself, so go [SLURPING], you might be hearing something descending in pitch. Are you hearing that? Just go [SLURPING]. And that's what you're hearing. It's that formant.

Yeah, by whispering, you're getting that to leap out at you. And you can hear it descending in pitch. Why is it descending in pitch? If you think about what you're doing, think about the inside of your vocal tract. As you go from "ee" to "oo," let's talk first about "oo."

So "ooh" ["u"] is a high, back rounded vowel. Was any of that surprising? Yeah? "Oo." So your tongue is high and bunched up in the back of your mouth. And your lips are rounded. Ooh. Yeah, that means that so what you're doing when you're making vowels is you're taking this column there that's in your vocal tract. And you're, depending on the vowel, making a partition somewhere that isn't complete.

You're not blocking off part of the tract. But you're putting your tongue in the way. So you're making part of that column of air narrower. Does that make sense? So for a high back rounded vowel, by bunching your tongue up toward the back of your mouth, you're making not a complete obstruction of the flow of air. There's still space for the air to flow past it. But you're making it narrower back there, yeah.

And when you make an "oo" by making a high back gesture with your tongue and by rounding your lips, you're creating a compartment for your vocal tract, which is as large as you can make it. Your lips are out there in front. And your tongue is as far back as it goes. Yeah, does that make sense? You're compartmentalizing off that top space of your vocal tract. And you're making that space as large as it can be.

As opposed to "ee" ["i"], where your lips are not rounded and your tongue is toward the front of your mouth. So that makes that space that you created for ooh. That makes that space collapse. It makes that space as small as it can possibly be because now your tongue is shoved up toward the front of your mouth. And your lips are not rounded. The space between your tongue and your lips is now as small as it gets. Yeah?

And that's why the transition from "ee" to "ooh" involves something descending in pitch. It's because you're going from a very small compartment with a little bit of vibration inside it to a large compartment with the same amount of vibration inside it because your vocal cords are vibrating at a constant rate. We're not-- you're not fooling around with pitch. Does that make sense?

So as you switch from a small compartment to a large one, one component of the very complicated things that make up this complicated waveform is descending in pitch because you're creating this little space that's getting larger, and by putting the same amount of energy to it, the molecules of air are not moving as fast. That's what we hear as a lower pitch. Does that make sense?

It's a way of talking about this, anyway. So encourage you to fool around with Praat. Let me just show you some consonants so that you can see what else you can do with Praat. We'll try another one here. "Bab. Dad. Gag." View that one.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: So here, I got the same vowel all three times. And you can see these nice clear bars in the middle. The difference has to do with what the consonants are on either side of the vowel. One of the things that this representation, this spectrogram, allows us to concentrate on, if you think about it, how do you tell the difference between "bab" and "gag"?

So we know articulatorially what the difference is. The difference is that, for "bab," you're making a bilabial stop. And for "gag," you're making a velar stop. But when you're hearing people make those sounds, how are you hearing what the difference is between a B and a G? Bear in mind that B and G are both stops. The flow of air is stopped, yeah, while you're making the sound. So while you're making the sound, you're not hearing things. Yeah?

The way you distinguish "bab" from "gag" is by looking at what it does to the vowel that's in between. You can see that these formants for the "ah" vowel, and remember that the vowel was the same in all three cases, it's especially clear for this last one. Here's "gag." And you can see that the formants, this format is smile-shaped. And this formant is frown-shaped. This one goes down as it goes close to the stop. And this one goes up as it goes close to the top.

As opposed to the bilabial, which is, if anything, slightly down on both sides. This is one of the things that makes speech perception so hard and that makes it so hard to get machines to understand speech. It's a problem that's more or less solved. But it's a hard problem because your speech is not just a sequence of sounds. It's a sequence of sounds that all influence each other. It's a mess in other words, yeah?

And the best cues for what sound you made at a particular point might not be at that point at all. They might be on neighboring points. That's how you find out what sound you're looking at. And that's what makes speech perception hard. It's also part of why-- so there are generalizations about the kinds of syllables that we find in the world.

There are plenty of languages out there in which it's OK for a syllable to start with a stop. Let's say you can have a syllable like "pa." That's an English word more or less. It's a word for father, "pa," but in which it's not OK to have a P followed by a fricative and then a vowel. So you don't have syllables like "psah," in English, or "pfah," yeah, or "pkah."

You can imagine that there are languages that allow syllables like that. But if a language is going to restrict its syllables, if it's only going to have one of these kinds, it's only going to have this kind. Or to put it another way, there are languages that have both of these. And there are languages that only have this. There aren't any languages that only have this, yeah?

And we can see why. The crucial cue to what, kind of, stop you're hearing, it comes from the vowel. So if you put a fricative in between the stop and the vowel, you deprive yourself of one of the big cues for figuring out what, kind of, stop you're listening to. And so it makes sense that we get this type of syllable everywhere. And the other type of syllable is only-- has a higher degree of difficulty, basically, as far as perception goes. Yeah, Joseph.

AUDIENCE: What effect does that have on [INAUDIBLE] especially.

NORVIN RICHARDS: Yeah.

AUDIENCE: For one example, where it's perfectly OK to string three stops in a row.

NORVIN RICHARDS: Yep.

AUDIENCE: Or at least two.

NORVIN RICHARDS: Yeah.

AUDIENCE: [INAUDIBLE] then you can just--

NORVIN RICHARDS: Right. So I've shown you the easiest way to figure out what a stop is, which is by looking at its effect on the nearby vowel. But you're absolutely right. There are languages out there that have strings of stops, strings of stops and fricatives. It absolutely happens. Russian has words like [RUSSIAN] it's got of a whole string of stops and fricatives at the beginning of a word, a beginning of a syllable.

The most famous examples of this are languages-- there are two kinds of languages that are especially famous for this. There's a Salish language called Bella Coola. The Salish languages are spoken in the Pacific Northwest.

Bella Coola, there's only one word of Bella Coola that I know. And it's this. So this is a uvular fricative, a voiceless uvular fricative. Anybody want to try to pronounce that? It's something like sauce.

[LAUGHTER]

It's the only thing I know how to say in Bella Coola. If I ever meet a Bella Coola, we'll have a very simple conversation. It means seal fat. And so here's a place where you hope there are other cues besides effects on vowels because there are no vowels in this word. Or the Berber languages of Northern Africa are famous for having sounds like this.

Here's the only word I know, the only word I know in [INAUDIBLE] Berber, which is spoken in Morocco. It means "you (feminine) sprained it." And it's something like [CLICKING]

Phonologists just get really interested in these languages for lots of reasons. One is the kind of thing Joseph is asking about, how do these people figure out what sounds they are hearing? And the answer has to be something like, yeah, there are lots of good cues on vowels.

But there are also cues on other kinds of things. And we have to figure out what they are, how-- what people are cueing in on. There are other questions too, like I was just talking about. Syllables, which is something we'll talk about as we get further into phonology. And the question is, are there any syllables in this word?

To which, the answer turns out to be yes. So if you look carefully at these languages, you can convince yourself that they have syllables, yeah. Sorry, very long answer to Joseph's question, to which the short version of the answer would be the best cues are on vowels. But there must be cues on other kinds of things as well, which are not as clear. All right? And it's a question of your level of tolerance for unclarity, yeah, or how good you are at picking up on those cues.

Cool. So Praat, was i going to do anything else with Praat? No, those were the things I was going to do with Praat. I will leave Praat up.

I think-- actually, we may be seeing Praat again pretty shortly. But I'll leave Praat on the website so you can play around with it at home. Going to full screen mode.

Oh, sorry. Go back out of screen mode. So we've just been talking about how you know what sounds it is that you are hearing. And some of the cues come from what's happening during the sound. And some of the cues come from neighboring sounds. And the study of this is one of the central studies of phonology and of phonetics.

I want to show you about another, kind of, information that we have, though. It's something called the McGurk effect. And I'll just demonstrate it to you. And then, we'll talk about it. This guy is going to repeat a syllable a couple of times. And then, when he's done, I'm going to ask you what syllable you heard. So here's the guy.

[AUDIO PLAYBACK]

- Bah. Bah. Bah. Bah. Bah. Bah.

[END PLAYBACK]

NORVIN RICHARDS: I'm going to turn up the volume and do that again so you can hear it better.

[AUDIO PLAYBACK]

- Bah. Bah. Bah. Bah. Bah. Bah. Bah. Bah. Bah. Bah. Bah. Bah.

[END PLAYBACK]

NORVIN RICHARDS: How many of you heard a "bah"? How many of you heard a "da"? How many of you heard a "gah"? Several of you are raising your hand several times.

[LAUGHTER]

You're just not sure what you heard? Or you thought you heard several things at once? Yeah, you thought you heard several things at once. So there's something very confusing going on. I'm going to play it again. And I want you to close your eyes.

AUDIENCE: [INTERPOSING VOICES]

NORVIN RICHARDS: Everybody got your eyes closed?

[AUDIO PLAYBACK]

- Bah. Bah. Bah. Bah. Bah. Bah.

[END PLAYBACK]

NORVIN RICHARDS: I'll put the link so that you can play with this at home. But here's what's happening. You're hearing a recording of "bah." That's what he's doing. He's saying "bah." But the "bah" is being carefully timed together with a video of him saying "gah".

[LAUGHTER]

And so you can only tell that it's "bah" if you don't look at him.

[LAUGHTER]

So if your eyes are closed, you hear it as "bah," yeah? But if your eyes are not closed, if you look at him-- you should try this at home maybe if you're on a better quality screen. The illusion becomes fairly clear. People generally report that they're hearing "dah," which is neither what they are seeing or what they are hearing, yeah?

So what this is teaching us is that although there's all this complicated phonology going on, all of these things that you do to try to figure out the speech signal, you are also paying attention to what you see. So apparently, what's going on here, again, the recording is of "bah." But you're looking at this guy. And he's clearly not saying "bah" because his lips are not closing.

And apparently, the evidence of your eyes is enough to convince your brain to ignore your ears when it's trying to figure out what you're hearing, yeah. So the cause of the illusion is that because you can see that he's not making a bilabial closure, your brain is rejecting the hypothesis that it's a bilabial closure and trying to come up with the closest sound that it can. And you end up with confusion. Yeah?

AUDIENCE: So then, what would language acquisition look like in individuals who are born blind?

NORVIN RICHARDS: Yeah, so that's a really good question. I don't know whether there's any work on that, that question of whether the McGurk effect has anything to say about that. We obviously can get along just fine without seeing the people that we're talking to. We can talk to people on the phone and all kinds of things.

But we are apparently geared to pay so much attention to visual input that it actually overrides the evidence of our ears. And it's a very powerful effect. I know what's going on. And it happens to me. You know what's going on now. Then it will happen to if you watch this again. Again, I'll put the link up. And you can amaze your friends with it.

It's a very robust phenomenon. It's been demonstrated for a bunch of different sounds and in a bunch of different languages. It's not just an English thing. It's all over the place.

Now, am I done with other things? Well, now I am about to start talking about something which is pretty complicated. And so I'll just give you-- yeah, so I'll tell you briefly what I'm going to talk about next time.

And we'll just start with this next time because I don't think we have time to talk about this in any detail. We've been talking-- well, here, let me show you something. And then we'll talk more about it next time.

Back to Praat. "Pie. Bye. Spy." Ah, darn. I failed to save that. Hang on just a second. Pi. Bye. Spy. So that's me saying "pie, bye, spy."

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: I'm sorry, the-- everything is up again. So here's-- let's just listen to "pie." Actually, let's just look at "pie." Can I do that? Come on, you.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: So that's the spectrogram of me saying "pie." And you can see-- here, I'll use my cursor instead. What's going on here, my-- here's the stop. And then, this little burst is my lips opening. And then, there's a little burst of white noise. And then, we start in on the vowel. And you can see the formants, the black bars that indicate that we're doing a vowel.

This little burst of white noise is the period that elapses in between my lips opening and my vocal chords beginning to engage. So there's this period where there's nothing coming out of my lungs but air. There's always air coming out of my lungs. Let me try that again. There's nothing coming out of my vocal tract but air. Yeah?

My vocal chords aren't vibrating yet. And it's not long. It lasts some fraction of a second. How long does it last? It lasts-- who cares how long it lasts? Do I care? Do I care long enough to find out? It lasts less time than that. It lasts 0.06 seconds. Yeah, there we go. So that's what's going on in "pie." Now let's look at "spy."

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: And you can see-- and actually, allow me to let you hear. So here's the "s." This is what fricatives look like, these bursts of light and noise. Lots more energy up here for the "s." Here's the stop. You can see what stops look like. It's blank. Here are my lips opening for the end of the stop. And let's just play it starting with the stop.

[AUDIO PLAYBACK]

[END PLAYBACK]

NORVIN RICHARDS: How many of you hear that as "pie"? How many of you here it as "bye"? Yeah, so this is a non-aspirated voiceless stop. So my lips are opening. And then, my vocal cords get busy right away. You can see there isn't a big gap right in between the "p' and what's happening after it.

So we will talk more about this next time. But this is what's called aspiration. English has aspiration in some places, but not in others. So we'll do this demonstration again next time. And then, we'll talk about what it means. So for now, I think we're done unless anybody has any questions about any of this. All right. See you not on Tuesday, but on Thursday. So we don't have class on Tuesday.