The Science behind Stellar Voice Operation:

avoiding that darn "again please?" with linguistic know-how

Pamela Toman, KB9SCM ◆ 14 September 2012

prepared for the Vienna Wireless Society

Topics

- The Science Behind Spoken Language
  - What sort of acoustic information is transmitted through the radio?
  - Why are vowels so important?
  - What is the physiology connecting articulation and clear acoustic patterns?
- Implications for Phone Operation
  - Why do we need an international phonetic spelling alphabet?
  - Why does the Alpha/Bravo alphabet work (or not)?
  - What is the most common sound you never noticed?
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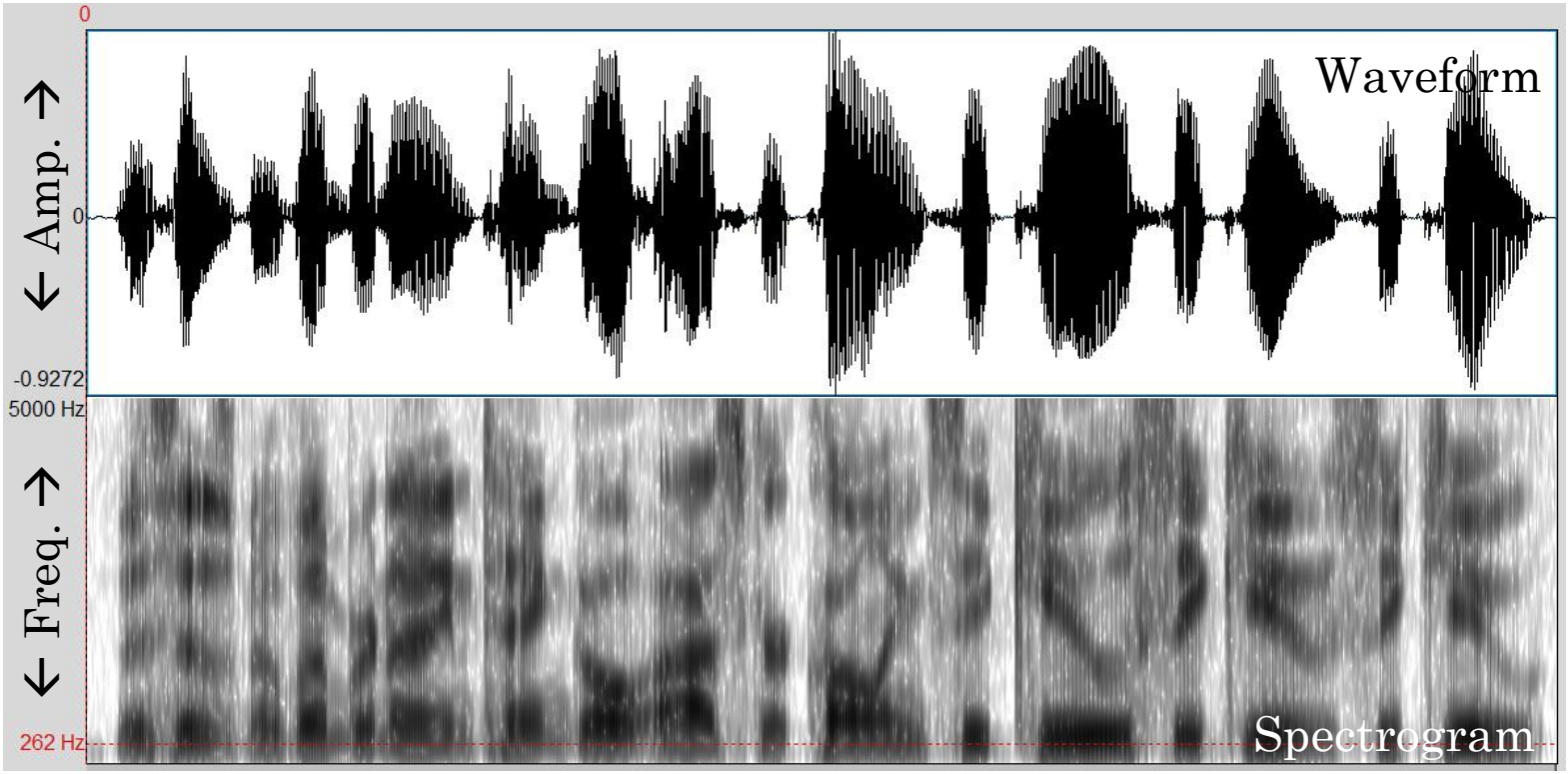
Voices are complex

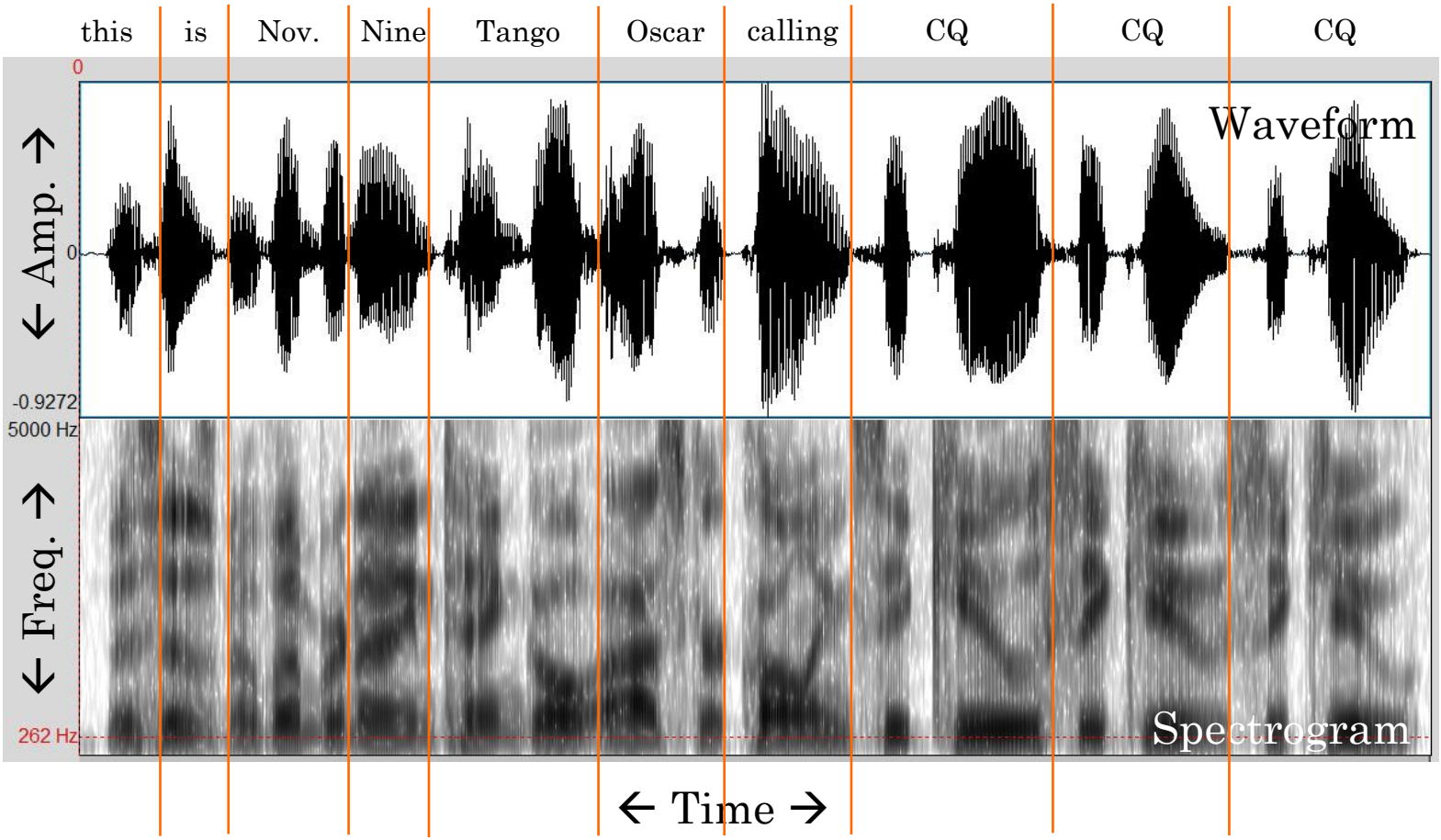
- "This is November Nine Tango Oscar calling CQ CQ CQ."



CQ – Invitation for anyone to respond

There is nothing in the audio signal that indicates when words begin and end

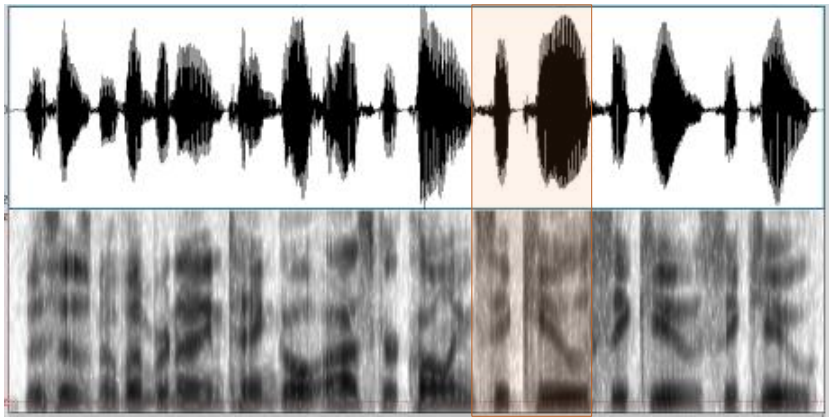
- "This is November Nine Tango Oscar calling CQ CQ CQ."

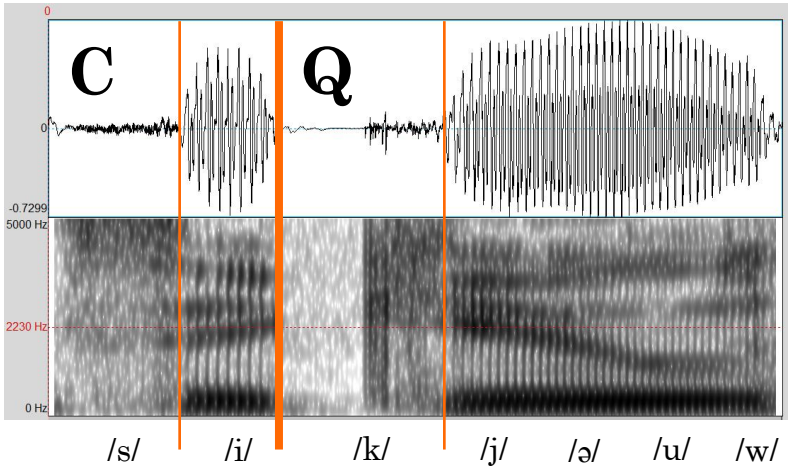


CQ – Invitation for anyone to respond

Vowels are a major part of the audio signal

- Vowels are resilient to noise on the air:
  - Vowels are loud
  - Vowels fill time
  - Vowels have structure (called formants)
  - Consonants lack that sort of structure
  - Consonants alone often sound like nothing or like fuzzy friction (noise)

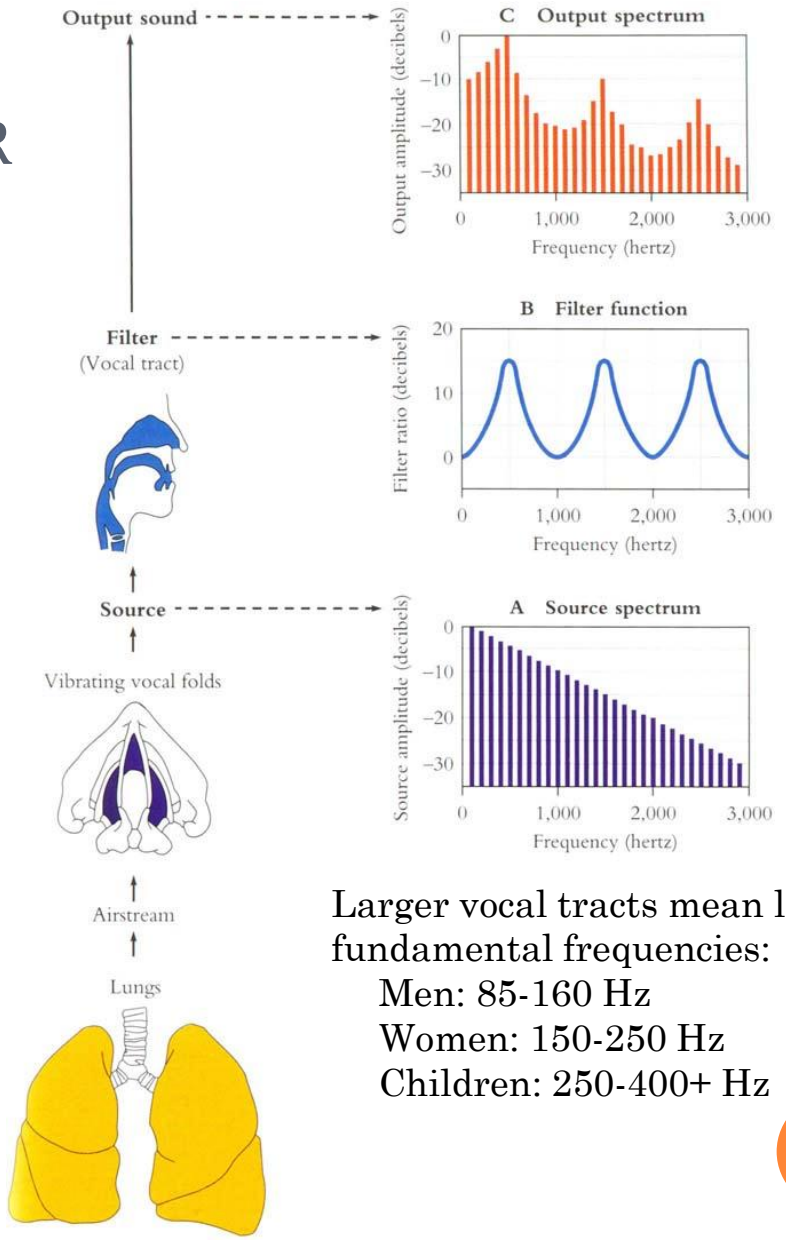




* Some consonants can be important in these ways too

Physically, the vocal tract is like a resonator

- Your voice has a power supply, oscillator and filter
  - The lungs are a power supply: the more air, the more sound
  - Vocal folds oscillate to produce the voice's fundamental frequency (and its harmonics)
  - Particular arrangements of the vocal tract (throat, oral cavity, tongue, lips, nasal cavity) filter the sound in particular ways
- Additionally there is a (largely unconscious) feedback loop between ears, lungs, and vocal folds



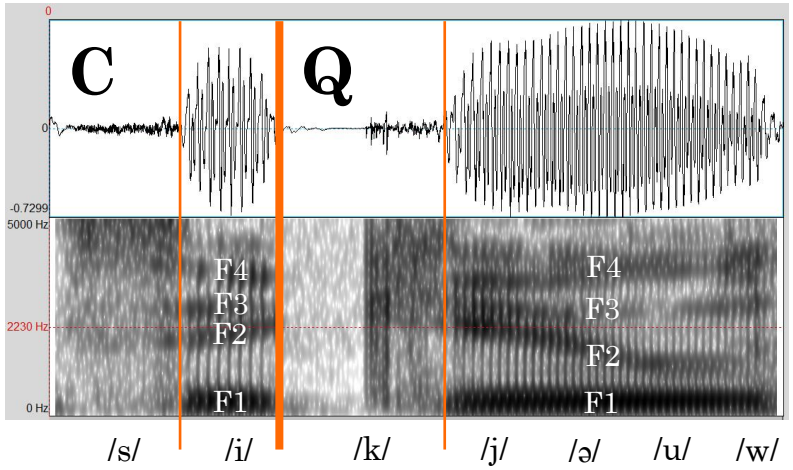
Larger vocal tracts mean lower fundamental frequencies:

Men: 85-160 Hz
Women: 150-250 Hz
Children: 250-400+ Hz

Diagram from: http://www.uni-bielefeld.de/lili/personen/vgramley/teaching/HTHS/acoustic_2010.html

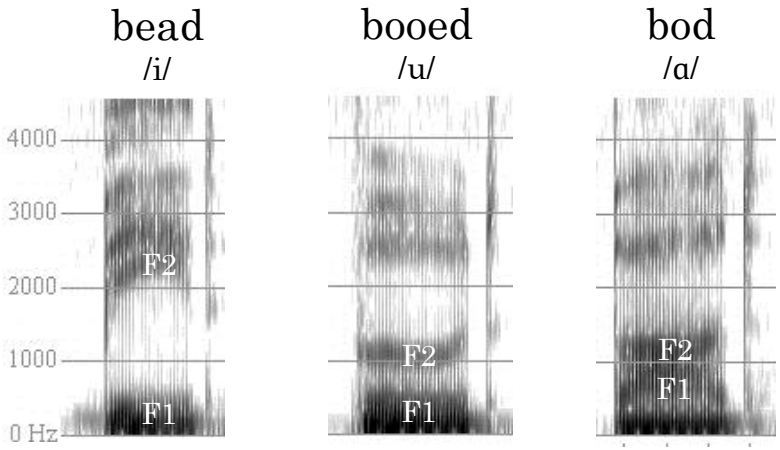
The vocal filter resonates at characteristic frequencies for each vowel

- The strongest resonant frequencies in a vowel are its formants
- Vowels almost always have 4+ distinguishable formants
  - The first two formants disambiguate vowels (~200-2500 Hz)
  - The third, fourth and higher formants define vocal timbre
- Tongue, jaw and lip positions determine the formants' frequencies

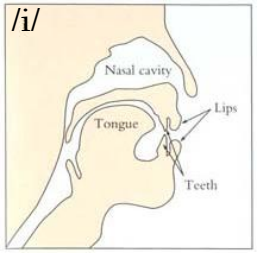


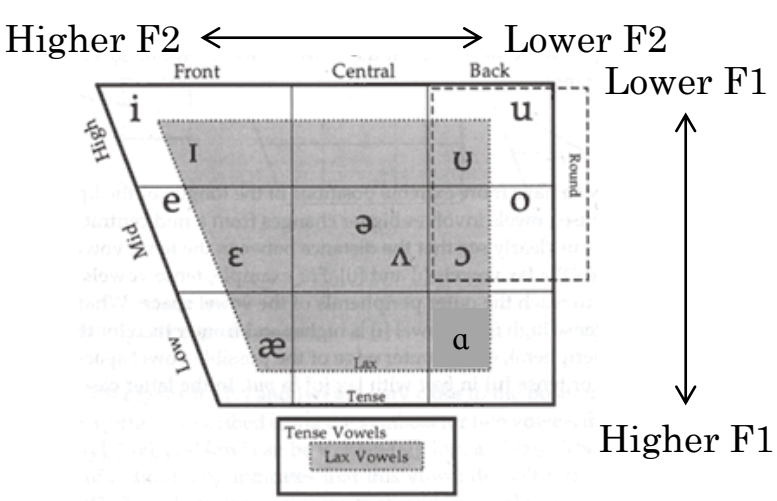
Filtering means listeners essentially "hear" the position of the speaker's tongue

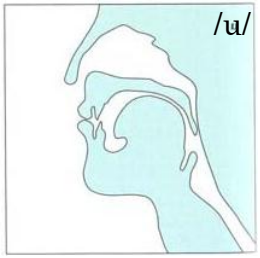
Acoustics:

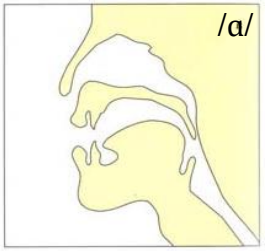


Articulation:









Operating take-aways: Enunciate to help your listeners

- When at the mic:
  - Use clear vowels – they make up the majority of what we hear, and they are more resilient to noise on the air
  - Move your articulators; remember: *people can hear your tongue*
  - Keep a clear cadence to help differentiate words and call letters despite the continuous nature of speech
  - Don't artificially insert spaces in your speech
- In your downtime:
  - Record and listen to yourself (for vowels and for mic usage)
- When receiving:
  - Listen for cues in cadence and intonation
  - Consider giving (respectful) feedback on lousy audio

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Spelling aloud can be very confusing, so we often use full words

- Traditional spelling only uses one vowel per letter
- Distinguishing letters on the basis of a single vowel is hard
  - The only distinguishing feature may be the consonant itself
  - The consonant may be overwhelmed by noise

	Same letter	**Different letters**
Same vowel sound	*Not Confusing (Clear Match)*	Spanish "i" vs. English "e" English: d, t, p, b, v, c, z, e, g a, k, j
Different vowel sounds	Spanish "d" vs. English "d"	*Not Confusing (Clear Mismatch)*

- We often use full words to help overcome the inherent confusion

Not all words are equally good for international phonetics

- It is much easier to choose bad full words than good ones
  - Good international phonetics should be pronounceable and understandable by a large portion of the world
  - But only a few sounds are very common (*m, k, j [y], p, i, a, u*)
- Which sounds (and thus words) are easy to hear and pronounce depends enormously on what language pathways are active in one's brain
  - Some necessary sounds may not exist
  - Some necessary sounds may not be allowed in particular positions
  - Some necessary sounds may not be recognized as distinct
- Further complicating the situation, some sounds are inherently hard to learn
  - English has many sounds and clusters that are tricky for non-natives (e.g., "r", "th", "ch", "tt", *should, little, strength, clothes, sixth*)
  - Many of these are also troublesome for young native speakers

Not all words are equally good for international phonetics (tangible examples)

- Challenges for Americans speaking other languages include:

	Sounds do not exist	Sounds are disallowed in particular positions	Sounds are not recognized as distinct
Example word:	*3alam* (علم)	*zehn*	*pot* and *spot*
Language:	Arabic	German	English
Word meaning:	flag, sign	ten	pot; spot
Explanation:	sounds similar to an */a/* – but is a pharyngeal consonant	a */ts/* cluster – very common in English, but never allowed to begin a word	very different */p/*s – other languages treat them as distinct consonants

- Analogous challenges face non-native speakers using English terms (including English phonetics)

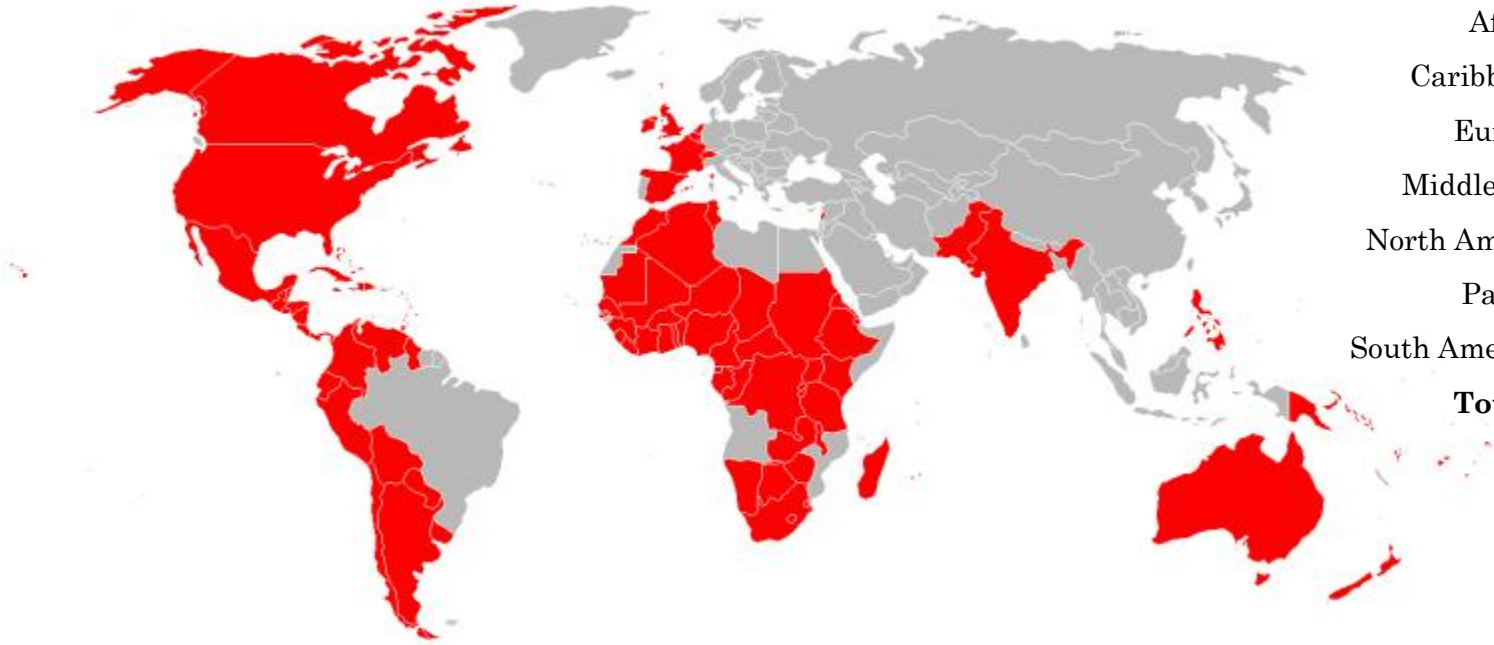
The Alpha/Bravo alphabet was developed to alleviate spelling problems

- The need for an international phonetic alphabet was recognized in the late 1940s, given increasing international air travel and telecommunications
  - After WWII, people had somewhat standardized on variants of the Able/Baker alphabet
  - However, some sounds were unique to English
  - Individual regions developed their own phonetic alphabets
- Between 1947 and 1956 the first international alphabet was developed (Alpha/Bravo)
  - Users were initially dissatisfied with the ease of term confusion
  - Tested with 31 nations; replaced 5 words (e.g., “metro”)
  - Final version was implemented 1 March 1956 by ICAO; other organizations followed through the late 1950s

NATO – North Atlantic Treaty Organization
ICAO – International Civil Aviation Organization
ITU – International Telecommunications Union

Alpha/Bravo phonetics cover a large portion of the world

- Alpha/Bravo phonetics were designed for native French, Spanish, and English speakers using English
  - Colonial history means these languages cover most of the world
  - Alpha/Bravo phonetics are less useful for other languages



Asia: 4	12.9%
Africa: 45	80.36%
Caribbean: 21	95.45%
Europe: 11	22.92%
Middle East: 1	4.76%
North America: 3	75%
Pacific: 14	70%
South America: 10	76.92%
Total: 109	**50.46%**

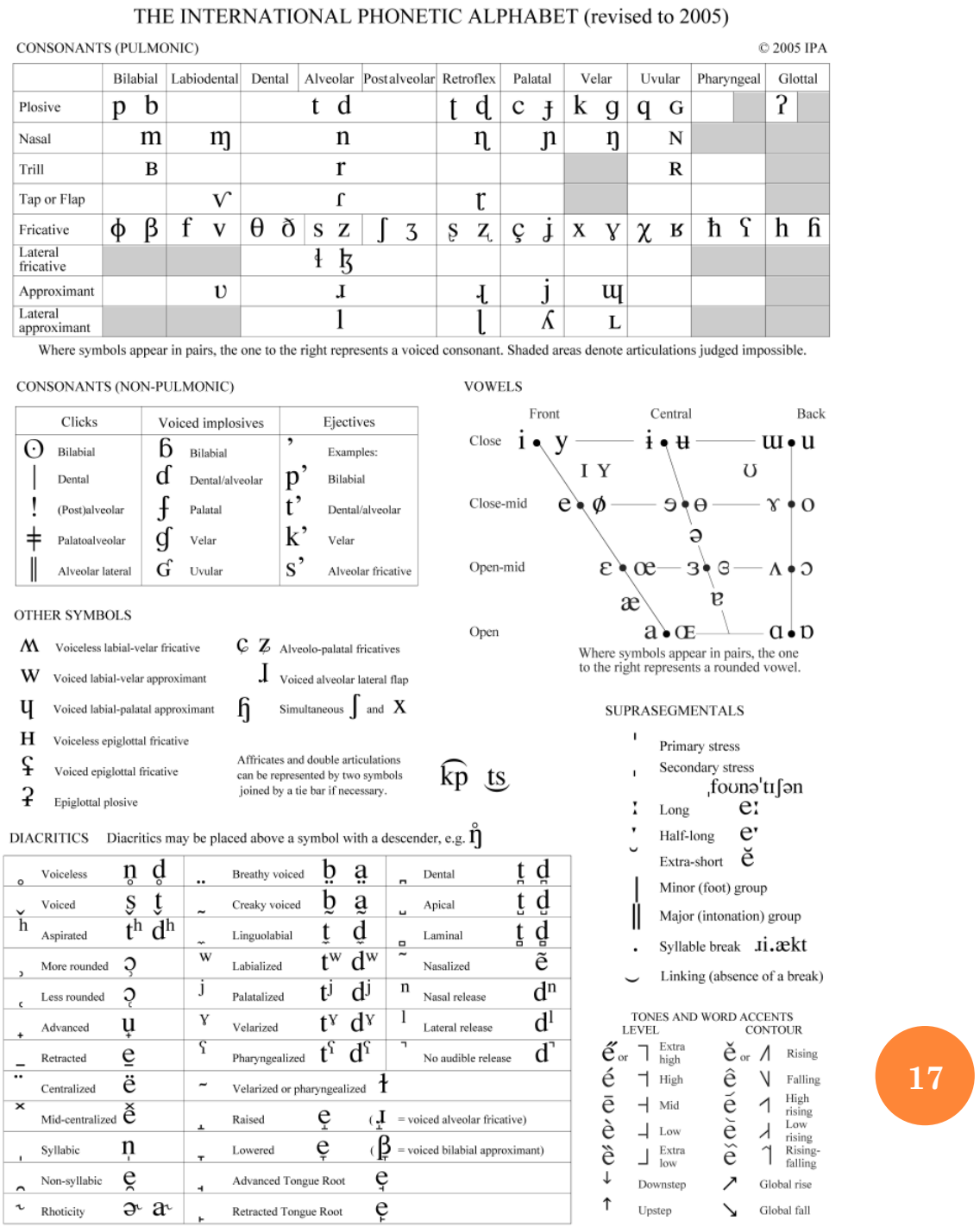
English/French/Spanish: de jure, official, or very commonly used

The Alpha/Bravo NATO Phonetic Alphabet uses a consistent word for every letter

A	Alfa	/ˈælfɑ/	ˈæ-ɑ	O	Oscar	/ˈɑskər/	ˈɑ-ər
B	Bravo	/ˈbrɑːvoʊ/	ˈɑː-oʊ	P	Papa	/pɑːˈpɑː/	ɑ-ˈɑ
C	Charlie	/ˈʧɑrliː/	ˈɑr-i	Q	Quebec	/kɛˈbɛk/	ɛ-ˈɛ
D	Delta	/ˈdɛltɑ/	ˈɛ-ɑ	R	Romeo	/ˈroʊmiːoʊ/	ˈoʊ-i-oʊ
E	Echo	/ˈɛkoʊ/	ˈɛ-oʊ	S	Sierra	/siːˈɛrɑː/	i-ˈɛr-ɑ
F	Foxtrot	/ˈfɑkstrɑt/	ˈɑ-ɑ	T	Tango	/ˈtæŋgoʊ/	ˈæ-oʊ
G	Golf	/ˈgɔlf/	ˈɔ	U	Uniform	/ˈjuːniːfɔrm/	ˈu-i-ɔr
H	Hotel	/hoʊˈtɛl/	oʊ-ˈɛ	V	Victor	/ˈvɪktər/	ˈɪ-ər
I	India	/ˈɪndiːɑː/	ˈɪ-i-ɑ	W	Whiskey	/ˈwɪskiː/	ˈɪ-i
J	Juliett	/ˈʤuːliːɛt/	ˈu-i-ɛ	X	X-ray	/ˈɛksreɪ/	ˈɛ-eɪ
K	Kilo	/ˈkiːloʊ/	ˈi-oʊ	Y	Yankee	/ˈjæŋkiː/	ˈæ-i
L	Lima	/ˈliːmʌ/	ˈi-ʌ	Z	Zulu	/ˈzuːluː/	ˈu-u
M	Mike	/ˈmaɪk/	ˈaɪ				
N	November	/noʊˈvɛmbər/	oʊ-ˈɛ-ər				

THE IPA IS DIFFERENT

- The International Phonetic Alphabet contains every sound in world languages
  - Each language only uses a subset of sounds
  - Shaded areas are believed to be physically impossible
- This is not the same as the Alpha/Bravo alphabet!



Phonetics work on multiple levels

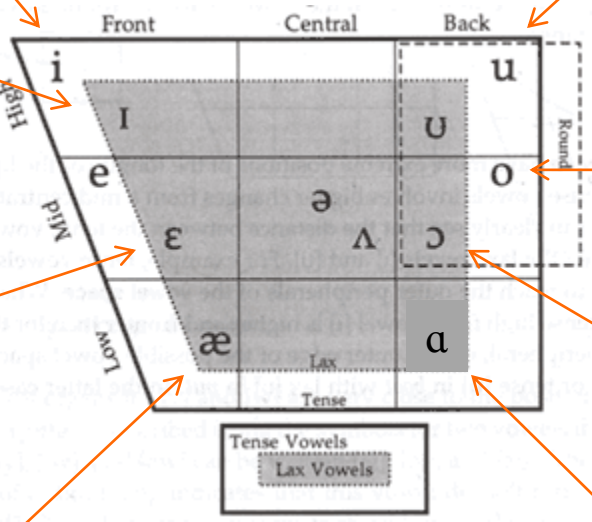
- Which description fits you best?

  When copying phonetics in bad conditions…
  - *I listen primarily for the first letter of each word*
  - *I listen primarily for something else*

- If you listen primarily for something else, what do you listen for?

The Alpha/Bravo Alphabet uses patterns in vowel qualities to improve communication

Kilo	ˈi-oʊ
Lima	ˈi-ʌ
Sierra	i-ˈɛr-ɑ
Victor	ˈɪ-ər
Whiskey	ˈɪ-i
India	ˈɪ-i-ɑ
Echo	ˈɛ-oʊ
Delta	ˈɛ-ʌ
Quebec	ɛ-ˈɛ
X-ray	ˈɛ-eɪ
Tango	ˈæ-oʊ
Alfa	ˈæ-ʌ
Yankee	ˈæ-i



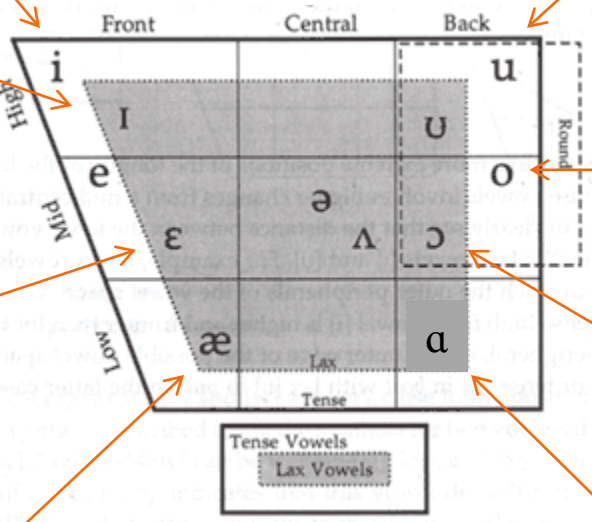
Zulu	ˈu-u
Uniform	ˈu-i-ɔr
Juliett	ˈu-i-ɛ
Hotel	oʊ-ˈɛ
November	oʊ-ˈɛ-ər
Romeo	ˈoʊ-i-oʊ
Golf	ˈɔ
Bravo	ˈɑ-oʊ
Papa	ɑ-ˈɑ
Foxtrot	ˈɑ-ɑ
Oscar	ˈɑ-ər
Charlie	ˈɑr-i

Each word is mapped to a section on the vowel chart by its first syllable. Within each section, words are ordered from "most back" to "most front".

Mike ˈaɪ

The five terms replaced in the Alpha/Bravo alphabet were especially confusing

	Kilo	ˈi-oʊ
	Lima	ˈi-ʌ
	Sierra	i-ˈɛr-ɑ
	Victor	ˈɪ-ər
	Whiskey	ˈɪ-i
	India	ˈɪ-i-ɑ
(Metro ⇒)	Echo	ˈɛ-oʊ
(Extra ⇒)	Delta	ˈɛ-ʌ
(Nectar⇗)	Quebec	ɛ-ˈɛ
	X-ray	ˈɛ-eɪ
	Tango	ˈæ-oʊ
	Alfa	ˈæ-ʌ
	Yankee	ˈæ-i

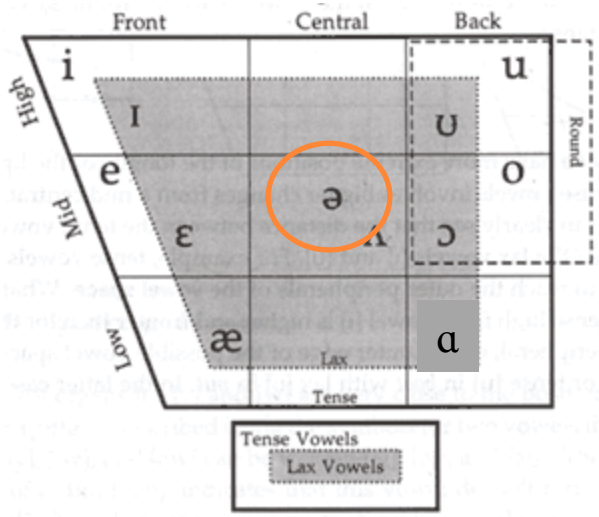


	Zulu	ˈu-u
	Uniform	ˈu-i-ɔr (⇐ Union)
	Juliett	ˈu-i-ɛ
	Hotel	oʊ-ˈɛ (⇐ Coca)
	November	oʊ-ˈɛ-ər
	Romeo	ˈoʊ-i-oʊ
	Golf	ˈɔ
	Bravo	ˈɑ-oʊ
	Papa	ɑ-ˈɑ
	Foxtrot	ˈɑ-ɑ
	Oscar	ˈɑ-ər
	Charlie	ˈɑr-i
	Mike	ˈaɪ

Each word is mapped to a section on the vowel chart by its first syllable. Within each section, words are ordered from "most back" to "most front".

The Alpha/Bravo phonetics only use vowels at the edges of the mouth

- None of the terms use the central mid vowel ə



- The schwa (ə) is a ubiquitous vowel:
  - *She sat in a chair.*
  - *She sat on a chair.*

The common central vowel (schwa) is meaningless among noise

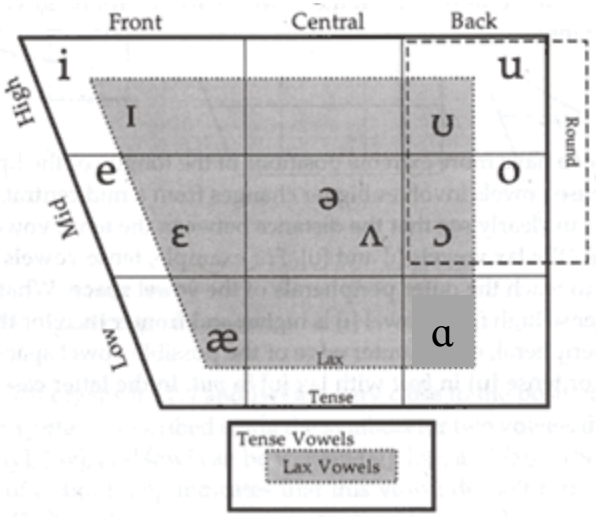
- Schwa is our most common vowel sound, used in:
  - Unstressed syllables (*emphasize*)
  - Function words in flowing speech (*the*, *a, on*)
- Schwa is perfectly acceptable in daily conversation
  - Usually both consonants and context are available
  - Precise articulation is unnecessary effort
- However, good enunciation includes avoiding excessive use of schwa
- Pronunciation of true vowels is especially important on the radio
  - Schwa is fast and hard to hear
  - Schwa does not signify any particular words

Some speakers distinguish fewer vowels

- Foreign speakers (and even some of us) may not make all the distinctions on the previous chart
  - Spanish and French only have /i/ – not /ɪ/
    (*beat* vs. *bit*)
  - Many US speakers only have /ɑ/ – not /ɔ/
    (*cot* vs. *caught*)
  - British and Australian accents are non-rhotic
    (no /r/ sound in syllable positions like *hard* and *butter*)
- It can be harder to copy operators who don't/can't distinguish as many vowels
- Awareness of accents helps operators to compensate

TV AND RADIO BROADCASTERS ARE VERY AWARE OF THEIR ACCENTS – WE CAN BECOME AWARE TOO

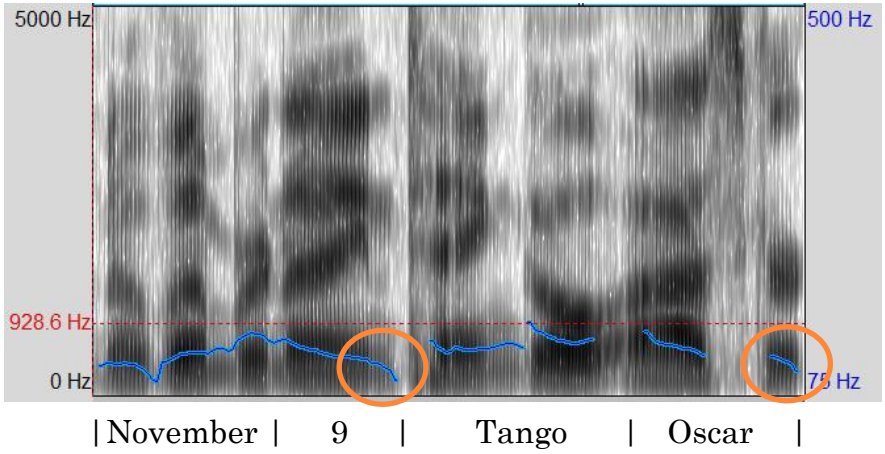
- Caught-cot
- On-dawn-don
- Pin-pen
- Mary-marry-merry-Murray
- Roof-book-tooth
- Father-bother
- Horse-hoarse
- Pour-poor
- Eight-eat
- Sad-mad
- Curl-coil

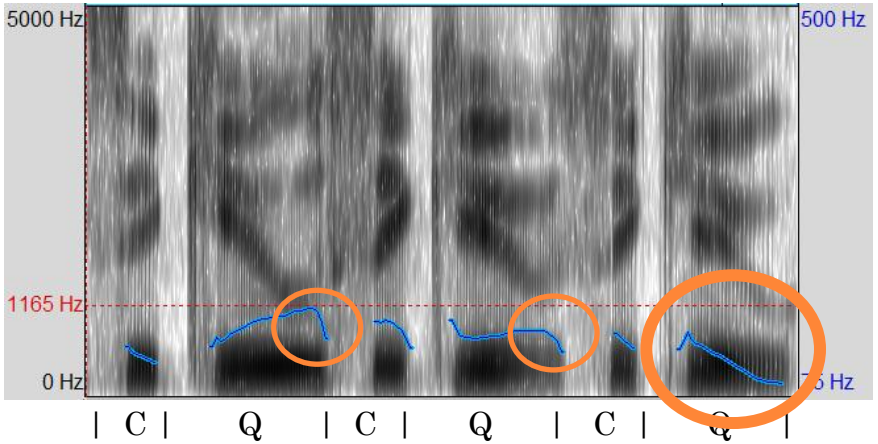


Whether you pronounce the vowels on each line the same or differently, someone from a different region does the opposite.

Pitch is an important signal for managing turn taking on the air

- Pitch falls:
  - At the end of a statement or turn
  - At the end of list
- Pitch rises:
  - To indicate incompleteness (e.g., in a list or a question)
  - At the main point of a statement/sentence
- "Over" is rarely necessary – intonation already carries that information





Common trigger words also help control turn taking

- Certain trigger words also indicate a switch in speaker:
  - "QRZ"
  - "CQ" (with falling pitch)
  - "… [from] <my callsign>" (with falling pitch)
  - "QSL?"
  - "Thanks for the contact."
- These may be recognizable from their vowel and pitch patterns (even when the operator is in the noise)

QRZ – Q code for "who is calling me?"
CQ – Invitation for anyone to respond
QSL – Q code for "receipt confirmed"

Operating take-aways: How to use the phonetic alphabet effectively

- When at the mic:
  - Take into account the incoming signal strength – there may be no need for phonetics
  - Use the expected Alpha/Bravo terms (not Able/Baker or your own version)
  - Enunciate, especially in confusable unstressed syllables
  - Focus on producing the vowel patterns, the initial consonant, and the stress
  - If you aren't being copied, repeat using alternative (but preferably common) terms
- When receiving:
  - Know the Alpha/Bravo terms
  - Listen to the patterns in vowels
  - Be familiar with phonetic alphabets other than Alpha/Bravo

Operating take-aways: How to use linguistic features to your advantage

- When at the mic:
  - Be aware of your accent – does it add redundancy or uncertainty?
  - Use falling intonation to signal intent to release the PTT (and rising intonation to signal intent *not* to release the PTT)
- When receiving:
  - Take into account the other operator's accent
  - Listen for cues in cadence and intonation

PTT – Push-to-talk (button on radio)

Questions?

- Contact information:
  - Pamela Toman, KB9SCM
  - <email form available on pamelatoman.net>

Take-aways:

- Vowels come through even in very noisy conditions
- Avoid the evils of the lackadaisical tongue/schwa!
- The Alpha/Bravo alphabet often works
  - It is internationally pronounceable/understandable
  - People expect it
  - It uses redundancy of information (first letter + vowel patterns)
  - It encourages speakers to think about enunciation
  - Good operators know to switch when it is unsuccessful
- Pitch can be very useful for managing who is speaking