



# **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*

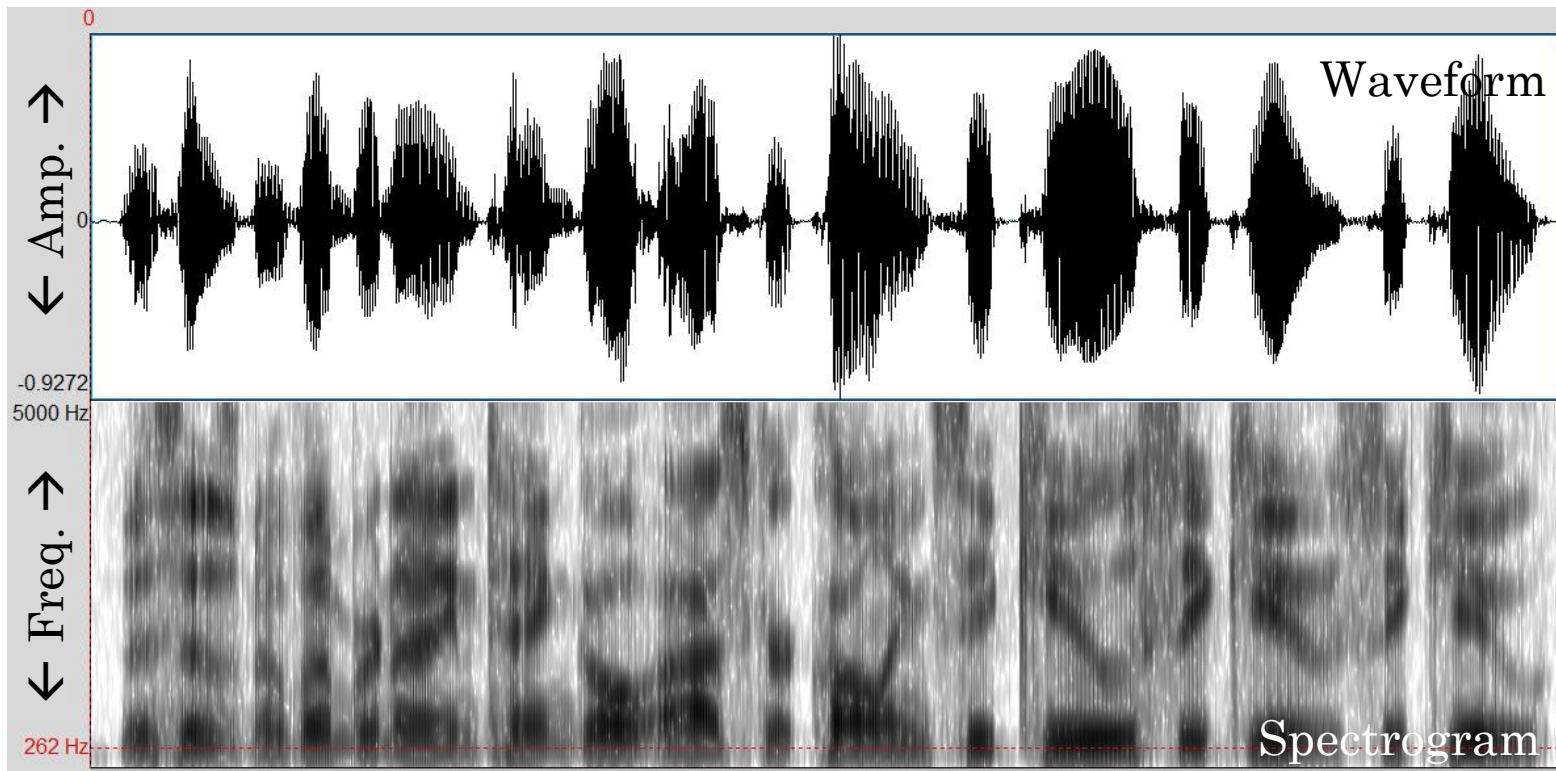
# TOPICS

- 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?
  - What effect do accents have on how we communicate?
  - How can you clearly signal that you are (not) ready for the other guy to talk?
- Contact

# VOICES ARE COMPLEX



- “This is November Nine Tango Oscar calling CQ CQ CQ.”

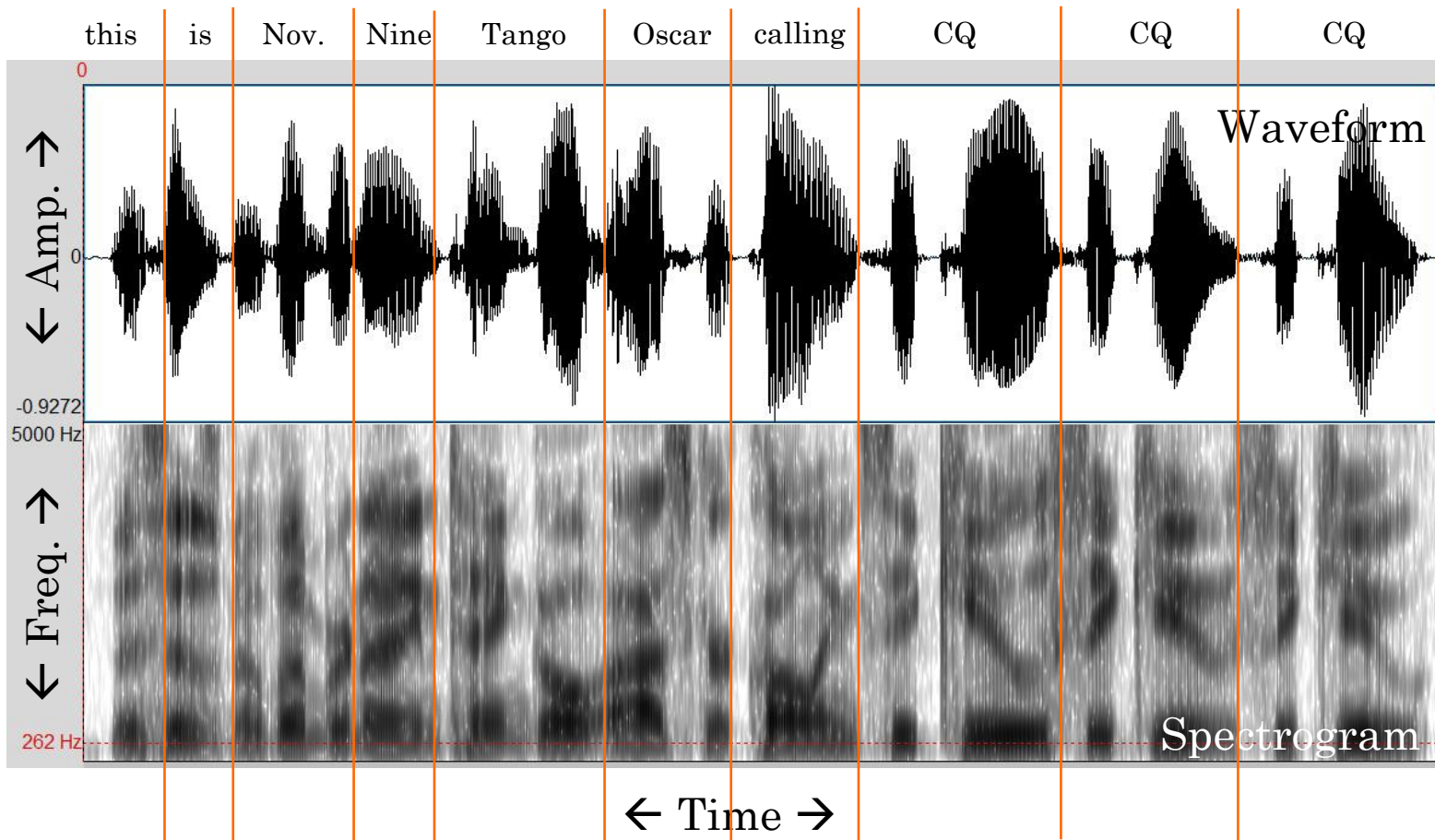


← Time →

# THERE IS NOTHING IN THE AUDIO SIGNAL THAT INDICATES WHEN WORDS BEGIN AND END



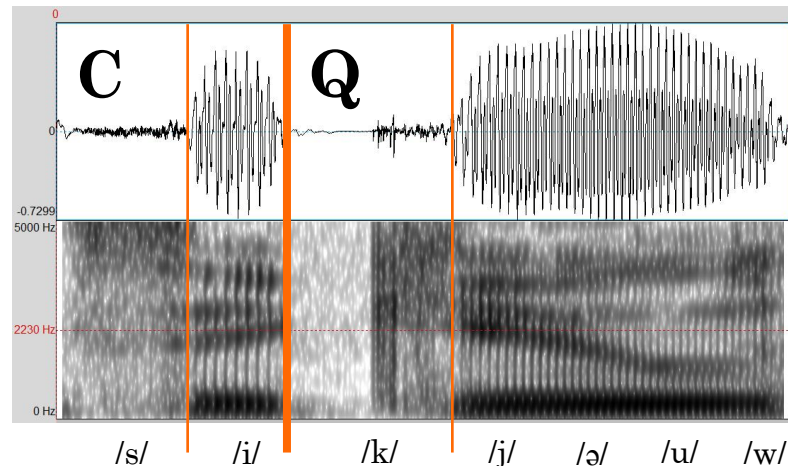
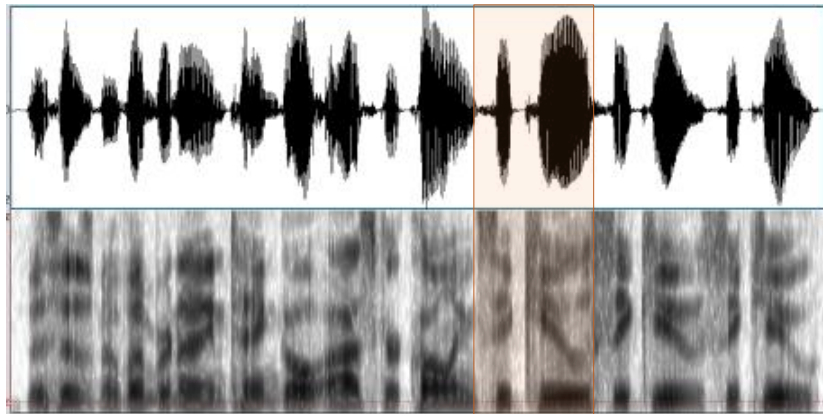
- “This is November Nine Tango Oscar calling CQ CQ CQ.”



CQ – Invitation for anyone to respond

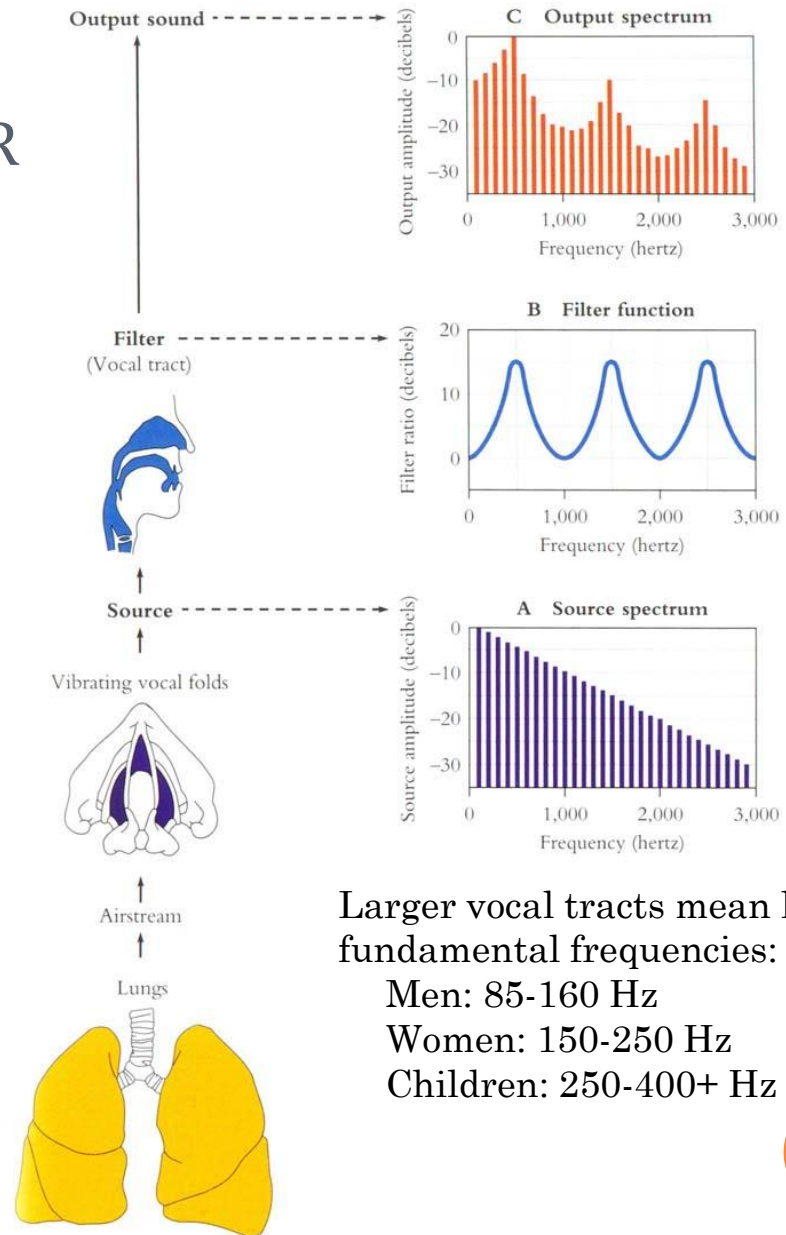
# VOWELS ARE A MAJOR PART OF THE AUDIO SIGNAL

- 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)



# PHYSICALLY, THE VOCAL TRACT IS LIKE A RESONATOR

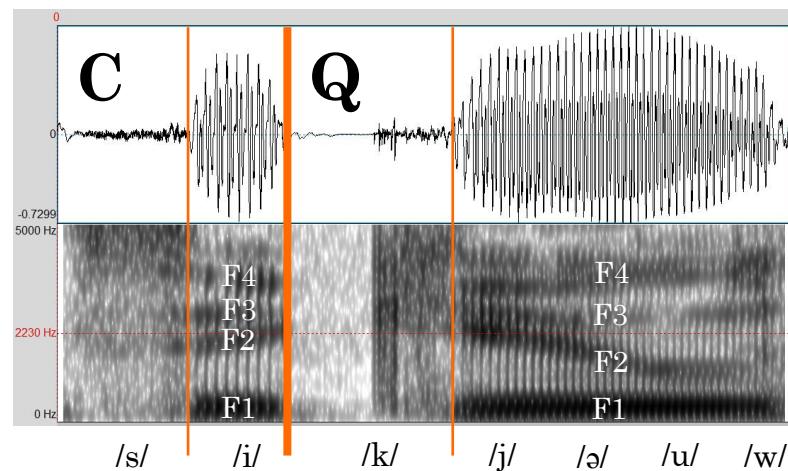
- Your voice has a power supply, oscillator and filter
  - The lungs are a power supply: the more air, the more sound
  - Vocal folds oscillate to produce the voice's fundamental frequency (and its harmonics)
  - Particular arrangements of the vocal tract (throat, oral cavity, tongue, lips, nasal cavity) 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

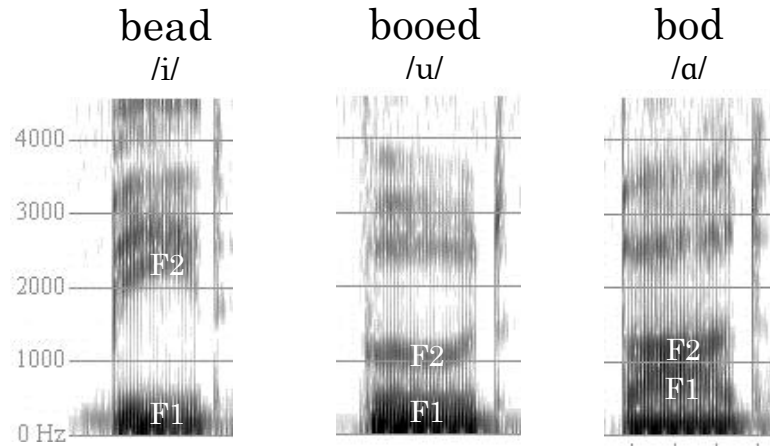
# THE VOCAL FILTER RESONATES AT CHARACTERISTIC FREQUENCIES FOR EACH VOWEL

- 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

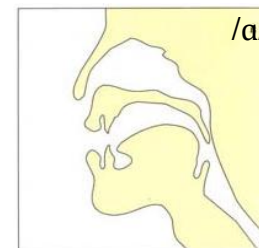
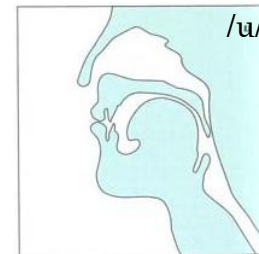
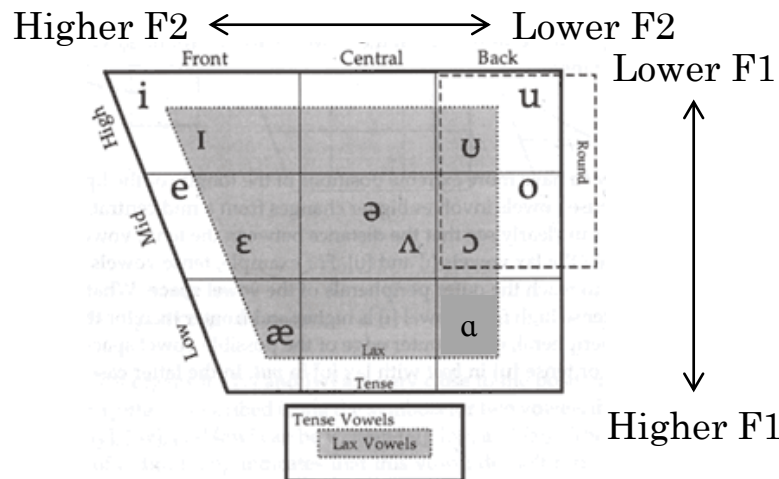
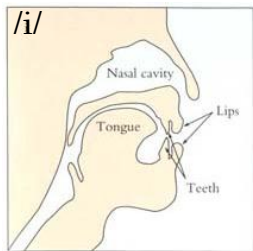


# FILTERING MEANS LISTENERS ESSENTIALLY “HEAR” THE POSITION OF THE SPEAKER’S TONGUE

## 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

# TOPICS

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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	<i>Not Confusing (Clear Match)</i>	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”	<i>Not Confusing (Clear Mismatch)</i>

- 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:	<i>ʔalam</i> (علم)	<i>zɛhn</i>	<i>pot</i> and <i>spot</i>
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)

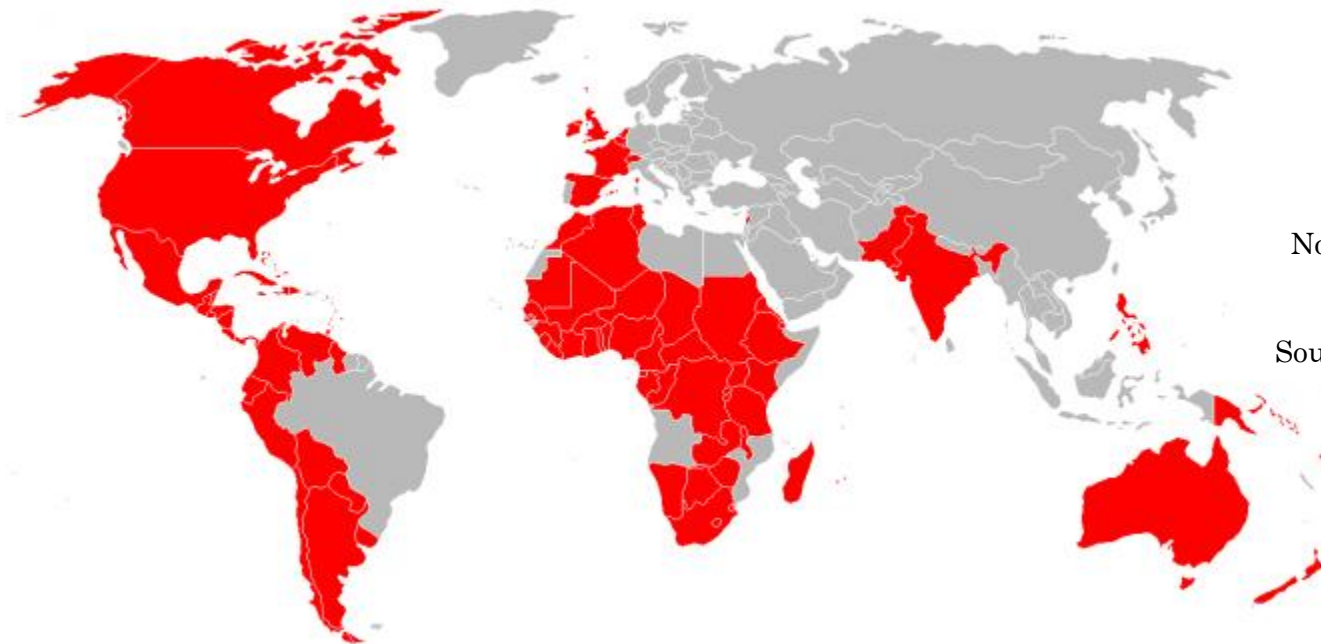
# THE ALPHA/BRAVO ALPHABET WAS DEVELOPED TO ALLEVIATE SPELLING PROBLEMS

- 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%
<b>Total: 109</b>	<b>50.46%</b>

# THE ALPHA/BRAVO NATO PHONETIC ALPHABET

## USES A CONSISTENT WORD FOR EVERY LETTER

A	Alfa	<u><i>/'ælfʌ/</i></u>	'æ-ʌ	O	Oscar	<u><i>/'askər/</i></u>	'ɑ-ər
B	Bravo	<u><i>/'brɑ:vou/</i></u>	'ɑ:-ou	P	Papa	<u><i>/pa:'pa:/</i></u>	ɑ-'ɑ
C	Charlie	<u><i>/'tʃɑ:li:/</i></u>	'ɑr-i	Q	Quebec	<u><i>/kɛ'bɛk/</i></u>	ɛ-'ɛ
D	Delta	<u><i>/'dɛltʌ/</i></u>	'ɛ-ʌ	R	Romeo	<u><i>/'roumi:ou/</i></u>	'ou-i-ou
E	Echo	<u><i>/'ɛkou/</i></u>	'ɛ-ou	S	Sierra	<u><i>/si:'ɛrɑ:/</i></u>	i-'ɛr-ɑ
F	Foxtrot	<u><i>/'fakstrat/</i></u>	'ɑ-ɑ	T	Tango	<u><i>/'tæŋɡou/</i></u>	'æ-ou
G	Golf	<u><i>/'ɡɔlf/</i></u>	'ɔ	U	Uniform	<u><i>/'ju:ni:fɔ:m/</i></u>	'u-i-ɔr
H	Hotel	<u><i>/hou'tel/</i></u>	ou-'ɛ	V	Victor	<u><i>/'viktər/</i></u>	'i-ər
I	India	<u><i>/'indi:ɑ:/</i></u>	'i-i-ɑ	W	Whiskey	<u><i>/'wiski:/</i></u>	'i-i
J	Juliett	<u><i>/'dʒu:li:ɛt/</i></u>	'u-i-ɛ	X	X-ray	<u><i>/'ɛksreɪ/</i></u>	'ɛ-eɪ
K	Kilo	<u><i>/'ki:lou/</i></u>	'i-ou	Y	Yankee	<u><i>/'jæŋki:/</i></u>	'æ-i
L	Lima	<u><i>/'li:mʌ/</i></u>	'i-ʌ	Z	Zulu	<u><i>/'zu:lu:/</i></u>	'u-u
M	Mike	<u><i>/'maɪk/</i></u>	'aɪ				
N	November	<u><i>/nou'vɛmbər/</i></u>	ou-'ɛ-ər				



	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill				r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

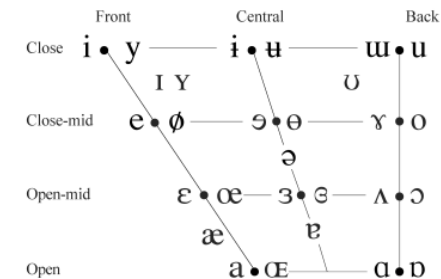
CONSONANTS (NON-PULMONIC)

Clicks	Voiced implosives	Ejectives
ʘ Bilabial	ɓ Bilabial	ʼ Examples:
ǀ Dental	ɗ Dental/alveolar	ɸ Bilabial
ǃ (Post)alveolar	ɟ Palatal	tʼ Dental/alveolar
ǂ Palatoalveolar	ɠ Velar	kʼ Velar
ǁ Alveolar lateral	ɠ Uvular	sʼ Alveolar fricative

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative	ɕ ʑ Alveolo-palatal fricatives	ɺ Voiced alveolar lateral flap
ʋ Voiced labial-velar approximant	ɻ Voiced alveolar lateral flap	
ɥ Voiced labial-palatal approximant	ɧ Simultaneous ʃ and x	
ʜ Voiceless epiglottal fricative		
ʕ Voiced epiglottal fricative	Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary.	
ʡ Epiglottal plosive		

VOWELS



Where symbols appear in pairs, the one to the right represents a rounded vowel.

SUPRASEGMENTALS

- ˈ Primary stress
- ˌ Secondary stress
- ː Long eː
- ˑ Half-long eˑ
- ˚ Extra-short e˚
- ◌˚ Minor (foot) group
- ◌ˑ Major (intonation) group
- ◌ˑˑ Syllable break ˑi.ækt
- ◌ˑ Linking (absence of a break)

TONES AND WORD ACCENTS LEVEL CONTOUR

- ↗ Extra high
- ↖ High
- ↕ Mid
- ↘ Low
- ↙ Extra low
- ↘ Downstep
- ↗ Upstep
- ↗ Rising
- ↘ Falling
- ↗ High rising
- ↘ Low rising
- ↗ Extra rising
- ↘ Rising-falling
- ↗ Global rise
- ↘ Global fall

# 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 'i-ou  
 Lima 'i-ʌ  
 Sierra i-'er-ɑ

Victor 'ɪ-ər  
 Whiskey 'ɪ-i  
 India 'ɪ-i-ɑ

Echo 'ɛ-ou  
 Delta 'ɛ-ʌ  
 Quebec ɛ-'ɛ  
 X-ray 'ɛ-θi

Tango 'æ-ou  
 Alfa 'æ-ʌ  
 Yankee 'æ-i

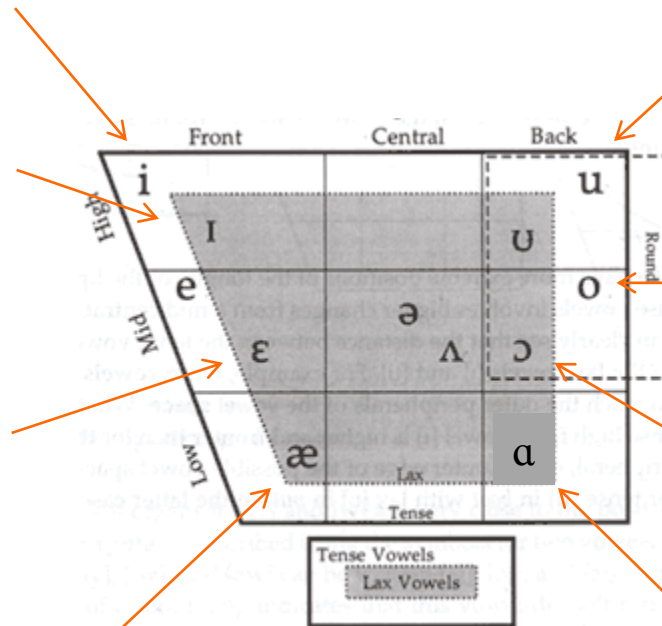
Mike 'aɪ

Zulu 'u-u  
 Uniform 'u-i-ər  
 Juliett 'u-i-ɛ

Hotel ou-'ɛ  
 November ou-'ɛ-ər  
 Romeo 'ou-i-ou

Golf 'ɔ

Bravo 'ɑ-ou  
 Papa ɑ-'ɑ  
 Foxtrot 'ɑ-ɑ  
 Oscar 'ɑ-ər  
 Charlie 'ɑ-r-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”.*

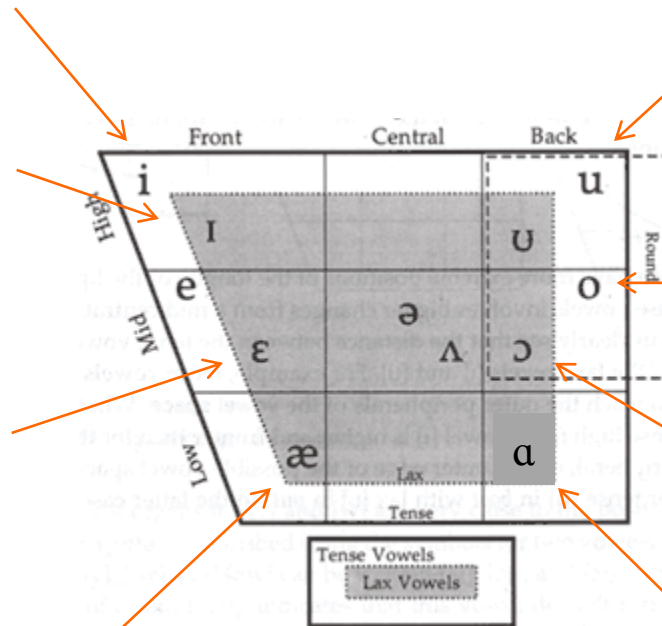
# THE FIVE TERMS REPLACED IN THE ALPHA/BRAVO ALPHABET WERE ESPECIALLY CONFUSING

Kilo 'i-oo  
 Lima 'i-Λ  
 Sierra i-'er-α

Victor 'i-ər  
 Whiskey 'i-i  
 India 'i-i-α

(Metro ⇒) Echo 'ε-oo  
 (Extra ⇒) Delta 'ε-Λ  
 (Nectar ↯) Quebec ε-'ε  
 X-ray 'ε-θi

Tango 'æ-oo  
 Alfa 'æ-Λ  
 Yankee 'æ-i



Zulu 'u-u  
 Uniform 'u-i-ər (⇐ Union)  
 Juliett 'u-i-ε

Hotel oo-'ε (⇐ Coca)  
 November oo-'ε-ər  
 Romeo 'oo-i-oo

Golf 'ɔ

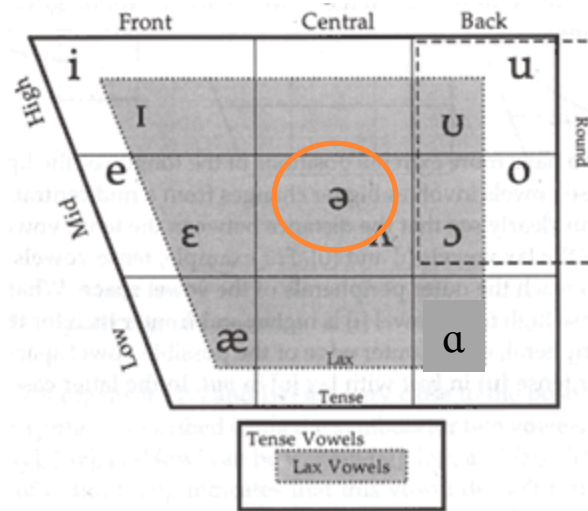
Bravo 'a-oo  
 Papa a-'a  
 Foxtrot 'a-a  
 Oscar 'a-ər  
 Charlie 'ar-i

Mike 'ai

*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

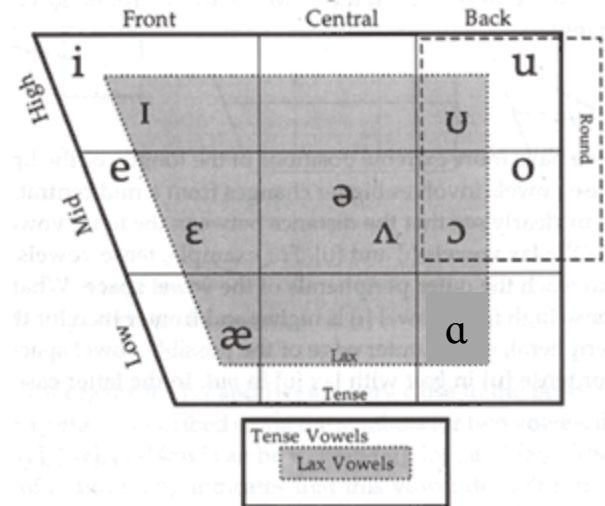
- Schwa is our most common vowel sound, used in:
  - Unstressed syllables (*emphasize*)
  - Function words in flowing speech (*the, a, on*)
- Schwa is perfectly acceptable in daily conversation
  - Usually both consonants and context are available
  - Precise articulation is unnecessary effort
- However, 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



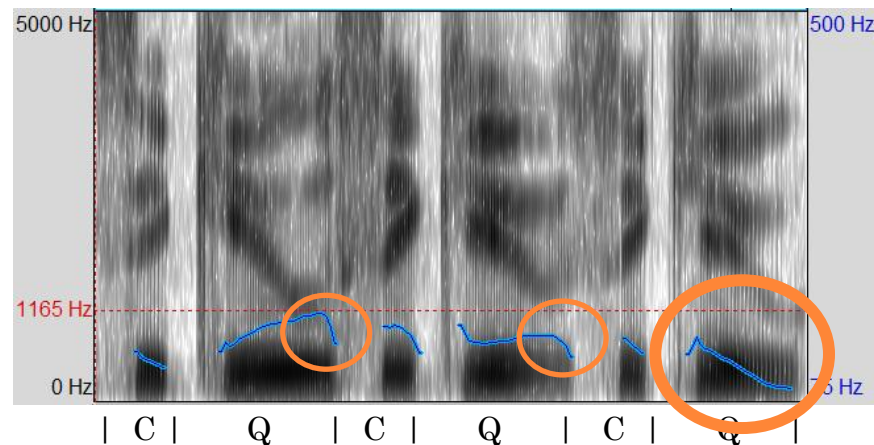
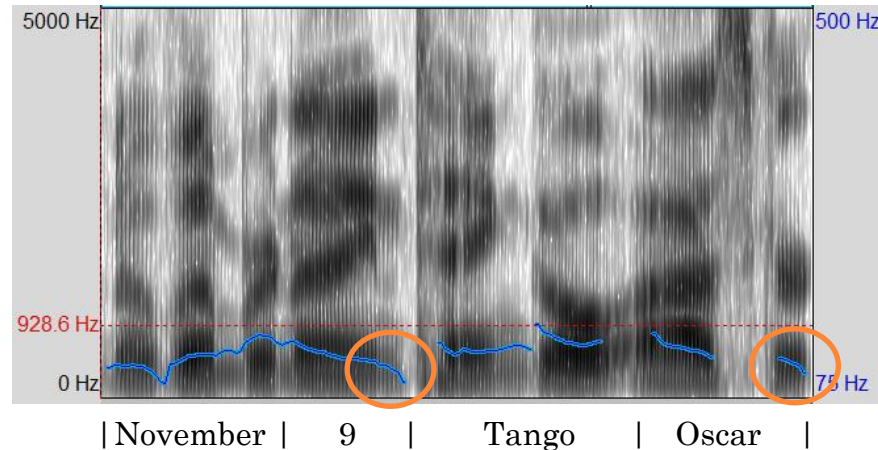
*Whether you pronounce the vowels on each line the same or differently, someone from a different region does the opposite.*



# 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

# QUESTIONS?

- Contact information:
  - Pamela Toman, KB9SCM
  - <email form available on [pamelatoman.net](http://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