

Introduction to acoustic phonetics

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Acoustic phonetics

- Acoustic phonetics is a subfield of phonetics, which deals with acoustic aspects of speech sounds.

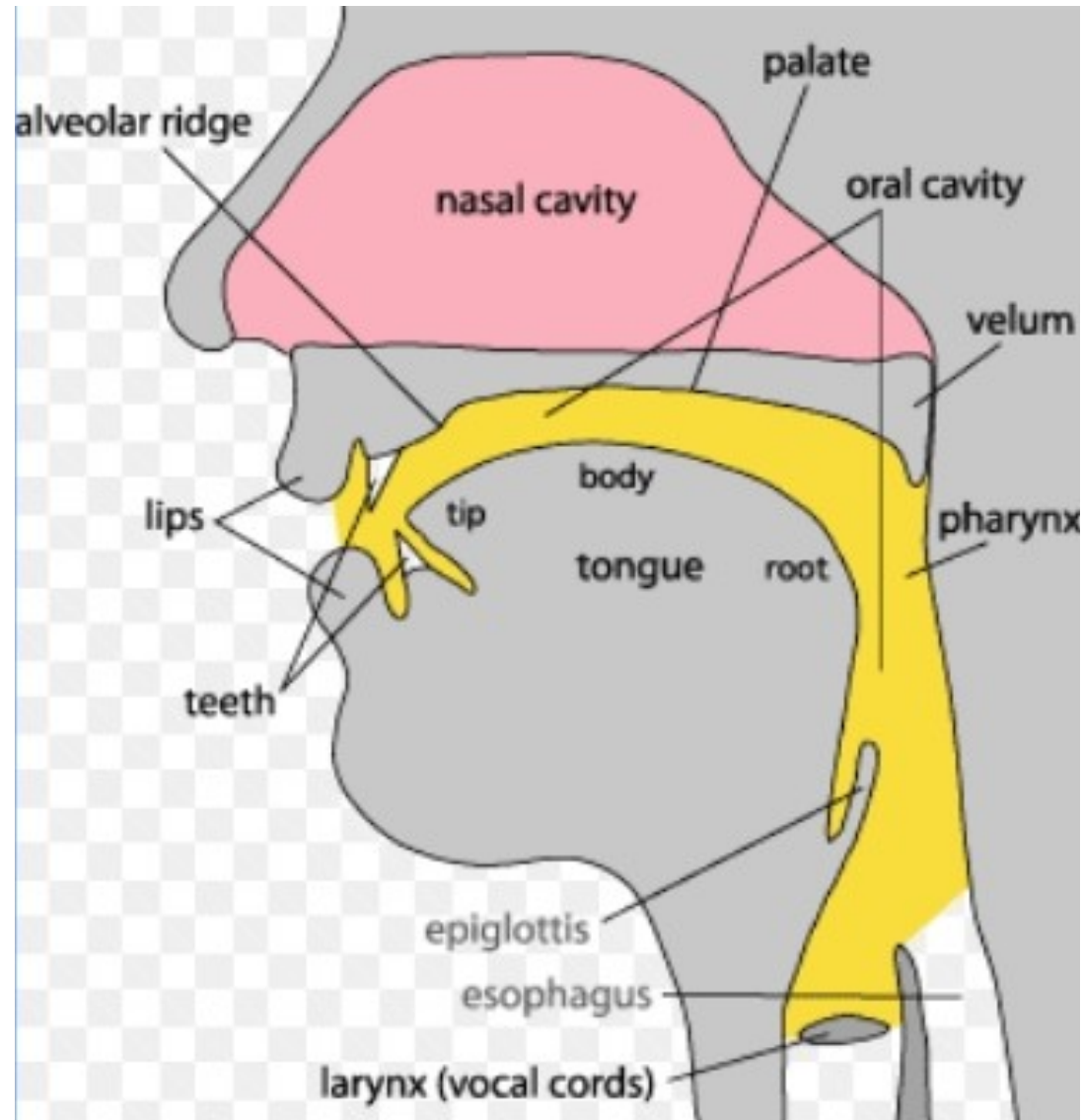
Do you know...?

- How many languages are spoken in the world?
- How many letters/signs there are in the scripts?
- How many speech sounds there are in all languages of the world?
 - Why?

Do you know...?

- How many languages are spoken in the world?
 - [Ethnologue](#)
- How many letters/signs there are in the scripts?
 - [Unicode Consortium](#)
- How many speech sounds there are in all languages of the world?
 - [International Phonetic Alphabet](#)
 - Why?
 - The same vocal tract for all the people

Vocal tract



Kazakh consonants

Kazakh consonant phonemes^[26]

	Labials		Alveolar		(Alveolo-)palatal		Velar		Uvular	
Nasal	m ⟨м/м⟩		n ⟨н/н⟩				ŋ ⟨ҥ/ҥ⟩			
Stop	p ⟨п/п⟩	b ⟨б/б⟩	t ⟨т/т⟩	d ⟨д/д⟩	ʧ ⟨ч/ч⟩		k ⟨к/к⟩	g ⟨г/г⟩	q ⟨қ/қ⟩	
Fricative	f ⟨ф/ф⟩	v ⟨в/в⟩	s ⟨с/с⟩	z ⟨з/з⟩	ɕ ⟨ш/ш⟩	ʑ ⟨ж/ж⟩			χ ⟨х/х⟩	ʁ ⟨ғ/ғ⟩
Approximant			l ⟨л/л⟩		j ⟨й/й⟩		w ⟨у/у⟩			
Rhotic			r ⟨р/р⟩							

Kazakh vowels -1

Kazakh vowel phonemes

	Front (-RTR)	Central (0RTR)	Back (+RTR)
Close	ɪ ⟨i/i⟩	ʉ ⟨ɣ/ú⟩	ʊ ⟨ʏ/u⟩
Diphthong	jɪ ⟨e/e⟩	əj ⟨ɯ/i⟩	ʊw ⟨y/ý⟩
Mid	e ⟨ə/e⟩	ə ⟨ɸ/y⟩	o ⟨o/o⟩
Open	æ ⟨ə/á⟩	œ ⟨ə/ó⟩	ɑ ⟨a/a⟩

Kazakh vowels -2

Kazakh vowels by their pronunciation

	Front		Back	
	unrounded	rounded	unrounded	rounded
Close	ɪ ⟨i/i⟩	ʉ ⟨γ/ü⟩	ə ⟨ɸ/ɪ⟩	ʊ ⟨ɣ/u⟩
Open	e ⟨ə/e⟩ / æ ⟨ə/ä⟩	œ ⟨ə/ö⟩	ɑ ⟨a/a⟩	o ⟨o/o⟩

Uzbek consonants

		Labial	Dental	Alveolar	Palatal	Velar	Uvular	Glottal
Nasal		m		n		ŋ		
Plosive/Affricate	voiceless	p	t̪	(ts)	tʃ	k	q	(ʔ)
	voiced	b	d̪		dʒ	g		
Fricative	voiceless	ɸ		s	ʃ		χ	h
	voiced			z	(ʒ)		ʁ	
Approximant				l	j	w		
Rhotic				r				

Uzbek vowels

	Unrounded	Rounded
Close	i	u
Mid	e	o
Open	æ	ɒ

IPA

The International Phonetic Alphabet (IPA) is an alphabetic system of phonetic notation based primarily on the Latin alphabet. It was devised by the International Phonetic Association in the late 19th century as a standardized representation of the sounds of spoken language.

Among the symbols of the IPA, 107 letters represent consonants and vowels, 31 diacritics are used to modify these, and 19 additional signs indicate suprasegmental qualities such as length, tone, stress, and intonation.

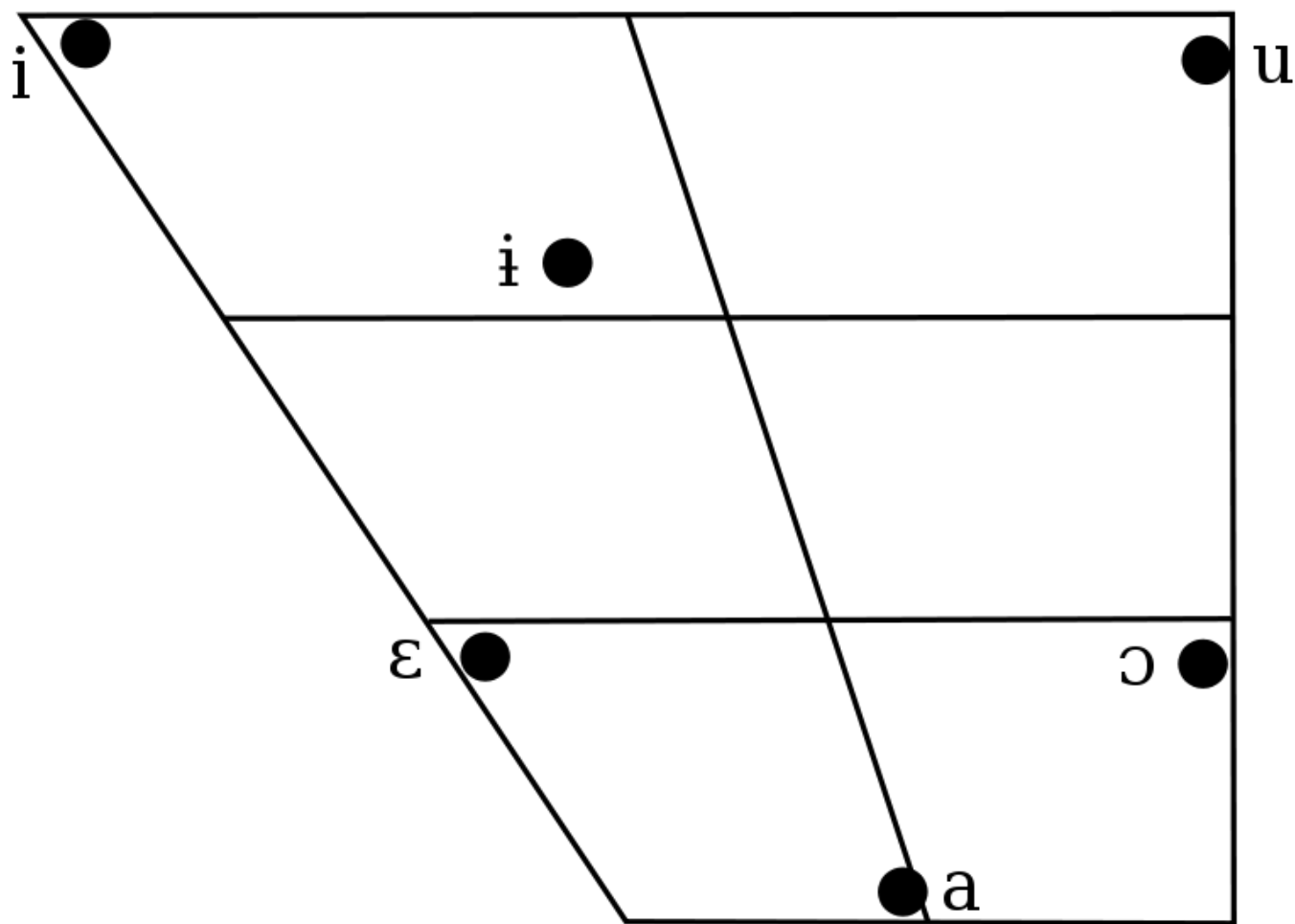
International Phonetic Association

- <https://www.internationalphoneticassociation.org/>
- IPA Chart

Polish consonants

	Dwuwargowe	Wargowo- zębowe	Zębowe	Zadziąsłowe	Przednio- podniebienne	Miękko- podniebienne
Zwarte	p b		t d			k g
Zwarto- szczelinowe			ts dz	tʃ dʒ	tɕ dʑ	
Szczelinowe		f v	s z	ʃ ʒ	ɕ ʑ	x
Nosowe	m		n		ɲ	ŋ
Półotwarte	w		ɫ	l r	j	

Polish vowels



and two nasal vowels $ã$ and $ɛ̃$

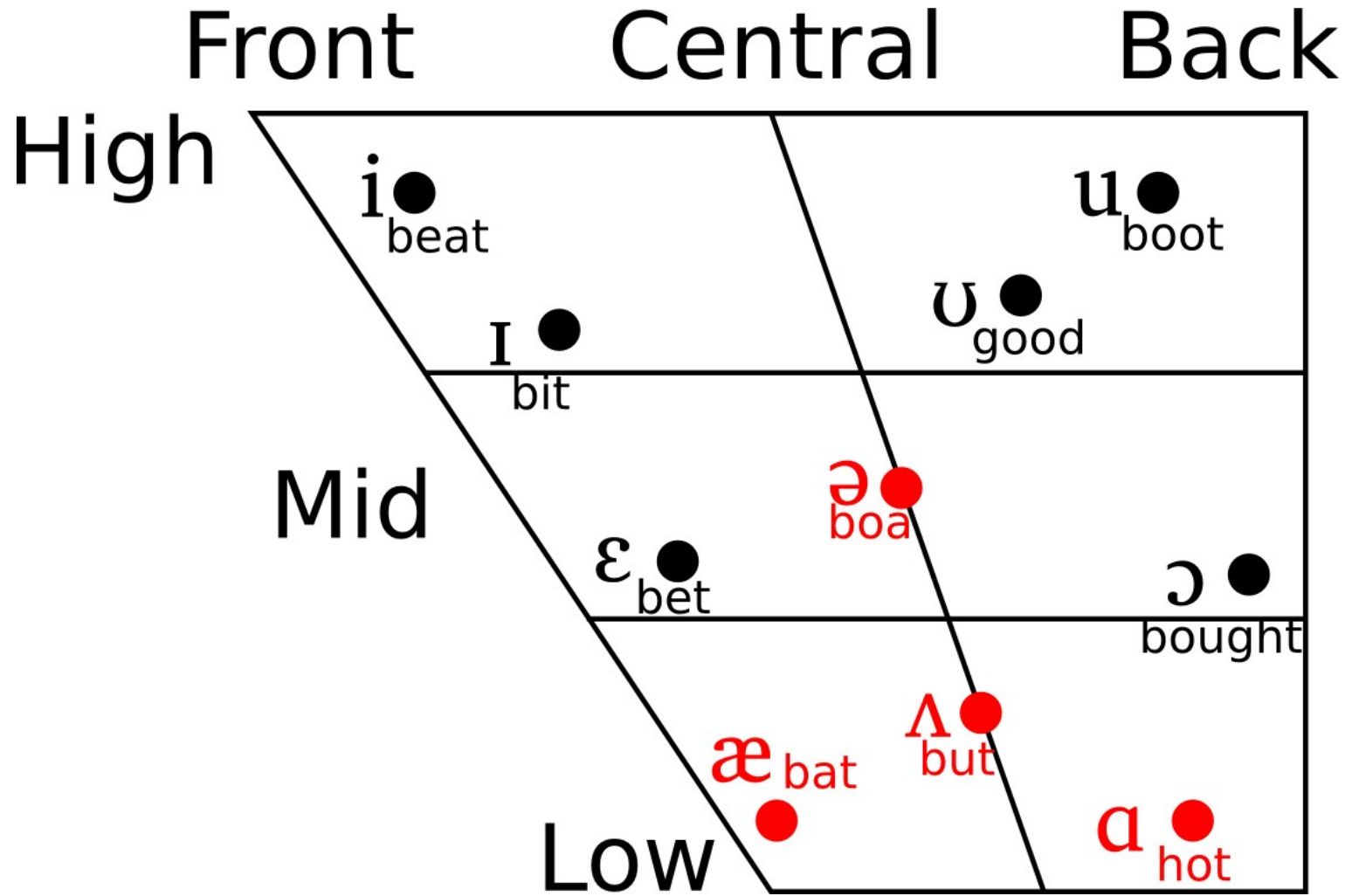
English consonants

Consonant phonemes

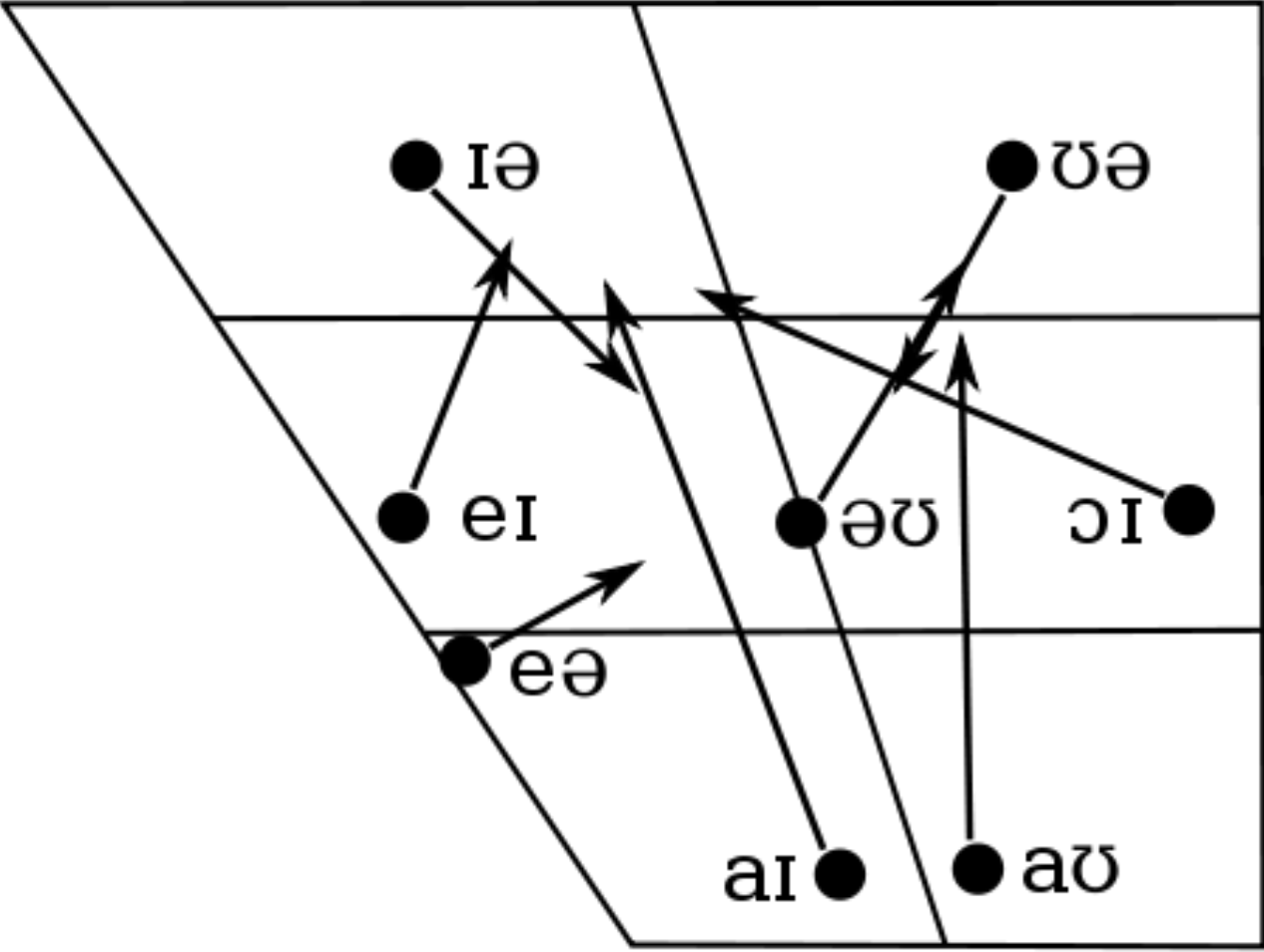
	Labial	Dental	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Nasal	m		n			ŋ	
Stop	p b		t d	tʃ dʒ		k g	
Fricative	f v	θ ð	s z	ʃ ʒ			h
Approximant			l	ɹ*	j	w	

* Conventionally transcribed /r/.

English vowels



Diphthongs



Reading

- IPA
 - https://en.wikipedia.org/wiki/International_Phonetic_Alphabet
- The sounds of language
 - <http://languagesindanger.eu/book-of-knowledge/the-sounds-of-language/>

IPA on the Web

- The International Phonetic Alphabet in Unicode
 - <http://www.phon.ucl.ac.uk/home/wells/ipa-unicode.htm>
- IPA The Phonetic Representation of Language
 - IPA Chart With Sounds
 - <http://www.internationalphoneticalphabet.org/ipa-sounds/ipa-chart-with-sounds/>
- Type IPA phonetic symbols
 - <http://ipa.typeit.org/full/>

North Wind and the Sun

ðə 'nɔ:θ ,wɪnd ən (ð)ə 'sʌn wə dɪs'pjʊtɪŋ 'wɪtʃ wəz
ðə 'stʌŋgə, wɛn ə 'tʌævələ ,kɛm ə'laŋ 'ræpt ɪn ə
'wɔ:ɪm 'kloʊk.

ðe ə'gʊɪd ðæt ðə 'wʌn hu 'fəst sək'sɪdəd ɪn 'mekɪŋ ðə
'tʌævələ 'tek ɪz 'kloʊk ,af ʃʊd bi kən'sɪdəd 'stʌŋgə
ðən ðɪ 'əðə.

ðɛn ðə 'nɔ:θ ,wɪnd 'blu əz 'hɑ:d əz ɪ 'kʊd, bət ðə
'mɔ: hi 'blu ðə 'mɔ: 'kloʊsli dɪd ðə 'tʌævlə 'fɔld hɪz
'kloʊk ə'raʊnd ɪm;

,æn ət 'læst ðə 'nɔ:θ ,wɪnd ,gev 'ʌp ðɪ ə'tɛmpt. 'ðɛn
ðə 'sʌn 'ʃaɪnd ,aʊt 'wɔ:ɪmli ənd ɪ'mɪdɪətli ðə 'tʌævlə
'tʊk ,af ɪz kloʊk.

ən 'sɔ: ðə 'nɔ:θ ,wɪnd wəz ə'blaɪdʒd tə kən'fɛs ðæt
ðə 'sʌn wəz ðə 'stʌŋgə əv ðə 'tu.

North Wind and the Sun

The North Wind and the Sun were disputing which was the stronger, when a traveler came along wrapped in a warm cloak.

They agreed that the one who first succeeded in making the traveler take his cloak off should be considered stronger than the other.

Then the North Wind blew as hard as he could, but the more he blew the more closely did the traveler fold his cloak around him;

and at last the North Wind gave up the attempt. Then the Sun shined out warmly, and immediately the traveler took off his cloak.

And so the North Wind was obliged to confess that the Sun was the stronger of the two.

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They agreed that the one who first succeeded in making the traveler take his cloak off should be considered stronger than the other.

ðe ə'grɪd ðæt ðə 'wʌn hu 'fəst sək'sɪdəd ɪn 'mekɪŋ ðə
'tʌævələ 'tek ɪz 'kloʊk ,ɒf ʃʊd bi kən'sɪdəd 'stʌŋgə
ðən ðɪ 'əðə.

http://en.wikipedia.org/wiki/The_North_Wind_and_the_Sun

Exercise

- Transcribe a sentence in Kazakh or Uzbek
- ... and then try with an English sentence

Praat



Praat: doing phonetics by computer



Download Praat:

- * [Macintosh](#)
- * [Windows](#)
- * [Linux, FreeBSD](#)
- * [SGI, Solaris, HPUX](#)
- * [the source code](#)



Information on Praat:

- * Introductory tutorial: choose **Intro** from Praat's **Help** menus.
- * Extensive manuals and tutorials: in Praat's **Help** menus.
- * Beginner's manuals by [Sidney Wood](#) and [Pascal van Lieshout](#).
- * Paul Boersma's [publications](#) on algorithms and tutorials.



[Paul](#)

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Downloading Praat for Windows

New: Praat requires the Doulos SIL or Charis SIL phonetic font; see below.

To download the latest **Windows** (2000, XP, Vista...) version of **Praat**, it is easiest to use the self-extracting archive:

[praat5023_winsit.exe](#) (May 9, 2008; 1.7 MB)



(if you have Windows 95/98/NT4/ME, try [praat4601_win98sit.exe](#))

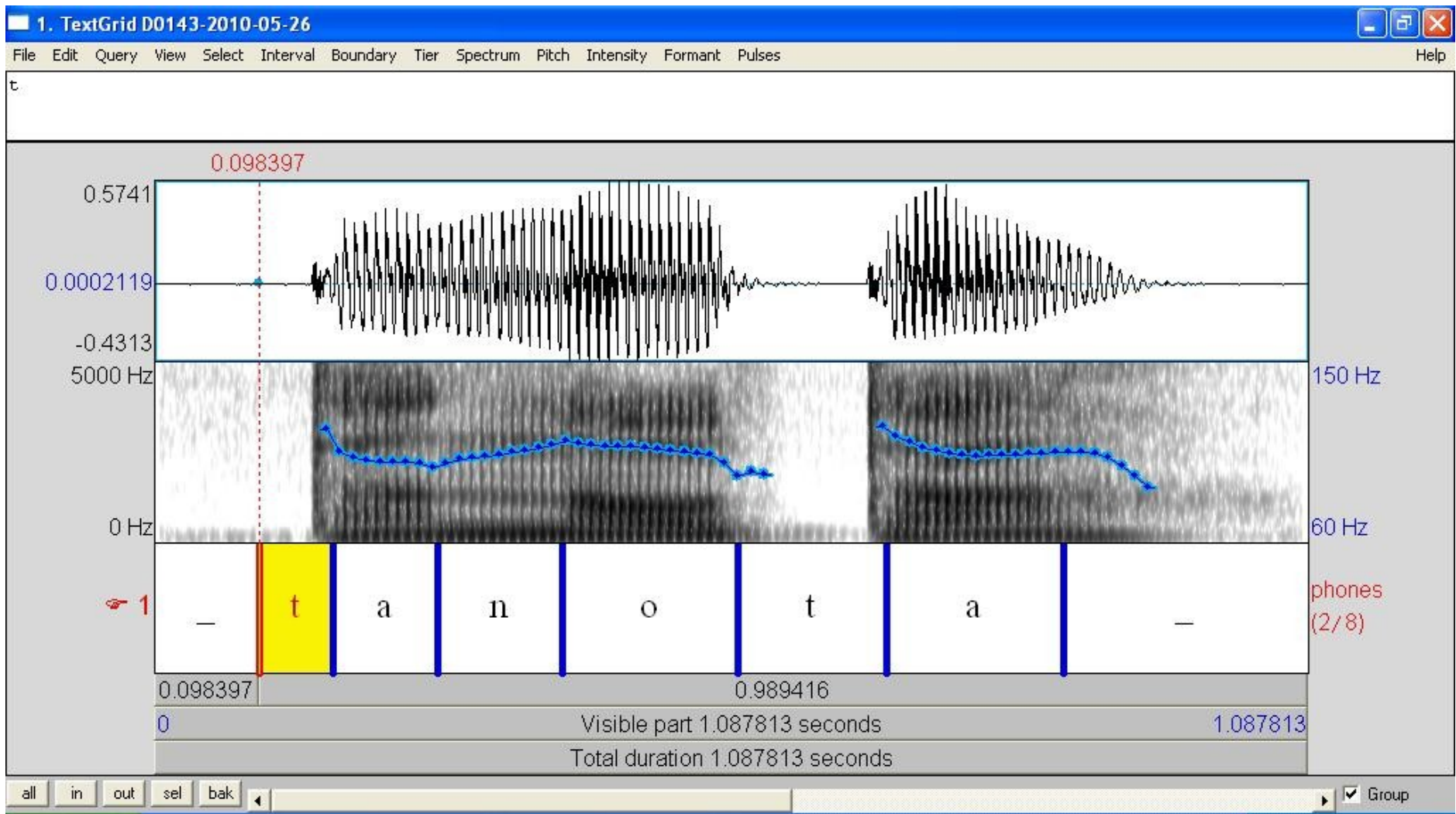
After downloading this file, double-click it and click OK to install Praat on your desktop. If this installation does not work, you may use the ZIP archive instead (after downloading, double-click to open):

[praat5023_win.zip](#) (May 9, 2008; 1.9 MB)

(if you have Windows 95/98/NT4/ME, try [praat4601_win98.zip](#))

Either way, a file called **Praat** or **Praat.exe** will appear. This is the Praat program. You can put it anywhere on your hard disk (so that you can use Praat even if your system administrator does not allow you to install other programs!).

Annotation



Spectrogram

Oscillogram Annotation

Fundamental frequency: F0

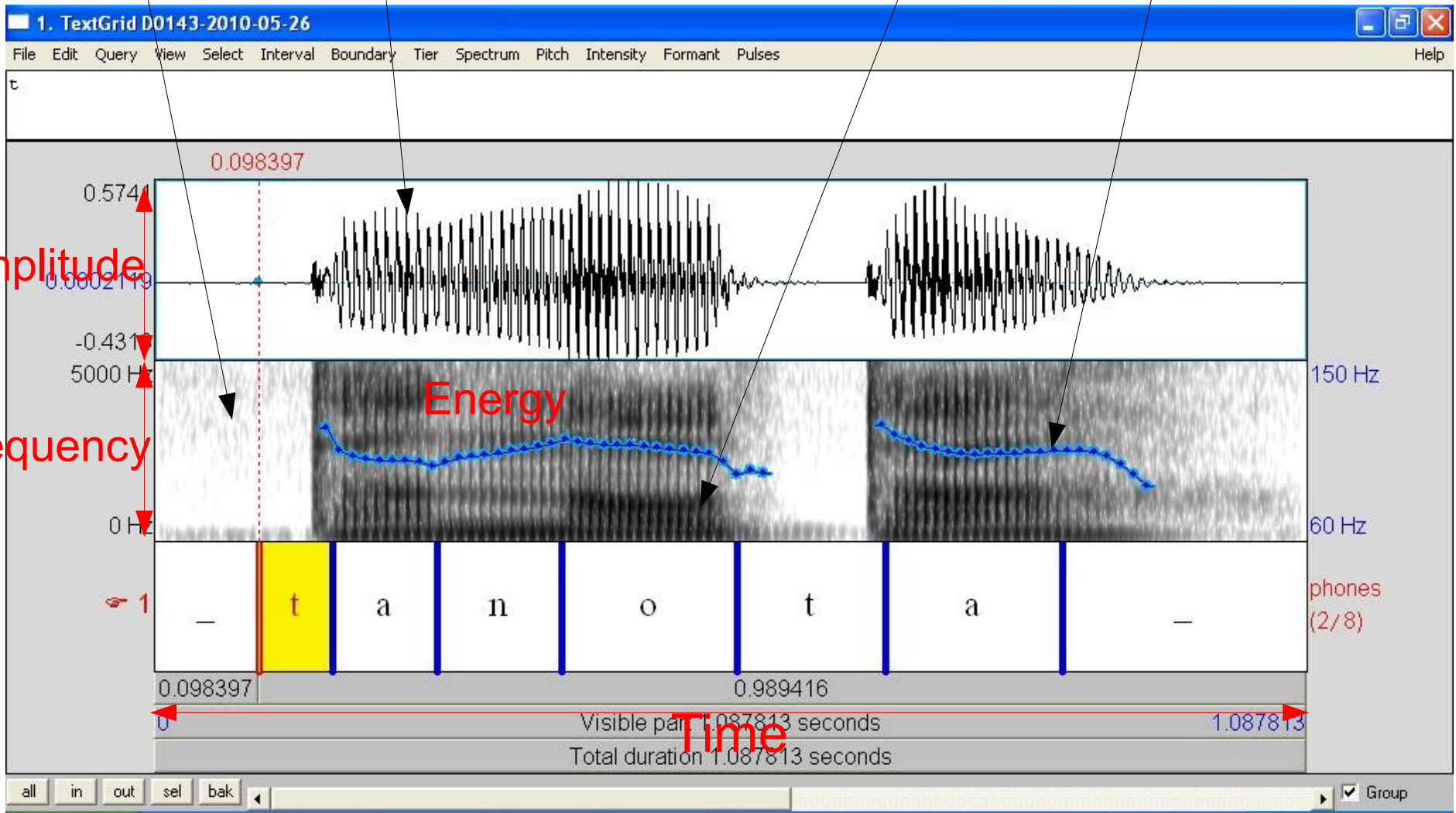
Formants

Amplitude

Frequency

Energy

Time



Formants of vowels

- Formant is a highlighted frequency band resulting from an acoustic resonance of the human vocal tract

Vowel formant centers

Vowel	IPA	Formant f_1	Formant f_2
u	u	320 Hz	800 Hz
o	o	500 Hz	1000 Hz
ɑ	ɑ	700 Hz	1150 Hz
a	a	1000 Hz	1400 Hz
ø	ø	500 Hz	1500 Hz
y	y	320 Hz	1650 Hz
æ	ɛ	700 Hz	1800 Hz
e	e	500 Hz	2300 Hz
i	i	320 Hz	2500 Hz

Study the examples of annotation

- Isolated sentence in Polish
- Isolated sentence in English
- Isolated sentence in English (foreign speech)
- Read speech in English
- Official speech in Polish Parliament
- Dialogue in an emergency scenario

Why do we do it?

- To teach acoustic phonetics
- To create speech synthesis systems
 - Text-To-Speech (TTS)
- To create automatic speech recognition systems
 - ASR
- To build dialogue systems

Praat: Exercise

- Download PRAAT:
 - <http://www.fon.hum.uva.nl/praat/>
- Open PRAAT
- Read in a speech file
 - Kazakh: <http://bachan.speechlabs.pl/files/Kazakh.zip>
 - Uzbek: <http://bachan.speechlabs.pl/files/Uzbek.zip>
- Annotate the files in PRAAT on 3 tiers:
 - words
 - syllables
 - phones

Praat: Exercise

- You can use the IPA notation for PRAAT
 - Help > Search Praat manual > "Phonetic symbols"
- Look at the TextGrid file and investigate the encoding of the notation

Praat TextGrid file format

```
File type = "ooTextFile"
Object class = "TextGrid"

xmin = 0
xmax = 0.2929375
tiers? <exists>
size = 1
item []:
  item [1]:
    class = "IntervalTier"
    name = "Phones"
    xmin = 0
    xmax = 0.2929375
    intervals: size = 4
```

```
intervals [1]:
  xmin = 0
  xmax = 0.0718
  text = "t_h"
intervals [2]:
  xmin = 0.0718
  xmax = 0.2323
  text = "aI"
intervals [3]:
  xmin = 0.2323
  xmax = 0.25579
  text = "g"
intervals [4]:
  xmin = 0.2557
  xmax = 0.2929
  text = "r\`="
```

How to ease your work?

How to ease your work?

SAMPA

computer readable phonetic alphabet

SAMPA
"**s{mpA:**

speech assessment methods
phonetic alphabet

<i>PL1 Polish SAMPA</i>	<i>Orthography</i>	<i>Phonemic transcription</i>		<i>PL1 Polish SAMPA</i>	<i>Orthography</i>	<i>Phonemic transcription</i>
p	pik	pik		i	kit	kit
b	bit	bit		l	typ	tlp
t	test	test		e	test	test
d	dym	dIm		a	pat	pat
k	kat	kat		o	pot	pot
g	gen	gen		u	puk	puk
f	fan	fan		e~	gęś	ge~s'
v	wilk	vilk		o~	wąs	vo~s
s	syk	slk		m	mysz	mlS
z	zbir	zbir		n	nasz	naS
S	зык	Slk		n'	koń	kon'
Z	żyto	Zlto		N	pęk	peNk
s'	świt	s'fit		l	luk	luk
z'	źle	z'le		r	ryk	rlk
x	hymn	xImn		w	łyk	wlk
ts	cyk	tslk		j	jak	jak
dz	dzwon	dzvon				
tS	czyn	tSIn				
dZ	dżem	dZem				
ts'	ćma	ts'ma				
dz'	dźwig	dz'vik				

Praat: Exercise

- Annotate the speech files in SAMPA for your language
- Try to annotate a Polish file:

<http://bachan.speechlabs.pl/files/A0310.wav>

Enjoy and good luck! :-)