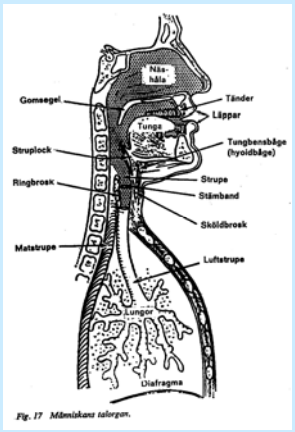
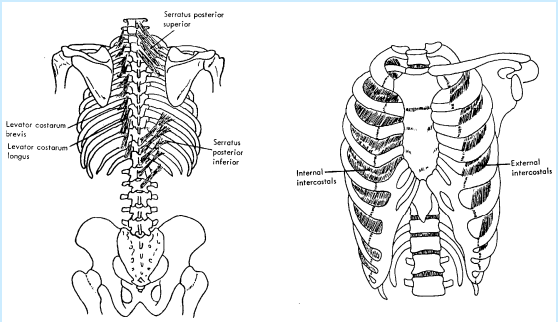
Speech physiology and speech acoustics

David House



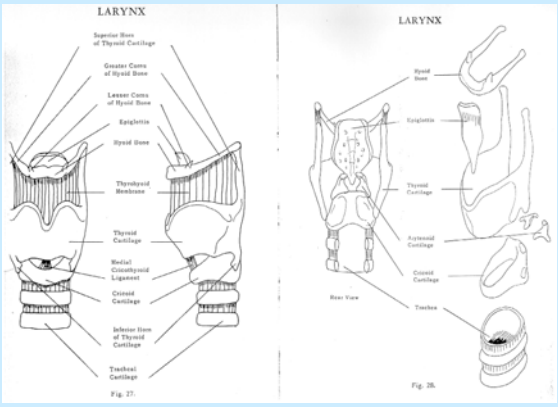
The lungs and the larynx

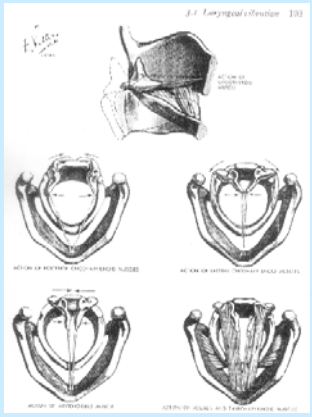
- Expiratory respiration – generate sound
- trachea *luftstrupen*
- larynx *struphuvudet*
  - cartilage, muscles and ligaments
  - glottis *röstspringan*
  - vocal folds *stämläpparna*
    - vocalis muscle, vocal ligament
- epiglottis *struplocket*



Voice

- Biological function of the larynx
  - Protect the lungs and airway for breathing
  - Stabilize the thorax for exertion
  - Expel foreign objects by coughing
- Phonation and voice source
  - Creation of periodic voiced sounds
  - Vocal folds are brought together, air is blown out through the folds, vibration is created





Muscular control of phonation

- Lateral control of the glottis
  - adduction (for protection and voiced sounds)
  - abduction (for breathing and voiceless sounds)
- Longitudinal control of the glottis
  - tension settings of the vocalis muscle
  - control of fundamental frequency (F0)

Voice quality

- Phonation type (lateral tension)
  - Tense (pressed) voice *pressad*
  - Normal (modal) voice *modal*
  - Flow phonation *flödig*
  - Breathy voice *läckande*
- Vocal intensity
  - Interaction between subglottal lung pressure and lateral (adductive) tension

Voice pitch

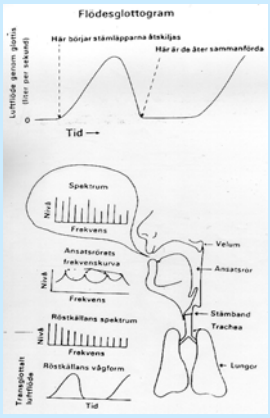
- Pitch level
  - high-pitched or low-pitched voice (average F0)
- Pitch range
  - large or small
- Register
  - modal
  - falsetto
  - creak *knarr*

Use of voice in normal speech

- Boundary signalling
  - vocal intensity greatest at phrase beginnings
  - pitch generally higher at phrase beginning
  - creak as a signal of phrase endings
- Social marker
  - voice quality as a signal of group identity (dialect)
- Expression of attitude and emotion
  - happy or angry
  - serious or sensual

Source-filter theory

- Voice-source waveform (during phonation)
  - Transglottal airflow measurements
- Spectrum of the voice source
  - Decreases in amplitude with increasing frequency
- Vocal tract resonances
  - Dependent on position of the tongue and lips
- Spectrum of radiated sound
  - Sum of voice source and vocal tract resonances



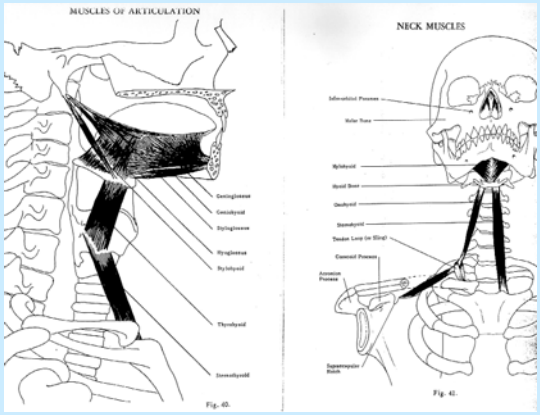
From Sundberg: Röstlära

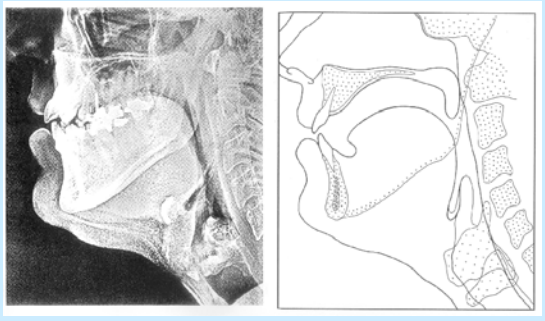
Vowels and consonants

- Speech production (phonetics)
  - Free air passage through the pharynx, mouth and the lips = vowel
  - Constricted or closed air passage = consonant
- Function (phonology)
  - Nuclear in the syllable = vowel
  - Marginal in the syllable = consonant
- Exceptions
  - Some voiced consonants (e.g. syllablic nasal)
  - Approximants or semi-vowels (e.g. [j] [w])

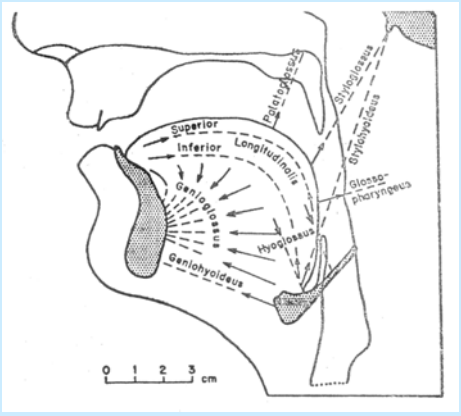
The vocal tract

- Throat, (svalget): *pharynx, faryngal*
- Oral cavity, (munhålan): *os, oral*
- Nasal cavity, (näshålan): *nasus, nasal*





From Laver: Principles of Phonetics

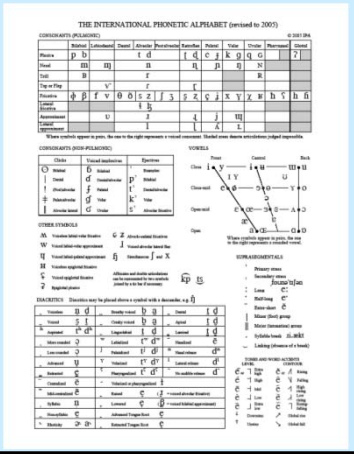


Vowel articulation

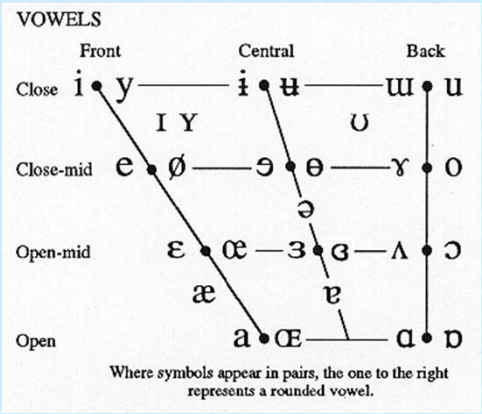
- Cardinal vowels
  - Reference vowels
  - Four corner vowels form the corners of the vowel chart
- Descriptive terminology
  - Close-open (high-low) *sluten-öppen*
  - Front-back *främre-bakre*
  - Unrounded-rounded *orundad-rundad*
  - Oral-nasal (e.g. French) *oral-nasal*

Tongue shapes of four of the cardinal vowels

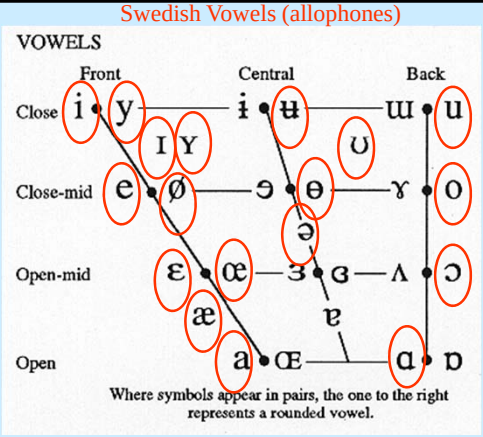
From Elert: Allmän och svensk fonetik



IPA charts from the International Phonetic Association (Department of Theoretical and Applied Linguistics, School of English, Aristotle University of Thessaloniki, Thessaloniki 54124, GREECE).



Swedish Vowels (allophones)



Tabell 5.1 De långa och korta vokalerna i svenskt rikssprakuttal.

Långa vokaler		*Korta vokaler*	
fonetiskt tecken	*nyckelord*	*fonetiskt tecken*	*nyckelord*
[ɑ:]	*mat*	[a]	*matt*
[e:]	*vet*	[e]	*vett, året*
[i:]	*vit*	[ɪ]	*vitt*
[u:]	*bo*	[ʊ]	*bott*
[ɯ:] el. [ʉ:]	*hus*	[ɵ]	*hund*
[y:]	*byt*	[ʏ]	*bytt*
[o:]	*gå*	[ɔ]	*gått*
[ɛ:]	*säl*	[ɛ]	*vätt*
[æ:]	*här*	[æ]	*kärr*
[ø:]	*hö*	[ø̞]	*höst*
[œ:]	*hör*	[œ]	*förr*

From Elert: Allmän och svensk fonetik

Phonological features

- Binary features for vowels
  - e.g.
    - ± high
    - ± low
    - ± back
    - ± round
- Feature matrix
  - Feature specification for each phoneme

Vokalfonem

A. Svenska

		förträngningens läge			
		främre			bakre
tungkroppens läge	högt	i	y	ʉ	u
	mellan	e	ø		o
	lågt	ɛ			ɑ
		orun-dade	utrun-dade	inrundade	
		läppartikulation			

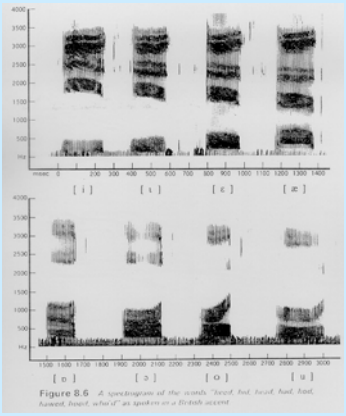
B. Finska

		förträngningens läge		
		främre		bakre
tungkroppens läge	högt	i	y	u
	mellan	e	ø	o
	lågt	ɛ		ɑ
		orun-dade	rundade	
		läppartikulation		

From Gårding: Kontrastiv fonetik och syntax med svenska i centrum

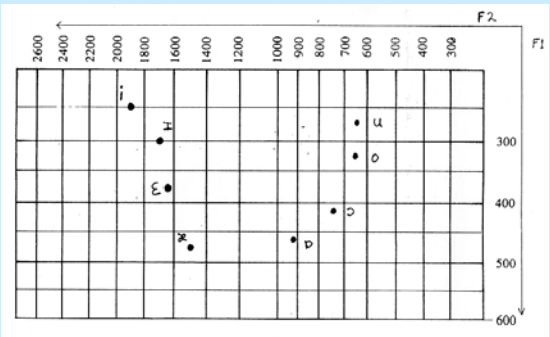
Vowel acoustics

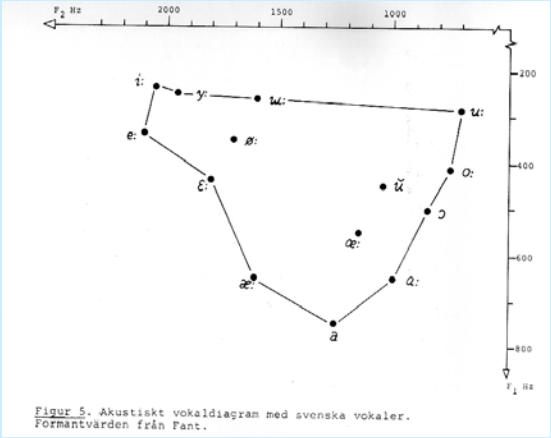
- Spectrogram
  - Narrow band spectrogram
  - Wide band spectrogram
- Formants (F1, F2, F3, F4)
- Acoustic vowel diagram (F1, F2)
- Formant transitions



From Ladefoged: A course in phonetics

Acoustic vowel diagram (F1, F2)





Figur 5. Akustiskt vokaldiagram med svenska vokaler. Formantvärden från Fant.

Consonant articulation

- Voiceless or voiced
  - fortis or lenis
  - aspirated or unaspirated
- Manner of articulation
  - How is the sound produced?
- Place of articulation
  - Where is the constriction or closure located?

Manner of articulation

- Fricatives *frikativor (spiranter)*
- Stops, plosives *klusiler, explosivor*
  - aspiration
  - unreleased
  - affricates (stop + fricative) *affrikator*
- Liquids *likvidor*
  - laterals *lateraler*
  - trills *tremulanter (vibranter)*
- Nasals *nasaler*

The tongue: *lingua*

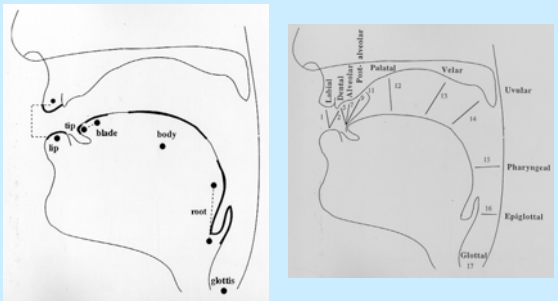
- Tongue tip: *apex, apikal*
- Tongue blade: *predorsum, predorsal* (also *corona, coronal*)
- Tongue back: *dorsum, dorsal*
- Tongue root: *radix*

The palate

- Alveolar ridge (tandvallen) *: alveoli, alveolar*
- Hard palate (hårda gommen): *palatum, palatal*
- Soft palate (mjuka gommen): *velum, velar*
- Uvula (tungspenen)*: uvula, uvular*

The teeth and lips

- teeth: *dentes, dental*
- lips: *labia, labial*
  - rounded - *labialised*
  - unrounded - *delabialised*



From Ladefoged: A course in phonetics

Place of articulation (IPA)

- Bilabial
- Labiodental
- Dental
- Alveolar
- Postalveolar
- Retroflex
- Palatal
- Velar
- Uvular
- Pharyngeal
- Glottal (laryngeal)

THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

CONSONANTS (PULMONIC) © 2005 IPA

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	B			r					R		
Tap or Flap		ⱱ		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.

SWEDISH CONSONANTS

THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

CONSONANTS (PULMONIC) © 2005 IPA

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	B			r					R		
Tap or Flap		ⱱ		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.

SJ-LJUDET I SVENSKA

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative

w Voiced labial-velar approximant

ɥ Voiced labial-palatal approximant

ʜ Voiceless epiglottal fricative

ʢ Voiced epiglottal fricative

ʡ Epiglottal plosive

ɕ ʑ Alveolo-palatal fricatives

ʃ Alveolar lateral flap

ʃ͡ɧ Simultaneous ʃ and x

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary.

k͡p t͡s

Phonological features

- ±consonant
- ±sonorant
- ±obstruent
- ±anterior
- ±coronal
- ±continuant
- ±voice

Konsonantfonem — Artikulationsställen

A. Svenska

Artikulationssätt				lab	labdent	dentalv	palvel	glott
egentliga konsonanter	klusiler		tonlösa	p		t	k	
			tonande	b		d	g	
	frikativor		tonlösa	ɧ	f	s	ç	h
			tonande		v		j	
vokalliknande konsonanter	likvidor	later				l		
		vibr				r		
	nasaler			m		n	ŋ	

B. Finska

egentliga konsonanter	klusiler		p		t	k	
	frikativor	tonlösa			s		h
		tonande		v		j	
vokalliknande konsonanter	likvidor later				l		
	likvidor vibr				r		
	nasaler		m		n	ŋ	

From Gårding: Kontrastiv fonetik och syntax med svenska i centrum

Consonant acoustics (1)

- Fricatives
  - Noise frequency
  - Formant transitions in adjoining vowels
- Stops
  - Occlusion phase (silence)
  - Plosive release
  - Aspiration
  - Formant transitions in adjoining vowels

Consonant acoustics (2)

- Liquids
  - Laterals
    - Formants similar to vowels, lower intensity
    - Formant transitions
  - Trills
    - Quickly repeated stops
    - Short vowel-like pulses
    - Formant transitions

Consonant acoustics (3)

- Nasals
  - Vowel-like with lower intensity
  - Nasal resonances (nasal formants)
  - Formant transitions in adjoining vowels

Prosody

- Suprasegmental speech characteristics
  - Temporal relationships
  - Stress patterns
  - Speech rhythm
  - Intonation
- Functions of prosody
  - Lend prominence (emphasize, de-emphasize)
  - Grouping function (combine, separate)

Prosodic categories

- Stress (syllable)
  - Speech rhythm, alternating stressed-unstressed
- Word accent (word)
  - accent I (acute), accent II (grave)
- Focus (phrase accent)
  - Emphasis, contrastive emphasis
- Juncture (phrase, utterance)
  - Boundary signals and connective signals

Acoustic features of prosody

- Time (quantity)
- Fundamental frequency (F0) (pitch, intonation)
- Intensity (loudness)

References

- Elert, Claes-Christian (1995) Allmän och svensk fonetik. Norstedts Förlag, Stockholm
- Ladefoged, Peter (1982) A course in phonetics. Harcourt Brace Jovanovich, New York
- Laver, John (1994) Principles of phonetics. Cambridge University Press, Cambridge
- Lundström-Holmberg, Eva & af Trampe, Peter (1987) *Elementär fonetik*. Studentlitteratur, Lund.
- Sundberg, Johan (1986) Röstlära. Proprius, Stockholm