Speech physiology and speech acoustics

David House

The lungs and the larynx

- Expiratory respiration – generate sound
- trachea  *luftstropen*
- larynx  *struphuvudet*
  - cartilage, muscles and ligaments
  - glottis  *råstspringan*
  - 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  
  - Normal (modal) voice
  - Flow phonation
  - Breathy voice
- 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

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. syllabic 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)  
  - Front-back
  - Unrounded-rounded
  - Oral-nasal (e.g. French)

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

Vowel acoustics

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

Acoustic vowel diagram (F1, F2)
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 (hårdagommen): *palatum, palatal*
- Soft palate (mjukagommen): *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)

Phonological features
- +consonant
- +sonorant
- +obstruent
- +anterior
- +coronal
- +continuant
- +voice

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

• Sundberg, Johan (1986) Röstlära. Proprius, Stockholm