PS Introduction to phonetics and phonology

SS 2003

Phonetics and phonology: introduction to the fields

body functions à recognition of pronunciation à sound wave à interpretation

- indicates high extent of sound organization

speech can be analyzed on various levels:
a. anatomy/physiology focus
b. unit of sound focus
c. analyzing and processing of incoming sound wave
Phonetics: concerned with a-c; corresponds with:
1. anatomy and physiology of speech
2. articulatory phonetics (identification and classification of individual sounds)
3. acoustic phonetics (instrument analysis and measurement of sound waves)
4. auditory/perceptual phonetics

Phonetics and phonology: introduction to the fields

Speech: purposeful activity
- speech patterns convey meanings à

cf. English vowel system - vowel sounds vs. vowel letters
[*limb/hymn/live/sieve*] - same vowel sound
vowel length: relative length before [g], [d], longer than before [k], [t]
à shortening effect: voiceless consonants
lengthening effect: voiced consonants
Phonology: concerned with organization of speech in specific languages
languages select from potentially infinite speech sound inventory (Hockett: phoneme inventory of all known languages: between 13 and 75)

Phonetics vs. phonology: differences

Differences in methodology:
- phonetics: methods from natural sciences
- phonology: methods from humanities; concerned with the mental aspects of language

Interpretation A: phonetics deals with objective reality; phonology deals with linguistic organization
Interpretation B: phonology tackles the true mental reality behind speech;
phonetics handles only the concrete outputs of this reality

In summary:
- character of phonetics: more general/universal
- character of phonology: more language specific

Phonetics vs. phonology: differences and integration

Phonetics	Phonology
• attempts generalization of speech organs and acoustics • concerned with actual physical properties, can be precisely measured and described	• less interested in generalization across languages • concerned with symbolic categories, e.g. describes allowed consonant sequences

à difference is not covered by competence/performance dichotomy
Integration: much work in phonetics IS language specific
both: justified empirically
- true reality: a "reality of integration" (Clark/Yallop 2002)

Phonetics and phonology: *Interdisciplinary research*

From: New Scientist 29 March 2003

From: New Scientist 22 February 2003

Phonetics: an outline

• Study of the physical aspects of speech events
Speech: most common medium of language transmission
à phonetic description is relevant for preservation of pronunciation
development: 19th century, parallel research to
a.) spelling reforms, b.) teaching, c.) deaf training,
d.) historical sound change: increase in phonetic research
today: phonetics is interdisciplinary: linguistics, psychology, computer science, engineering

Areas of phonetic research:
1. production of speech
2. acoustics
3. perception

Areas of phonetic research

Areas 1-3 concerned with universal linguistic questions:
• What is the range of speech sounds in human languages?
• Why do languages prefer certain combinations?
• How does speech convey linguistic structure (not actually meaning) to listeners?
à interesting: what sounds are used across languages

Reasons for phonetic research:
• standardization of spelling
• to capture the variation in dialect research
• to record indigenous languages
• speech therapy
• speech generation and understanding

Areas: 1. Production of speech

Basis for:
a.) traditional transcription, cf. IPA and
b.) for phonological feature systems (cf. Ladefoged)
features: all sounds share some properties, cf. nasality
à interface between phonetics and phonology
A airstream mechanisms
B phonation/voicing
C articulation
D oro-nasal processes
à speech sounds are a combination of A-D
E suprasegmental variation/prosody
= some segments/combinations of segments are made more prominent via: loudness, length, pitch
(phonetically analyzed as: amplitude, duration, frequency)

Areas: 2. speech acoustics

Sound wave transmission from speaker to hearer is described after prominent frequency components and interval durations
à speech: result of acoustic sources
• sources: phonation, larynx-produced noise, airstream constriction
vocal tract has filter functions
• function of these sources as "formants"
• formant resonances depend on airway size/shape
• airway size/shape: modified by articulators

Use of visual displays (frequency or intensity over time)
à spectrograms

Areas: 2. speech acoustics - *spectrograms*

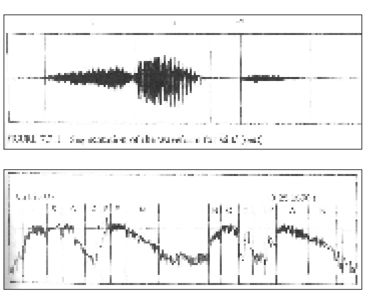


Fig. adapted from Clark/Yallop 2002:227

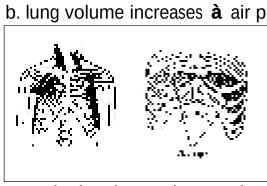
Anatomy and physiology of speech production

1. Airstream mechanisms and 2. Places of articulation
speech organs: body structures with varying tissue types
organs of speech: no system of primary biological functioning

1. Airstream mechanisms - subglottal and supraglottal
• respiratory system: starts subglottally
respiration cycle: source of airflow + for sequential organization of speech
• subglottal tract: contained in thorax (chest)
thoracic cage consists of ribs, shoulder blades, collar bones + diaphragm
• reservoir for airflow: lungs; connected to windpipe (trachea) by bronchial tubes (join at trachea base)

Anatomy of speech production: *The lung-thorax system*

• system of contraction vs. expansion
a. inspiration: thoracic cavity enlarges by expansion of ribcage (structure rises)
b. lung volume increases à air pressure decreases

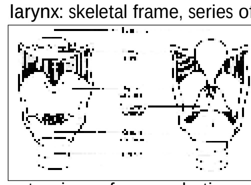


• diaphragm and elastic recoil forces: control quiet breathing and create relaxation pressure
• extreme expiration: even back muscles are used (shout)
• tendency: consistent pressure below glottis (subglottal pressure Psg)

c. expiration: lung volume reduces à rising pressure relative to external atmosphere

Anatomy of speech production: *Larynx*

• basic function: valve between esophagus and windpipe
• speech function: source of sound and articulator
windpipe (trachea): series of cartilaginous sections
larynx: skeletal frame, series of cartilages



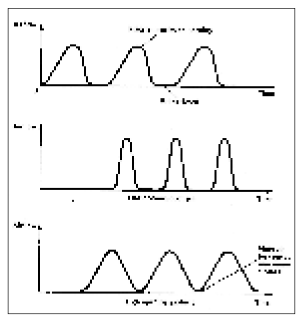
• thyroid angle: gender difference 90° male, 120° female
• tilting: important for vocal fold tension
• upper anterior part: epiglottis deflects food
• conus elasticus and arytenoid cartilages form glottis

extensions of conus elasticus: vocal folds
• function controlled by muscles (*abduction* - opening, *adduction* - closing and *tensioning* of vocal folds)

Anatomy of speech production: *Phonation anatomy*

Phonation: vocal fold vibration
1. glottis closed, vocal folds adducted
à expiration airflow builds pressure until folds are forced apart
2. folds start to open from bottom to top; air escapes through opening
3. Bernoulli effect: air escapes and accelerates/pressure reduces à vocal folds close again
(pressure reduction presses folds together, supported by muscular elasticity)
4. repitition of 1.-3. à folds vibrate, escaping packets of air generate sound;
à this produces a modulated airstream

Anatomy of speech production: *Phonation modulation*



1. Normal modulation during speech
• folds take longer for opening than for closing

2. Loud and bright speech
• speech modulation via rapid opening/closing
• less time spent with open folds

3. Soft speech, "breathy" voice
• folds do not close completely

Anatomy of speech production: *Phonation parameters*

a.) loudness; b.) pitch; c.) timbre
a.) loudness: related to subglottal pressure
b.) pitch: correlate of frequency of vibration; determined by length and tension of the folds
c.) timbre: "mellowness"/"sharpness"; determined by mode of vocal fold vibration
à increasing loudness: folds are closed for longer periods because: Bernoulli effect forces folds further apart/pulled together faster
• more "sharpness" generated by rapid velocity changes of airstream
Parameters are influenced by age effects: e.g. *jitter* (vibration in frequency), *shimmer* (vibration in loudness)

Anatomy of speech production: *Pharynx*

Pharynx: muscular tube between glottis and skull base
à air passage for respiration, only passive contribution to speech production

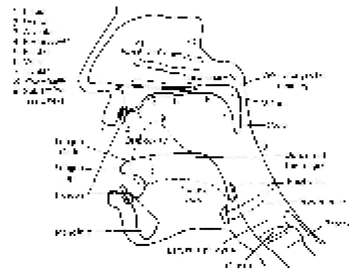
a.) lowest section: laryngo-pharynx
b.) mid section: oro-pharynx, bound by soft palate
c.) upper section: naso-pharynx

Anatomy of speech production: *Velum and nasal cavity*

Velum: continuation of roof of mouth, flexible muscular tissue, ends in uvula (small tip of muscle)
• seals off entrance to naso-pharynx (velopharyngeal port)
• muscles serve to lower/raise velum and enhance closure
• some languages (French, Portuguese): oral/nasal vowels
• English/German: only oral vowels
• stops: intra-oral pressure build-up **à** only when velum is fully raised

Uvula: responsible for trill sounds in some languages
Nasal cavity: air intake system, mucous membranes line complex cavities without muscular structures

Anatomy of speech production: *Oral cavity*



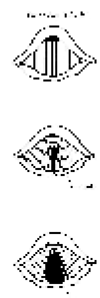
Oral cavity: important for quality of speech sounds
• shape/volume can be modified
• limited by: tongue, palatoglossus muscle, roof of mouth, alveolar ridge
• place of most articulators: *lips, teeth, alveolar ridge, hard palate, soft palate*

Anatomy of speech production: *Tongue and lips*

Tongue: changes volume/shape of oral cavity
• tongue complex muscular structure
• surface area: can be separated into *tip, blade, front, center, back*
• no anatomic reason for classification/subdivision, only phonetic reasons
• muscle systems shorten/(expand, raise/lower, flatten/contract tongue

Lips: termination of oral cavity
• two muscular folds; functions: opening/closure, raising/lowering, rounding/protrusion
• different movements **à** precise lip control relevant in articulation: rapid opening/closure

Places of articulation: *Glottis articulation*



1. Closed glottis: vocal folds brought close together, no air passes
• speech sounds emerge via closure and subsequent opening **à** *glottal stop*, cf. forcefully pronounced vowels (*Out!*),
• used in many British accents
2. Narrow glottis: narrow gap for air
• vibration of folds propagates up the pharynx; all vowels and [m], [l], [v], [b] are *voiced speech sounds*
3. Open glottis
gap for airstream, no vibration
à *voiceless speech sounds* [s], [k]

Places of articulation: *Oro-nasal articulation process*

Airstream can pass: 1. nasal cavity; 2. oral cavity;
• direction determined by *velum*
Velum can be manipulated by speaker
à two linguistically significant positions

1. Raised velum; raised and pressed against back of pharynx,
• nasal cavity is blocked
• air emerges through oral cavity,
• creates *oral speech sounds*
cf. all English vowels, [v], [f], [l]
• additionally, the oral cavity can be blocked as well **à** temporary full stoppage, cf. [p],]t], [*happy*]

Places of articulation: *Oro-nasal articulation process*

2. Lowered velum
• airstream has access to nasal cavity
• if oral cavity is blocked, **à** entire airstream escapes through nasal cavity, creates *nasal speech sounds* [m], [n] [*might, night*]
• some languages: oral passage is not independently blocked, airstream divided in two
• creates *nasalized oral speech sounds*
cf. French vowels [*vin*]

Places of articulation: *Oral tract places - articulation*

- Classified according to: - where articulation takes place
  and - position of tongue (if active)

1. labial: concerns lips; a.) labiodental (*feel, veal*)
   b.) bilabial (*pea, bee, me*)
2. dental: refers to upper teeth (*think, this*)
3. alveolar (*toe, dough, no*)
4. postalveolar: from tooth ridge to start of hard palate (*ray, sky*)
5. palatal: from hard palate to beginning velum (*you, keep*)
6. velar: from velum to uvula (*core, gore*)
7. uvular: tongue back touches uvula (*Trompete*)
8. pharyngeal: from pharynx to tongue root (used in Arabic)
9. glottal: glottal stop (*pu'* for *put*, London accents)

Places of articulation: *Oral tract places - tongue position*

1. apical (tip/front of tongue, used in English and German alveolars)
2. laminal (anterior part of tongue blade, used in Australian aboriginal languages)
3. dorsal (from tongue blade to tongue root)
4. sublaminal (underside, used for retroflex, Hindi)

cf. *heed/hard/hoard* [i:] [a:] [ɔ:]

- identical phonation and velum position
- different: resonant properties of the oral cavity
- determined by: tongue position, lip shape, mandible opening

Places of articulation: *Vowels and consonants*

[i:] - tongue: front and raised, lips are spread
[a:] - tongue neutral and retracted, lips open in neutral position
[ɔ:] - tongue retracted, lips are rounded
à vowel sounds: shaped by varying geometry but without obstruction/constriction of the airstream
à consonant sounds: obstruction and interference of airstream via speech organs

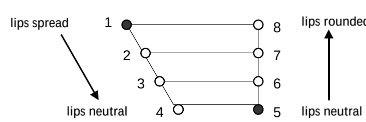
Properties of vowels:
- central/nuclear in syllables
- stand as an entire syllable (cf. *I, a, awe*)
- prominent, constriction is irrelevant

Properties of consonants:
- greater constriction/less prominence than vowels
- cannot stand as an entire syllable
- classified according to degree of constriction

Manners of articulation: *Unobstructed vowel articulation*

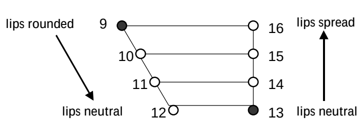
A classification of speech sounds in terms of the type of obstruction made to the flow of air. A vowel makes very little obstruction, while a plosive (stop) makes a total obstruction. (Roach 1992)

- System of cardinal vowels (Jones):



Cardinal vowels:
1: tongue as high and fronted as possible
5: as low and retracted as possible
- established with lateral X-ray shots
- all known vowels can be placed in this diagram
- recent research: vowels can be produced with alternatives, not all vowels are covered

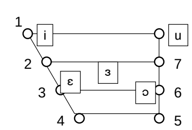
Manners of articulation: *Cardinal vowels*



à cardinal vowels are no exact specifications but approximations of vocalic sounds
- most world languages have fewer vowels
- classical Arabic, Aboriginal languages: only 3 distinctive vowels
- vowel systems usually inhabit the outer regions of the cardinal vowels

Manners of articulation: *Cardinal vowel approximation*

	English	German		English	German	Other
1 [i]	*beat*		9 [y]		*für*	
2 [e]		*Leben*	10 [ø]		*Goethe*	
3 [ɛ]	*bet*		11 [œ]		*Götter*	
4 [a]	*spa*		12 [ɶ]	-	-	-
5 [ɑ]		*hat*	13 [ɒ]	*hock*		
6 [ɔ]	*hawk*		14 [ʌ]	*but*		
7 [o]		*Moral*	15 [ɤ]			Vietnam. o
8 [u]		*gut*	16 [ɯ]			Japanese u



Manners of articulation: *Types of consonant articulation*

Parameters of description: degree of constriction; shape of constriction (stricture) and process (dynamic or stable)
Manners: stop, fricative, approximant, nasal, flap, tap, trill
1. obstruents
a.) stop: formation and rapid release of complete closure
- dynamic, velum raised
- egressive pulmonic air escapes à plosives (*pie*)

b.) fricative: constriction is narrow enough to create a turbulent airstream, can be prolonged à stable
- parameters: stricture, place, phonation
- airflow rate: higher in voiceless consonants (*thought*)
- lower in voiced consonants (*there*)

Manners of articulation: *Types of consonant articulation*

2. approximant (glide, semivowel):
- constriction greater than vowel but not sufficient for turbulence à semivowel (*law, war, you, raw*)
- usually voiced

3. nasals: stoppage in oral cavity
- unlike stops, they are stable (*many*)

4. dynamic manners
a.) flap (*Resultat*) b.) tap (*matter*) c.) trill (*perro*)

Stricture: shape of constriction
1. central: neutral concerning tongue (*trip, chip*)
2. grooved: tongue creates narrow area along vocal tract [s], [z], [ʃ]
3. lateral: airstream is diverted from center to both sides [l]

The units of speech: *Identification of speech units*

- language depends on discrete/finite options
- humans perceive relative contrasts; cf. pitch

System: a finite number of elements forms set of contrasting options

Units point to systemic nature, depend on levels of description (speech sounds/syllables/words)
- levels depend on focus, cf. description of stress à relative parameter à syllable
- articulation: no discrete, comfortable entities
- working theory: any sound can be established as a stable state of articulatory mechanisms (= target)
- reality for stable sounds, only theory for dynamic sounds

The units of speech: *Parameters of speech units*

1. energy as parameter: à peaks of prominence: vowels
- in syllables: vowels = nuclei
- consonants: surround nucleus as onset/coda
- vowels: high acoustic energy

2. sonority as parameter = energy in proportion to effort
- sonorous sound: high output relative to effort

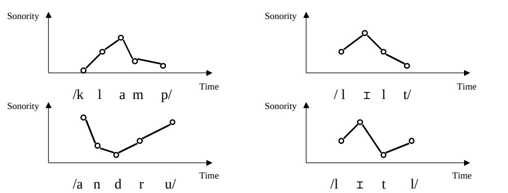
à notions are: segmentation and structural organization

3. articulation: has primary features (place / manner)
- has secondary features: has constrictions lower than primary and has alternative places

The units of speech: *Sonority and syllables*

Speech sounds: ranked according to relative sonority
- voiceless oral stops: minimal sonority, low vowels: high sonority; between these extremes: sonority spectrum

oral stops - fricatives - nasals - laterals - semivowels - high vowels - low vowels
à peaks of sonority used to predict numbers of syllables



Variation of segments: *Consonants*

1. nasalization: permanent nasal articulation; pathological condition, dialectal or habit
2. labialization: rounded lips for any sound that has normally spread lips
3. palatalization: tendency of the tongue to move to a high front position
difference clear [l] / dark [l] (German/English)
4. affrication: stops are produced with more friction than necessary
5. vowel retroflexion: [r] - focusing in *car, rear*

Variation of segments: *Vowel length*

1. length/duration depends on: a.) vowel quality;
b.) surrounding components
a.) low vowels are longer than high vowels, need more vocalic effort to produce
b.) vowels are longer in front of voiced consonants than in front of voiceless consonants, cf. *rib/rip; food/soot*
• length can be a differentiating feature,
cf. *seat/sit; seek/sick*
• is a relative parameter, depending on comparable contexts

Variation of segments: *Onglide/offglide and diphthongs*

2. onglide/offglide effects: simple vowels are stable,
• articulators have steady target configuration
• start/end of a vowel involve articulatory movement **à** vowel is preceded and followed by a transition of articulators; **à** results in change in auditory quality: onglide/offglide, cf. *fee* in different varieties of English
• glide component can be distinctive, cf. diphthongs
3. diphthongization: 2 vocalic targets determine the glide in between;
= a sound in which there is a glide from one vowel quality to another (Roach)
RP: [ɪ] **à** [eɪ, aɪ, ɔɪ]; [ʊ] **à** [əʊ, aʊ]; [ə] **à** [ɪə, eə, ʊə]
• are on a continuum with onglide/offglide

Variation of segments: *Vowels and consonants*

Syllabicity; syllabic nucleus: usually a vowel but can also be formed by nasal or lateral consonants
sudden [sʌdn], *model* [mɒdl]
• German unstressed final *-en* as in *haben* [ha:bm]
Segmentation: distribution of vowels and consonants according to phonotactic rules
• in sequences, phonemes are not allowed to appear in any possible order
• phonotactics involve intuitive findings:
bump, lump, hump, rump, clump **à** large, blunt objects
muddle, fumble, straddle, fiddle, struggle, wriggle **à** clumsy, difficult action

Units of speech: *Units in phonology*

Phoneme: smallest unit of speech with distinctive function
• each language has a relatively fixed set of phonemes
• defined in contrast to phonemes of the same language
• language acquisition includes phoneme acquisition

Feature: minimal contrastive element in phonology
à originally phoneme considered the smallest constituent but: could be broken down into features
• features form system of polar contrasts, labeled +, - or 0
• features distinguish each phoneme from other phonemes
à minimum number of features needed
Standard assumption: 12 features to be sufficient

Distinctive features: *Jakobson/Halle system*

Jakobson: one language has limited number of oppositions
• can be captured as differential qualities
à of two languages, the distinctive features must be language-specific
Jakobson/Halle: use perceptual terms for acoustic perception
à spectrum between polar features:

acute	grave
high end of spectrum	low end of spectrum
high front vowels	back vowels
palatal consonants	velar and labial consonants

Jakobson/Halle system: 12 polar contrasts (relative contrasts)

Distinctive features: *Prime features (Ladefoged)*

Prime features: measurable properties, e.g. [+/- nasal] = degree of raising of velum
• any sound can be described according to this feature
• most basic prime feature: [+/- voiced], binary
• some features: multivalued (e.g. place), have more than 2 positions

feature	options	English
voice	[+ voice]	/b, d, g/
	[- voice]	/p, t, k/
place	[labial]	/p, b/
	[dental]	/θ, ð/
	[alveolar]	/t, d/
	...	
stop	[stop]	/p, t, k/
	[fricative]	/f, θ, s/
	[approxim]	/w, v, l/

• other binary features: nasal, lateral, sonorant, back, syllabic
• other multivalued features: height

Distinctive features: *Chomsky - Halle feature system 1*

Any feature defined as binary à multivalued features (place, stop, height) to be replaced

1. place: a.) anterior vs. nonanterior
   obstruction in front of palato-aolveolar region
   [+ anterior]: /p, t/ [- anterior]: /k, g/
   b.) coronal vs. noncoronal
   tongue blade raised from neutral position
   [+ coronal]: /t, d, n/ [- coronal]: /p, b, m/
   c.) distributed vs. nondistributed
   constriction with considerable distance along air flow
   feature differentiates fricatives
   [+ distributed]: /x/ [- distributed]: /f, θ/

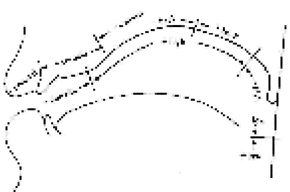
Distinctive features: *Chomsky - Halle feature system 2*

d.) back vs. nonback
tongue body retracted from neutral position
[+ back]: /ʊ, o, ɔ/ [- back]: /i, e/

e.) high vs. nonhigh
tongue body raised from neutral position
[+ high]: /i/ [- high]: /e/

f.) low vs. nonlow
tongue body lowered from neutral position
[+ low]: /a/ [- low]: /e/

Distinctive features: *Chomsky - Halle feature system 3*



	anterior	coronal	high	back	low
bilabial	+	-	-	-	-
labiodent	+	-	-	-	-
dental	+	+	-	-	-
alveolar	+	+	-	-	-
retroflex	-	+	+	-	-
palatal	-	-	+	-	-
velar	-	-	+	+	-
glottal	-	-	-	+	+

fig. & table adapted from Ladefoged 1993

2. Stop: a.) continuant vs. noncontinuant
   airflow is not entirely blocked
   [+ continuant]: /z, l/ [- continuant]: /d/
   b.) instantaneous release vs. delayed release
   [-/+ delayed]: less/more turbulence created, cf. stops/affric.

Acoustic phonetics: *Introduction*

Def: The study of the physics of the speech signal. Mechanical vibrations of air to be analyzed by experimental techniques, e.g. spectrographs (Roach 1996)

Sound waves: variations of air pressure, are superimposed on outgoing air
Variations propagate through air as mechanical waves

pitch: depends on glottis vibration frequency, [ɔ:] 100 Hz
• proportional to frequency, = peaks per second
Voiced speech sounds: have regular waveform
male: 80 - 200 Hz
female speakers: 400 Hz

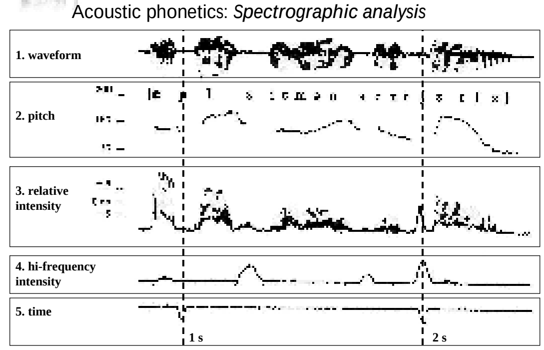
Acoustic phonetics: *Pitch and intensity*

Voiceless sounds: airstream goes across irregular surfaces higher rate of pressure changes; -- around 2000 Hz

• waveform of the vowel [ɔ:] at 100 Hz
(adapted from Ladefoged)

loudness/intensity: proportional to extent of pressure variation, measured in decibels (dB)
vowels: highest intensity; voiceless fricatives: low intensity

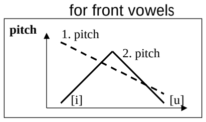
Acoustic phonetics: *Spectrographic analysis*



Acoustic phonetics: *Quality of speech sounds*

• depends on overtone structure; vowels distinguishable from overtones
• overtone noticeable when vowels are whispered
highest overtones: [i] lowest overtones: [u]
à vowels have therefore 2 characteristic pitches

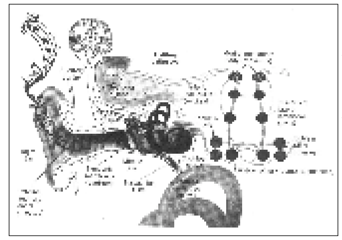
1.pitch → decrease
[i I ɛ æ a ɔ o u]
2. pitch ← increase for front vowels | decrease for back vowels →



1./2. pitch = 1./2. formant
• result of air vibration difference
• in vocal tract: air vibrates at different frequencies simultaneously = resonant frequencies

Auditory phonetics: *Theory of speech perception*

Audition/function of hearing: auditory communication and localization of sound
Helmholtz 1885: auditory system as a frequency analyzer



Békésy 1960: incoming sound wave from tympanic membrane along basilar membrane to cochlea located in the inner ear

fig. adapted from Wilson/Keil 2001:54

Auditory phonetics: *Audition and speech recognition*

Dependent on frequency, wave has different amplitudes at different locations à frequency is translated into a location code
• high frequency: near base of cochlea
• low frequency: near apex of cochlea
• resonance mechanisms stimulate cochlea hair cells

Speech perception = mapping of serial acoustic signals onto sets of discrete linguistic representations
• representations: sequences of phonetic segments (C/V)
• no 1:1 mapping of acoustic properties and phonetic utterance
• parameters of complexity: coarticulation, context, lexicon

Auditory phonetics: *Parameters of complexity*

1. coarticulation: any acoustic signal contains parallel information for more than one phonetic segment
keep à /k iː p/ /k/ different than in /k uː l/ à *cool*
à no precise form of acoustic properties that specify phonetic segments
2. context dependence
• context influences acoustic consequences of variation
3. lexicon: an ambiguous sound is perceived as the correct segment cf. /p/ - /b/ perceived as /p/ in *place*, as /b/ in *beef*

= processes of spoken word recognition
à listener needs to decode the speech signal

Auditory phonetics: *Debate in speech perception*

A: modular, speech specific mechanisms compute input
B: general perceptual mechanisms apply

Acquisition issues: in early L1 acquisition children map different variants spoken by different speakers to the correct phonetic utterance;
• later L1 acquisition: fine-tuning of speech perception
• children develop from "language-general" to "language-specific" perceivers of speech

Auditory phonetics: *Spoken word recognition*

Words are heard in sequence, seldom in isolation
à process involves segmentation and recombination
• limited set of phonemes leads to similar words

steak /steɪk/ includes: *stay* /steɪ/ *take* /teɪk/ *ache* /eɪk/

resembles:
state /steɪt/
snake /sneɪk/
stage /steɪdʒ/

is included in: *mistake* /misteɪk/

Auditory phonetics: *Word recognition models*

1. Marslen-Wilson/Welsch: cohort model
• incoming word activates all other words beginning the same way (the whole "cohort" is activated)
• gradual reduction of activation of rejected words
2. Luce/Pisoni/Goldinger: neighborhood activation model
• lexical neighborhood is determining
• most frequent words in a language are easier to recognize
3. McClelland/Elman: TRACE model
• competition model of activated words via connectionist networks; network has feature detectors that analyze spectral components every 5 ms
• competition offers solution to segmentation problem
• general phenomenon: co-activation of competing words

Phonological organization of speech: *Output issues*

Human languages: systematizes output that is potentially possible
• speakers use output within limitations of rule systems **à** phonological normativity
• phonological norms are acquired, not learned
à perception of the "same" word even when uttered differently by different speakers
• variation of size/shape of vocal tract **à** differences
• context-sensitive variation: articulation is influenced by neighboring sequences **à** overlapping
effects: 1. Physiological 2. Cognitive
3. Historical 4. Articulatory

Aspects of change in phonological organization

1. biomechanical and neuromuscular limitations (tongue tip speed, lip rounding rate change etc.)
• inherent inertia, delay of motion, coarticulation
• rapid talk: tendency of vowels to become centralized

2. relationship of thinking/speaking; effects: slips of the tongue, spoonerisms as in *to shake a tower* etc.

3. historical changes: assimilation (*special* /sj/ **à** / ʃ /)
pan /n/ **à** /ŋ/ *pancake*
• change of consonant in front of velars

Prosody and intonation in phonetics and phonology

Prosody: grouping/relative prominence of elements making up the speech signal **à** e.g. perceived rhythm of speech
• hierarchy: from intonation phrase to syllable components
• intermediate: syllable, metrical foot, prosodic word

Intonation: melody of voice; used to mark the pragmatic force of the information in the utterance
à intonational events are aligned with most prominent elements of prosodic structure and at the edges
à intonation provides information about prosodic structure

Prosody: refers to intonation contour, stress pattern and tempo of an utterance prosody phonetic correlates: pitch, amplitude, duration

Intonation correlates: fundamental frequency of voice F0, perceived as pitch determined by: configuration of larynx subglottal pressure & degree of oral closure

Prosodic markers of the speech signal

Segments in prosodically prominent positions: more forceful and fully articulated than in weak positions
• edges of prosodic units: consonantal articulation strengthened at initial edges; final syllables: lengthened
• a phoneme in one prosodic position can be like another phoneme, cf. /z/ **à** /s/ [*clothes*]

Prosody and intonation are language universals
Mandarin Chinese: lexical tone prosody: English permits prominence located anywhere in phrase
other languages: more prominent parts are moved to fixed prosodically prominent positions (German)

Prosody and syntax: Segmentation issues

Relevance of melody in recognition: aids in segmenting continuous input
• listeners use rhythmic structure to determine where word boundaries are
à segmentation: stress-based (English)
syllable-based (French)
mora-based (Japanese)
• Stress used for disambiguation:
I read about the repayment with interest
• therefore: importance of prosodic salience; semantically central words are highlighted via accent
• but: no evidence that syntactic structure is derived from prosodic/intonational cues
• placement of accent on new info/deaccenting of old info

Is prosodic info used to locate lexically unfilled positions?

Which book did the teacher read ____$_i$ *to the class?*

Wh-movement

filler gap

Bresnan et al: filler is "reactivated" when gap is auditorily processed; sentence processing theory: constituent hierarchy must be identified in order to process the right constituent at the gap

à paradox: how can a "phonetically invisible" element (the gap) be identified?

• Hypothesis: prosodic markers provide information on determining gap locations (Nagel et al.)

Parsing strategies on gap-filling processes

1. Fodor: parser delays possible gaps until input is reached
• problem: real-time processing constraints
2. Parser places possible gaps anywhere
• problem: more than one possible gap

Which student did the teacher walk (___) to the cafeteria with ____$_i$*?*

• *walk* opens argument position which turns out not to be the "true" gap

à results are ambiguous sentences

3. Cues within sentence enable an "informed decision"
• lexical expectation hypothesis, supported predominantly by syntactic cues as e.g. strong transitivity, cf.

Which book did the teacher read ____$_i$ *to the class?*

• problem: intransitive verbs

Experimental evidence for prosodic cues in gap-filling

Mary had orange juice this morning and I had grape ____ just last night

Mary had orange juice this morning and I had grape juice just last night

• differences in gap region:
1. duration, word preceding gap is longer
2. pitch: greater extent between maximum and minimum

Result: dependent on reaction times a priming of the fillers occurred that can be correlated with prosodic cues

• gaps are not "phonetically invisible"

Word boundary independence: (Supra) segmental contrast

• allophonic rules ignore word boundaries

à implementation depends on tempo (= Prosody)

• segmental phoneme function: primarily a contrastive function in single monomorphemic words

à for segmental contrast, the size of the linguistic unit is irrelevant

cf. *cab/cap* as in: *I took a cab/cap*

à for subrasegmental contrast

ˈ*black* ˌ*bird* vs. ˌ*black* ˈ*bird* ; forms minimal pair concerning stress contour (à difference in meaning)

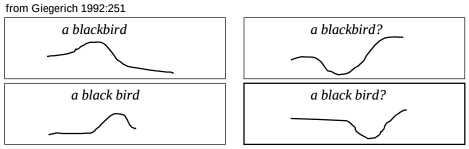
• involves units larger than single words
• phonological analysis is therefore not confined to words as segmental/morphological units

Stress beyond the single word

Linguistic unit with more than one stressed syllable: stresses of different relative prominence (primary and secondary stress); cf. ˌ*polysyl*ˈ*labic*

• similar stress contour: in syntactic phrases e.g. blackbird
• stress (acoustic definition): syllable is marked with greater duration/loudness than unstressed syllable
• primary stress: also marked in pitch contour (intonation)

from Giegerich 1992:251

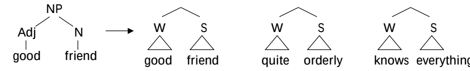


Phrasal stress and syntactic structure: Prominence rule

NP	*good friend*	VP	*knows everything*
	heavy metal		*drinks heavily*
AP	*very good*	AvP	*very well*
	incredibly heavy		*quite orderly*

sentences *Cigars smell*
Janet smokes

• unmarked: all carry final stress, changed only for special emphasis
• metrical trees reflect syntactic trees

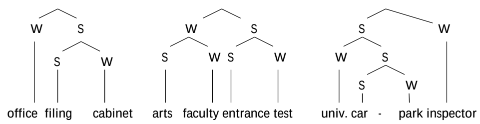


à phrasal prominence rule: in a pair of sister nodes $[N_1, N_2]_P$ where P is a phrasal category, N_2 is strong

Compound stress and morphol. structure: Prominence rule

['AB] *greenhouse*
[A['BC]] *office filing cabinet*
[['AB]C] *blackboard eraser*
[[ˌAB]['CD]] *arts faculty entrance test*
[[A['BC]]D] *university car-park inspector*

à complex prominence patterns



à compound prominence rule: in a pair of sister nodes $[N_1, N_2]_L$ where L is a lexical category, N_2 is strong if it branches above the word level

- rule difference: in phrases, final parts are strong