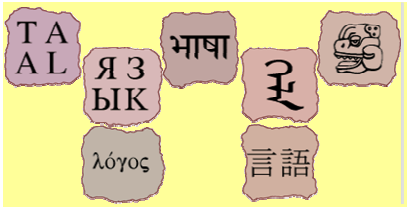
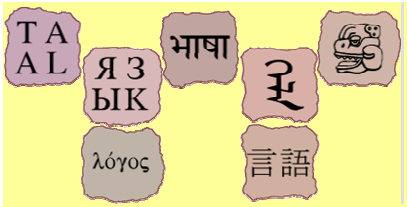


Phonology - How Speech Sounds Combine

Introduction to Linguistics for Computational Linguists

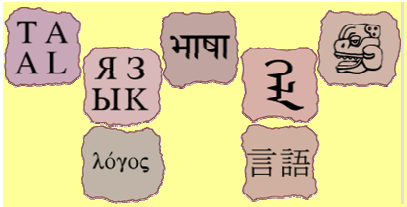


Speech Sounds

- Phonetics - Physical basis of speech sounds
  - Physiology of pronunciation, perception
  - Acoustics of speech sounds
- Phonology - Patterns of combination of speech sounds
  - Which sequences are allowed (phonotactics)
  - Effects of context on speech

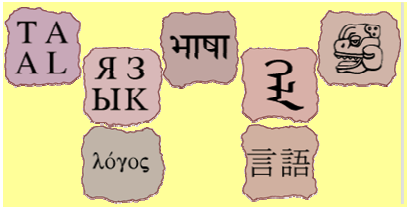
Phonology

- Basic elements are *phonemes*.
- Patterns of organization are *phonology*.
  - *Structure of phoneme set*
  - *Syllables, phonotactics* (order of phonemes)
  - *Processes* (adjustments in pronunciation)
  - Rhythm, stress, tempo (not in this course)
- Phonological principles are psychological, sometimes with phonetic (physical) base



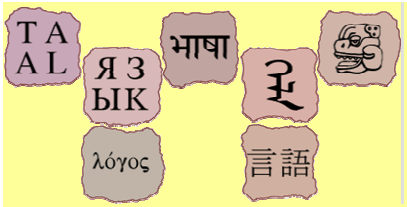
Other Phonology

- Stress, rhythm, intonation
  - Stress: *'Verb und Nomen* vs. *Ver'bundnomen*
  - Rhythm*: Nicht! Aufhören!* vs. *Nicht aufhören!*
  - Intonation: *Ich bin der Nächste.* vs. *Ich bin der Nächste?*
- Tempo, intensity (loudness) also
- Emphasis (here) on segmental level
  - Stress, rhythm, intonation are *suprasegmental*



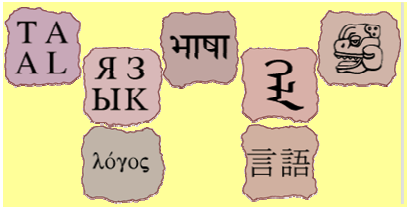
Phoneme Inventory

- Structure in set of phonemes
  - cross-classification in phonetic features
  - multidimensional matrix
  - place, manner, voice
  - [p,t,k] vs. [b,d,g] / [f,s,χ] vs. [v,z,-]
- Symmetry, but imperfect
  - gaps (German voiced velar fricative)
  - crowding ([s,ʃ] structurally close)
  - unique elements [l,R,ɘ]



Phonotactics

- Phonotactics - allowable phoneme sequences
  - reduce combinatorics of sequencing
- Which could be German?
  - [frIŋ] [fstrɛtʃ] [kwɛtʃ] [kto] [χruʃtʃof] [kRil] [ŋu] [ptero]
- Preserved in “jargon” aphasia
- Japanese allows only CV(n), i.e., consonsant followed by vowel perhaps followed by [n]
  - Borrowings with final consonants, consonant clusters modified
  - [besiboru] ‘baseball’ ; [kurIsumasu] ‘Christmas’

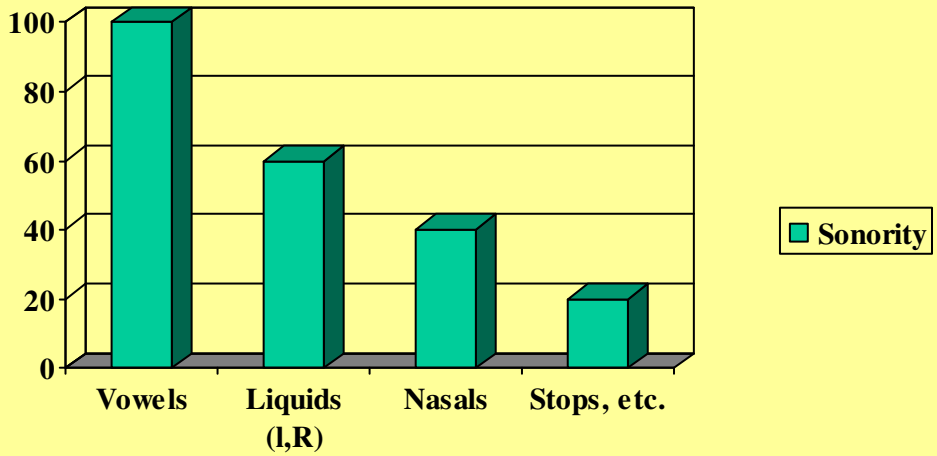


Syllables

- (onset rime) = (onset (nucleus coda))
- Rime determines what rhymes (in one syll.)
  - *groß, los* [os]; *Rad, Tat* [at]; *Zahl, Kanal* [al]
- Nucleus always vowel
- Possible clusters largely determined by *sonority*

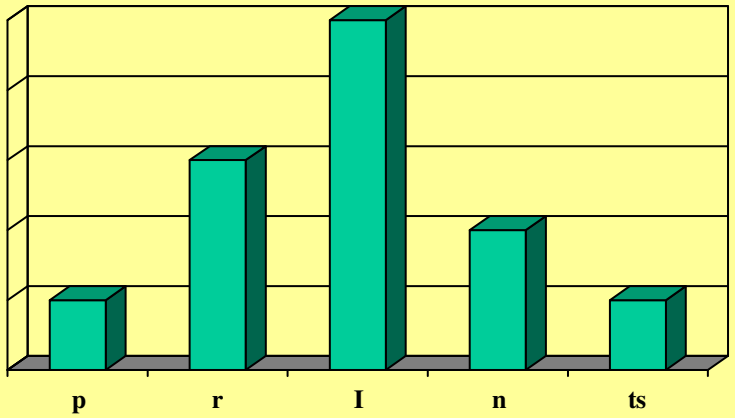
Sonority and Syllables

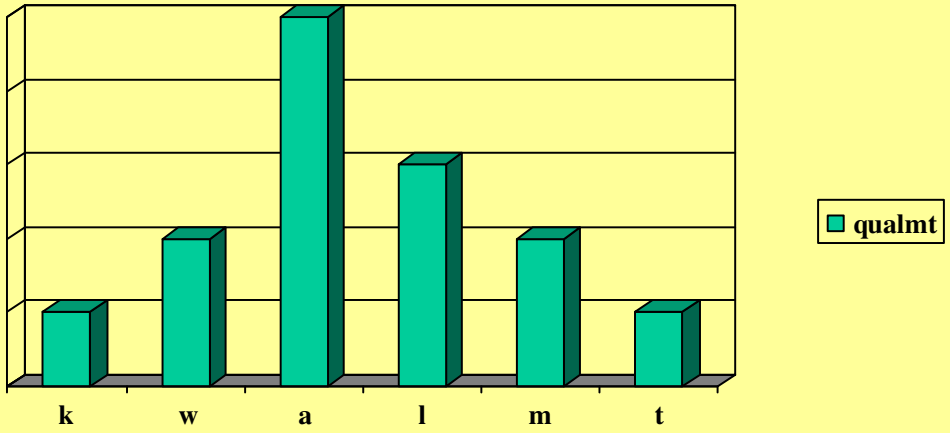
- Observation: mirror antisymmetry in consonant order in clusters in onset vs. coda
  - [plɐts], [ɐlp]; [trɐp], [fart]; [flaiʃ], [hɛlft]
- Sonority - relative prominence



Sonority in Syllable

- Sonority climbs toward peak, then declines



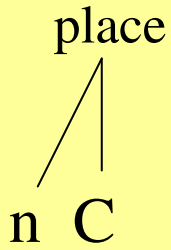


Phonological Processes

- Compare *Susi und Peter/Tom/Gabi* spoken quickly
- [zu.zi.m.petəR] / [n.tɔm] / [ŋgabi]
- ‘und’ is pronounced [m/n/ŋ]
- Similary /n/ in *Es könnte dann passen/gehen*
- Sloppy?

Nasal Assimilation

- Speech requires lots of coordination
- Nerves, muscles are preparing several segments ahead
- Often we see effects in adjacent phonemes

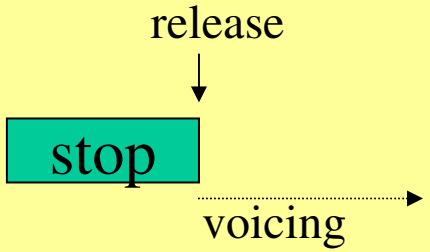


n adjusts its place of articulation to anticipate the following consonant

- Processes modify phonemes

Aspiration Revisited

- Recall from Phonetics lecture that voiceless stops are normally aspirated, i.e. voicing starts well after stop is released
- Unaspirated [b,d,g]



- Aspirated [p,t,k] -- note puff!

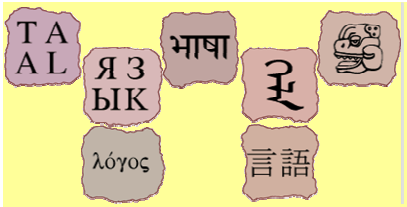
Aspiration

- [p,t,k] unaspirated after [ʃ,s]
  - [ʃpɛk] *Speck*, [ʃtImə] *Stimme,* [ski] *Ski*
- We note aspiration with [p^h], etc.
  - *Tücke/Stücke* [t^hʏkə]/ [ʃtʏkə]
- [t^h], [t] are *allophones* (variants) of the same phoneme; likewise [p^h], [p]
- Since they are found in different contexts, they are in *complementary distribution*

Informal Rule Notation

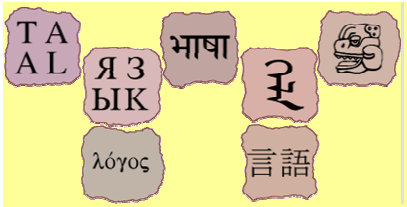
- $C_{[-voi,+stop]} \rightarrow C^{h} / . \_\_ V$

- "Voiceless Stops become aspirated in the environment (/) after syllable begin (.) and before vowels"
  - Tücke /tʏkə/ → [t^{h}ʏ.k^{h}ə]
  - phonemes → "are realized as" phones



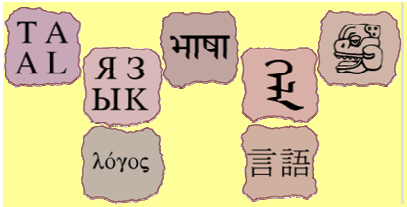
Final Devoicing

- *Auslautverhärtung*
  - *lobe* [lob.ɛ] but *lob!* [lop]
  - *blase* [blaz.ɛ] but *blas!* [blas]
  - *steige* [ʃtaig.ɛ] but *steig!* [ʃtaik]
- $C \rightarrow C_{[-voice]} / \_\_ \#$,
  - where '#' is a word boundary
  - or morpheme boundary? --See lecture on Morphology.
  - or syllable boundary? *Wagner* [wɐg.nəR] / [wɐk.nəR]



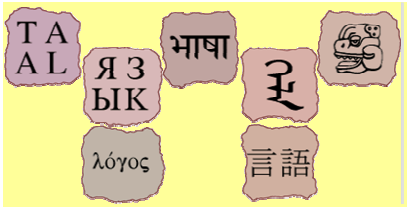
Release

- /p,t,k/ may be unreleased finally
- *Morgen geht Peter weg*. [get^{h}] or [get^{-}]
- Alternative pronunciations arising through optional processes also *allophones*, said to be in *free variation*



Releasing

- Stops before other stops are normally not released
  - [ɐkt], [kIpt] *Akt, kipt*
  - IPA [ɐk^{-}t], [kIp^{-}t]
- Third allophone of /p/: [p^{h},p^{-},p]
  - in complementary distribution and/or free variation
- $C_{[+stop]} \rightarrow C^{-} / \_\_ C_{[+stop]}$



Finding Phonemes

- To determine phonemic inventory, linguists analyze all (apparent) cases of complementary distribution and free variation

- Earlier seen as part of automatic (discovery) procedure, which is infeasible.
  - But still standard procedure

Nasalisation

- Vowels before nasals ([n,m,ŋ]) are pronounced with velum lowered
  - *eng* [ɛ̃ŋ] vs. *Eck(e)* [ɛk]
  - tilde normally above the nasalized symbol
- V → V˜ / __ N, where N is [n,m] or [ŋ]
  - allophone in complentary distribution
- French uses nasalized vowels *contrastively*
  - *beau* [bo] vs *bon* [bõ]

Intrusive [t], etc.

- Why does *Benz* [bɛnts] rhyme with *Jens* [jɛns]?
- ∅ → t / n __ s
- *Sims* [zIms] or [zImps]? Example with [ŋ]?
  - *Hamster* [hɐmp.stəR], *des Lamms* [lɐmps]
- See *Tim und Struppi* detectives *Schultze und Schulze*, English *Thomson and Thompson*

Whispered Sonorants

- [l,R,w,j] are *sonorants* (likewise nasals)
- Pronounced after voiceless stops, they are also voiceless (because of aspiration)
  - Prinz [pR̥Ints], Tratsch [tR̥at͡ʃ], Quatsch [kw̥ɐt͡ʃ], Klauen [kl̥auɘn]
- $S \rightarrow S̥ / C^{h}$ __

Weak Syllables

- Second, unstressed syllables followed by sonorants
  - *Boden* [bo.dən] or [bod.n̩]
  - *Sattel* [zɐt.əl] or [zɐt.l̩]
  - *Butter* [bʊt.əR], [bʊtə^{R}], or [bʊtə]
- əR → ə^{R}/ __ #, where '#' signifies end of word
  - kleinere [klainəRə], not [klainə^{R}ə],
- əS → S̩/ __ #

Nasals in Weak Syllables

- *Lappen* [lɐp.m̩], *loben* [lob.m̩], *kommen* [kom.m̩]
- *Boden* [bod.n̩], *Ratten* [Rɐt.n̩], *lassen* [lɐs.n̩]
- *packen* [pɐk.ŋ̍], *sagen* [zɐg.ŋ̍], *singen* [zɪŋ.ŋ̍]

- Same reduction to syllabic sonorant plus assimilation in place.
- Can create unusual pronunciations!
  - *kommen* [kom:], rennen [rɛn:], *singen* [zɪŋ:]

Reduced Nasals after Labiodentals

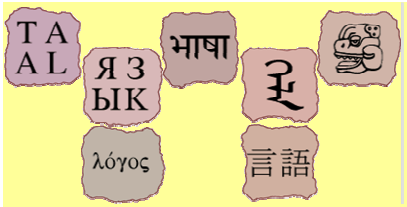
- *Laufen* [lauf.n̩], [lauf.m̩], [lauf.ɱ̩];
- *Löwen* [løv.n̩], [løv.m̩], [løv.ɱ̩];

- [ɱ] is a labiodental nasal (i.e., shares place of articulation with [f,v])

- [ɱ̩] is a syllabic version

Velar/Palatal Fricative

- [χ] (velar fricative) also pronounced palatally
  - *Aachen, [a*χ.ən*], Bach* [bɐχ], *Buch* [buχ], *Loch* [lɔχ]
  - *ich* [iç], *echt* [ɛçt], *Bücher* [bʏç.əR], *Löcher* [lœç.əR]
- χ → ç / V[+front] __
  - complementary distribution, allophones
- But *liebchen* [lib.çən], *Mädchen* [met.çən] -- Why palatal?
- ç → χ / V[+back] __ ?? (with ç as basic)

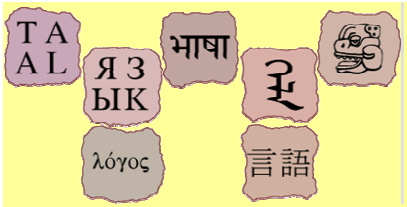


Phonemic Analysis

- *liebchen* [lib.ɕən] palatal, not after front V
- ɕ → χ / V[+back] __ but Kuhchen/Kuchen
- *Frauchen* [fRau.ɕən] vs. *Rauchen* [Rauχ.ən]
  - Near-minimal pair: with χ → ɕ rule, no account
    - we don't wish to say that *-chen* is [-ɕən] since phonological processes work on phonemes, and (under χ → ɕ rule), χ is the phoneme
  - ɕ → χ preferable
    - [fRau.ɕən] has no χ because of the syllable ('.')

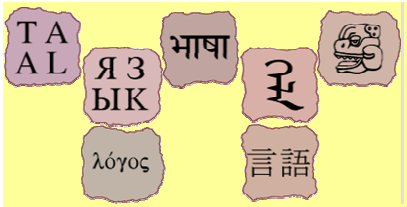
Why are there Phonological Processes?

- Speech is hard -- 2 wd./sec. (~ 10 phon/sec)
- Signals reach muscles at different speeds, which then contract in varying times
  - long nerve pathway to intercostals (in chest)
  - velum is slow compared to tongue
- Some processes simply make speech easier
  - nasal assimilation, velar/palatal alternation [ç/χ], nasalization of vowels



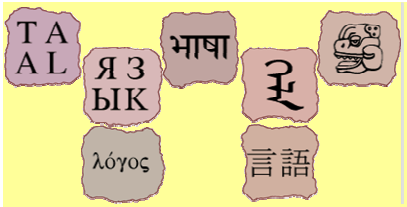
Why Phonological Processes?

- Speech is also hard to understand
- Some processes make sounds more distinct
  - aspiration
  - exaggerated release of final stops
    - Halt! [hɐlt^{h}] Gut! [gut^{h}] (compare [gut^{-}])
  - vowel lengthening under emphasis
    - Das tue ich nie [dɐs tuɛ iç ni:]



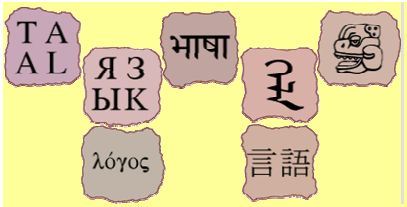
How "Real" is Phonology?

- Could patterns be accidental?
- Speakers apply native phonology even when dealing with unknown material
  - inventory
  - phonotactics
  - processes
- Evidence in generality, application to foreign material (accents/mishearings), even errors



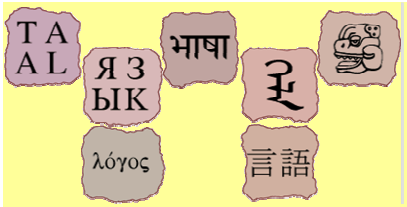
Inventory

- We tend to hear/pronounce foreign languages as composed of "our" sounds
  - Eng. ð/θ then/thin pronounced [z/d;s/t] by French, Germans
  - German front rounded vowels hard for English, Russian, Spanish speakers [y,ʏ,ø,œ]
  - Spanish trilled [r], English retroflex [r] hard for French, German speakers Sp. *perro,* Eng. *Red*
  - Initial [h] hard for French speakers
    - Eng. home [om]; Germ. *Haus* [aus]
  - Japanese r/l "Conglaturations on Erection!"



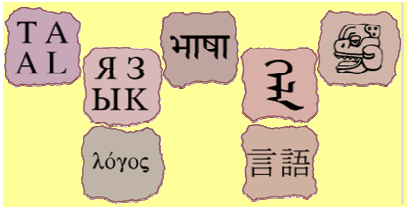
Phonotactics

- We find it hard to pronounce sounds out of place -- even if they exist in our language
  - Dutch [sχ…] used to detect Germans: *Scheveningen*
  - Sp. has sequences [prjeto] *(prieto),* [kljente] *(cliente),* [krwel] *(cruel)* -- Eng./Ger. tend to mispronounce [prijeto], [klijente], [kruwel]
  - Vietnamese initial [ŋ] hard for Europeans
    - Ngu Van Thieu [ŋu ...] “simplified” to [nju ...]



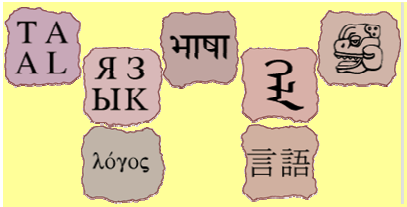
Processes

- We mishear/mispronounce by using native language processes in foreign languages
  - French hear English/German as “nasal” and *vice versa*
    - nasality in unexpected places Fr. [bõ] Eng. [bõn]
  - English/German aspiration interferes w. French
    - French [p] , Eng./German [b] similar VOT’s ;
    - French accent in English ‘You pig!’ [ju big]
  - German final devoicing in English
    - ‘Child’ [tʃailt], ‘could’ [kʊt]



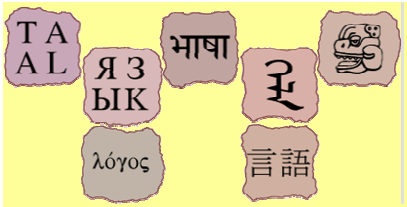
Psychological Reality

- Processes apply where they were never heard
  - foreign speech
  - errors ‘tip of the slung’ [t^{h}Ip …]
  - nonsense words
    - “’Twas brillig and the slithy toves” … [t^{h}ovz]



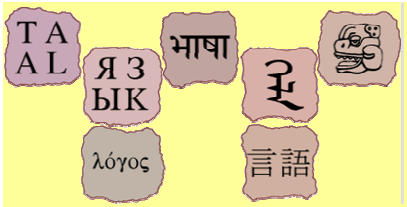
Bigger Picture

- Processes here tip of iceberg
  - [k] in *Kind* [kInd] further front than in *Kuh* [ku]
- Constant anticipation, perserverance
  - Effect of consonant on formants [ku] vs. [tu]
- Creates redundancy in signal
  - enable understanding even when perception lags
- Shifts information to acoustically prominent elements (vowels)



Phonology

- Patterns of combination of speech sounds
  - Inventory of basic sounds
  - Which sequences are allowed (phonotactics)
  - Processes -- effects of context on speech
- Emphasis (here) on segmental level
  - Stress, rhythm, & intonation are suprasegmental
- Phonology involves imposition of structure
  - seen in novel applications (foreign words, nonsense words, and even errors)



Phonology

- Phonological processes serve to **ease production and perception of speech**

- Even apparent production-simplifying processes may enhance redundancy, ensuring perception.