Coarticulation

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Introduction

- Coarticulation refers to changes in articulation and in the acoustic signal induced by one phonetic segment (*the trigger*) during another (*the target*) due to ovelap in articulatory gestures.

  E.g. *s**e**nd* → *anticipatory velar lowering*

- It may involve:
  - many articulatory structures
  - acoustic properties
  - one or more articulatory gestures

Introduction

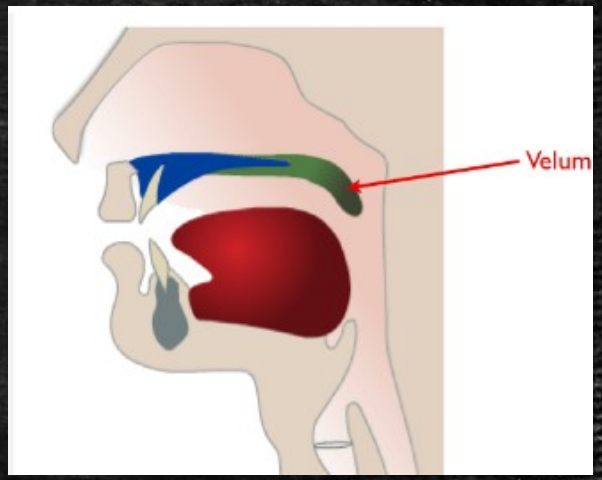
- Parameters of coarticulation:
  - spatial
  - temporal aspect (e.g. /ə/ +/ ʃ / vs /i/ +/ ʃ /)
  - direction
    - Anticipatory (leftwards): relates to phonemic planning
      →Example: it is **a** shame
    - carryover (rightwards): relates to current state of articulatory structure -
      →Example: mash **a** potato
- Direction varies by language.

Why?

- Provides information about:
  - phonological assimilatory processes
  - sound change patterns
- Coarticulatory effects: phonetic, gradual and universal.
- Assimilatory effects: phonological, categorical, systematic and language specific.
- This straightforward distinction has been put to question.
  - Counterexample #1: vowel nasalization
  - Counter example #2: final /n/ assimilation

Velum (aka Soft Palate)

- Velar Lowering in English is in line with the time-locked model of coarticulation
  - CVN sequence
  - CVVN sequence has two stages:
    a) Slow moving action
    b) Subsequent higher velocity movement
- Velar Lowering varies across languages in time and amplitude



Example: Spanish vs English VC sequences

Lips

- The two stages of anticipatory lip-rounding associated with /u/ in /iCu/ sequences.
  a) a gradual onset of lip protrusion
  b) a subsequent faster second phase from acceleration maximum to protrusion maximum (onset is speaker dependent)
- Languages differences on onset time and amplitude as a function of number of rounded vowels (E.g. Swedish vs English).

Voicing

- Voicing transmission in heterosyllabic consonant sequences is language dependent.

  Example: Catalan vs English

- Catalan : underlyingly voiced stops, unaspirated voiceless stops
  - Phonetically gradient voiceless-voiced sequences
  - Conditioned by the aerodynamic requirements of the trigger and target consonants

  Example #1: /kb/ > [gb] e.g ***sac buit*** 'empty sack'

- English: voiced stops with voiced lead or lag, aspirated voiceless stops

  → voiceless-voiced, or progressive devoicing

Voicing

- Language differences also detected in phonological regressive voicing assimilation process.
- Voicing ratio : Russian > Hungarian > Catalan
- Systematically present in C#C and CC#C sequences.
- Voicing also present in tautosyllabic syllable-onset clusters (e.g. *prayed, plead, smell*)

Tone

- Tone languages distinguish words by Fo.
- Tonal coarticulation in sequences of conflicting or antagonistic tones.
- The degree of spatiotemporal adaptation varies with direction
- Carryover effects more prominent than anticipatory effects
- Anticipatory effects more fixed and extend until vowel onset (E.g. Vietnamese).

Tongue and coarticulatory resistance

- Coarticulation occurs in flexible tongue parts not used for closures.
- Consonants and vowels can be classified depending on lingual coarticulatory resistance.
- Consonants: Resistance varies with place and manner of articulation
- Labials > dental/alveolars > alveolopalatals/palatoalveolars/palatals > /s/, /r/
- Vowels: /ə/ > /a, o, u / > /i,e/

Temporal Effects

- Coarticulatory aggressiveness: the degree a segment modifies characteristics of other phonetic segments.
- Positive correlation between resistance and aggressiveness

  Example: /əʃə/

- Production characteristics affect the direction and the extend of coarticulatory effects.
  - Anticipatory coarticulation: dark /l/
  - Carryover (alveolo)palatal consonants effects more extensive (e.g. /aɲa/).

Temporal Effects

- The strength of these effects depends:
  - the consonant's influence at the same point
    - Anticipatory: /d/ vs /ʃ/, ɲ/
    - Carryover: dark /l/ vs /d/
  - the distance between the segments
    - Arabic pharyngealized dentoalveolars
    - English VC[ə]CV sequences
  - the language (e.g. English vs Swahili)

Consonant sequences (Heterosyllabic sequences)

- Consonants have stricter production demands in consonant sequences.
- Consonant sequences show coarticulation effects in more flexible areas of the tongue (e.g. *expe**ct**ing, eleve**n sh**oes)*
- Consonant coarticulation relates to the the degree of articulatory constraints.
  - regressive assimilation when C2 is more constrained than C1. (e.g. /t, n/ + /r, s, ʃ/)
  - Gestural blending for consonant sequences with no lingual fricatives and rhotics /nɻ, ɲt/.
- Counter-examples: /r, s, ʃ/ + /t, n/

Consonant sequences (Heterorganic sequences)

- Regressive place assimilation is often triggered by velars and labials
- Front linguals more prone to assimilate.
- Example: /tk/ vs /kt/, /nk/ vs /kn/
- Consonants can blend into a single sound if their closure or constriction points are close both spatially and temporally.
- Example: "onion," /n/ blends with /j/ into [ɲ].

Consonant sequences (Heterorganic sequences)

- Manner of articulation requirements are relevant in gestural overlap (fricatives and stops < stops).
- Patterns of regressive place assimilation are language specific.
- English/ German :
  - mix of residual gestures
  - regressive assimilation
  - no assimilation at all.
- Italian/Spanish: regressive place assimilation is more commo (e.g. /n/)
- Homorganic consonants can facilitate manner assimilation.

Jaw

- Jaw height is linked to the height of the tongue dorsum for vowels.
- Jaw height varies based on how (manner) and where (place) consonants are articulated

  Consontants: /s, ʃ/, (alveolo)palatal vs. /l/, the trill /r/, and /n/

- Jaw height of consonants related to influence by adjacent vowels.
- High vowels, articulated with a high jaw, are less affected by surrounding consonants.

Acoustics

- Coarticulation can be observed in spectrographic analysis.
- Consonants can influence vowel sounds affecting:
  - tongue position (F2)
  - openness (F1)
- Vowels influence consonants, affecting:
  - endpoint and trajectory of formant transitions
  - frequency of the burst for stops
  - fricative noise (fricatives)
  - formant structure (sonorants)

Non-segmental factors

- Non-segmental factors affect coarticulation:
  - stress
    - Stressed vowels less affected by coarticulation
  - position within the syllable, word, utterance
    - More coarticulation of consonants at then end of a syllable
    - Counterexample: darker /l/ (English)
  - speech rate
    - Increased speech rate leads to increased coarticulation
  - word frequency
    - Example: you vs. union.

Perception and Sound Change

- Listeners adjust for coarticulation by attributing coarticulatory effects to their source sound.
- Example: Perception of the/ʃ/-/s/ noise continuum
- Failure to adjust for coarticulation may trigger language change.
- Mixed evidence on the relation between producing coarticulation and perceptual sensitivity.
- Example: older vs. younger Standard British English speakers and /u/

Acquisition

- Conflicting results on articulation and language acquisition:
  - **6- to 9-year-olds** show more coarticulation on /ʃ/ but less on /s/

vs.

  - **4- to 5-year-olds** have similar vowel coarticulation on /t/ as adults

→Younger children display greater variability and less consistency

Research gaps

- Limited research on jaw and lingual coarticulation in consonant clusters.
- Focus on speaker and language-dependent differences in coarticulation.
- Perception of coarticulation and long-distance coarticulatory effects (e.g. vowel harmony)
- Acquisition
- Speech disorders → planning or execution difficulties?

Conclusion

- Large-scale phonetic studies have advanced our knowledge of coarticulatory patterns.
- Greater overlap occurs in consonant-vowel (CV) sequences than in consonant clusters ◊assimilation or blending.
- Direction is influenced by the timing and spatial demands of the gestures involved.
- Coarticulatory resistance and aggressiveness are positively correlated.

Conclusions

- Anticipatory effects are more time fixed reflecting speech planning.
- Carryover effects are flexible and influenced by physical constraints.
- Coarticulation varies with factors like :
  - speech rate
  - stress
  - segmental position
  - speaker differences
  - lexical frequency
  - language characteristics.

Thank you very much for your attention!

Questions?