COARTICULATION AND CONNECTED SPEECH PROCESSES

Edda Farnetani and Daniel Recasens (2010)
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SUMMARY

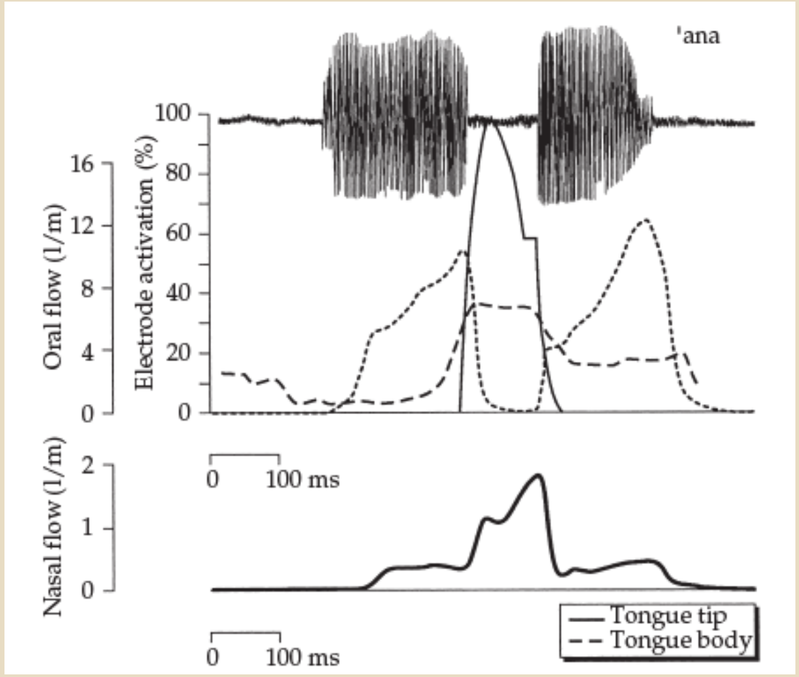
INTRODUCTION

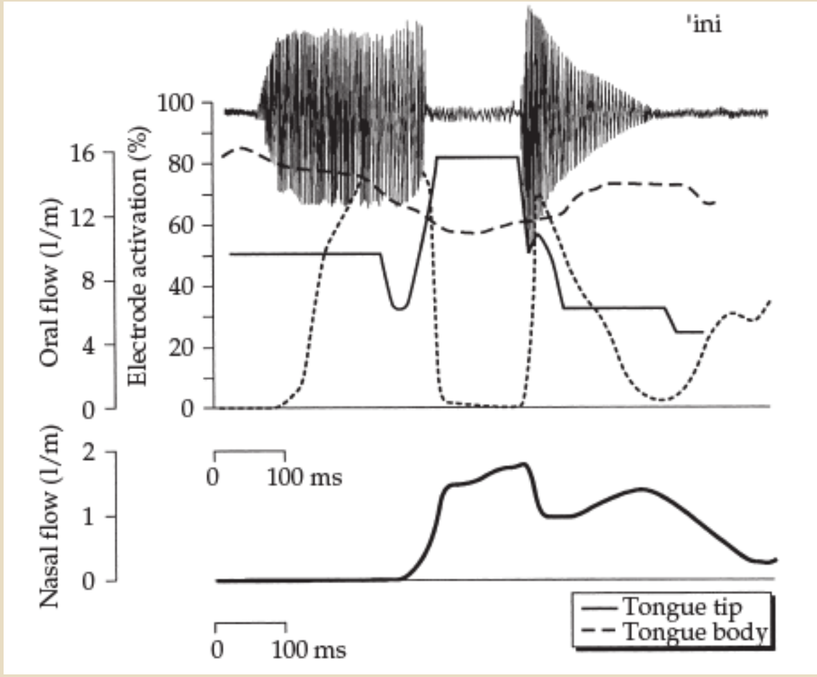
Coarticulation:

- The movements of different articulators for the production of successive phonetic segments overlap in time and interact with one another
  - When the vocal tract configuration is influenced by more than one segment at any point in time
- Levels of description: articulators and their activities, muscles, acoustic consequences
- Universal, even if it differs among languages

EXAMPLE

Velar and lingual coarticulation in Italian (Farnetani, 1986):





ASSIMILATION

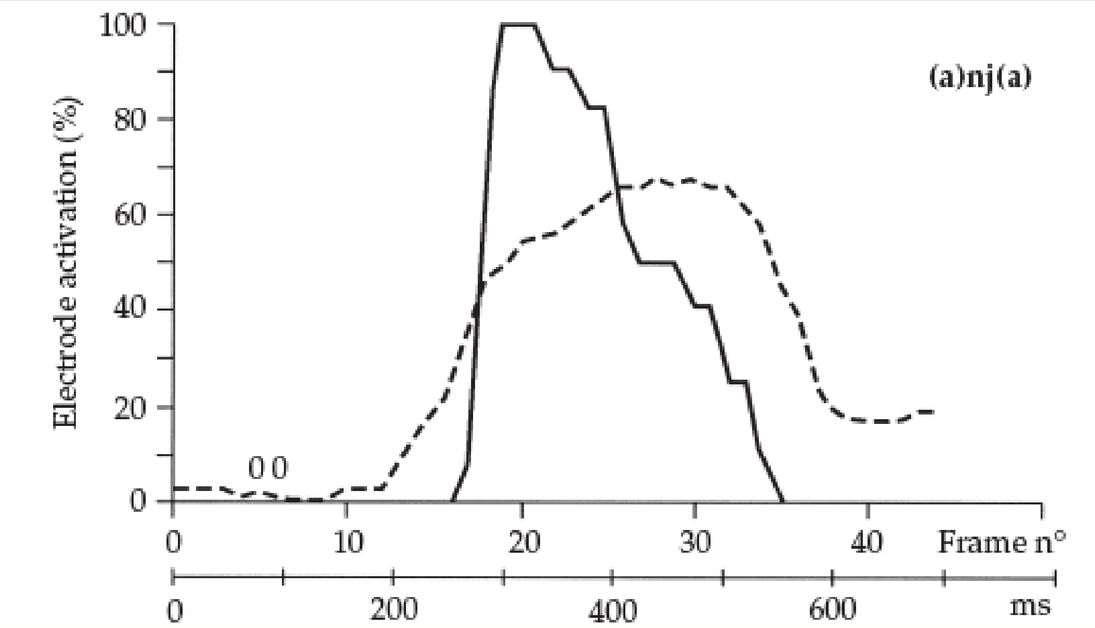
- When one or more of the phonetic properties of a sound are modified and become like those of the adjacent segment
- Generative phonology: clear distinction between coarticulation and assimilation:
  - Assimilation: language-specific, part of linguistic competence
  - Coarticulation: results from physical properties of speech; performance
- Possible to distinguish universal phonetic behavior from language-particular rules
  - Difference between vowel harmony
  - Vowel-to-vowel coarticulation

ASSIMILATION

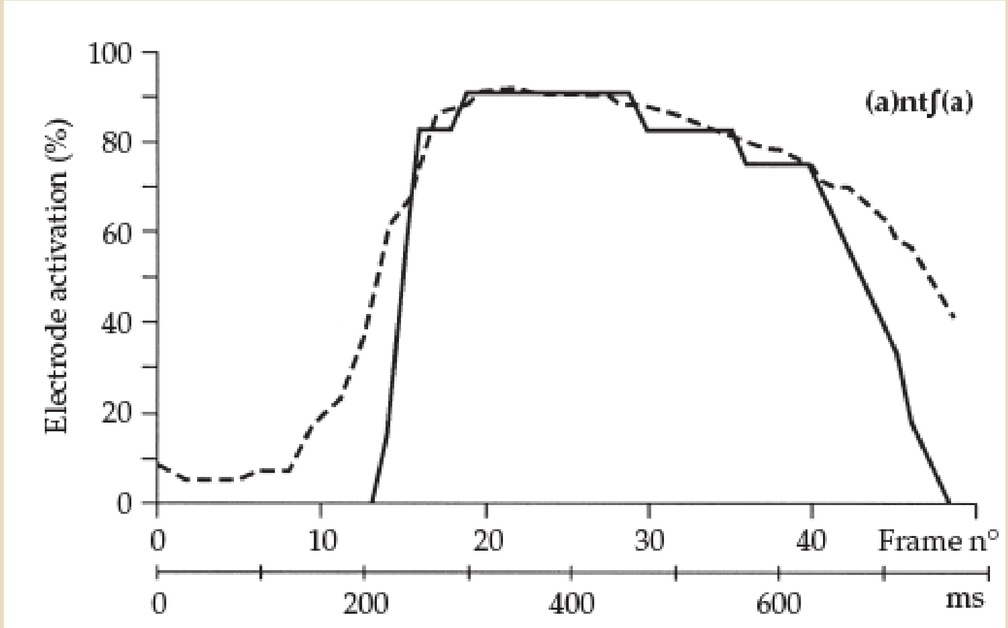
- A strict universal vs. language-specific dichotomy overlooks cross-language data showing varying degrees of coarticulation
- Context-dependent variations within a language may indicate distinct processes or quantitative variations from the same mechanism
  - Or both at the same time
- Current theories have controversial views on whether there are differences between assimilatory and coarticulatory processes

EXAMPLE

Farnetani, 1986:



ANTICIPATORY COARTICULATION



PLACE ASSIMILATION

CONNECTED SPEECH

- Phonetic variation: influenced by linguistic, communicative, and pragmatic factors
- Connected speech processes explain phonetic changes in continuous speech vs. isolated words
  - Also imply modifications of the basic units of speech (e.g. elimination and replacements of articulatory gestures, changes in articulation places)
- Connected speech X assimilation:
  - Connected speech varies with context (e.g. rapid, casual speech)
  - Assimilation is consistent across contexts

THEORETICAL ACCOUNTS

- Menzerath and de Lacerda (1933): speech segments can be articulated simultaneously, not just sequentially
- Joos (1948): vowel qualities vary based on neighboring consonants, even in steady states
  - Introduced the "overlapping innervation wave theory": phonetic commands are invariant waves that overlap in time

MODELS

Feature spreading

- Daniloff & Hammarberg (1973)
- Coarticulation as a phonological process rather than a physiological one

Henke's articulatory model

- Allows overlap across segments without strict boundaries
- Look-ahead mechanism: features can propagate to unspecified segments

Coarticulatory resistance

- Not a model, but a contradiction in the predictions of the previous two
- More on that on the next slides

FEATURE SPREADING

- Arguments:
  - Coarticulation is part of the phonological component of a language
  - Phonology precedes phonetics in speech sound production
  - Phonological segments are abstract entities (can’t be altered by physical mechanisms)
  - Speech mechanism execute high-level phonological commands
- The function of coarticulation is to smooth out transitions, minimizing differences between adjacent sounds

COARTICULATORY RESISTANCE

- The feature spreading and look-ahead mechanism contradict spatial/temporal predictions
  - E.g. carryover effects in V-to-V coarticulation
- Segments with contradictory features in asymmetric VCV sequences can still undergo coarticulation
  - Ex.: in French and English lip rounding for /u/ can begin during /i/ in certain contexts, indicating that coarticulation can occur even when features conflict
- These V-to-V effects appear to vary to some degree across languages

COARTICULATORY RESISTANCE

- Phonologically unspecified segments: data on Japanese indicates that unspecified segments can fully acquire contextual features
- Certain consonants exhibit varying degrees of coarticulatory resistance
  - Example: fricatives require specific tongue positions for noise production, while stops and laterals allow for more variation
- Bladon and al-Bamerni (1976): coarticulatory resistance scale
  - Coarticulatory behavior cannot be fully explained by binary feature analysis

SPEECH ECONOMY

- Adaptive variability and hyper-/hypo-speech theory:
- Lindblom: phonetics should explain linguistic forms through biological, social, and communicative principles
- Phonetic variation adapts continuously to communicative demands, where production strategies shift based on the need for perceptual contrast
- Leads to acoustic variations from hypo to hyper speech

SPEECH ECONOMY

- Coarticulation is identified as a low-cost motor behavior, reflecting an economical speaking strategy
- Lindblom: introduced the idea of an "acoustic target"
  - Formants may not reach ideal values, especially with shorter vowels
  - Linked to coarticulatory processes rather than phonological ones
- Vowel duration and speech style significantly influence formant undershoot
- In clear speech, vowels are longer and less reduced compared to normal speech, with larger formant values

SPEECH ECONOMY

- Locus equation metric: measures coarticulation
- Demonstrates that the degree of coarticulation varies with consonant place of articulation:
  - Flatter slopes: more invariant *loci*
  - Steeper slopes: greater coarticulation

THE WINDOW MODEL

- Keating (1985): explains continuous spatial/temporal changes and cross-language coarticulation differences
- Phonological rules alone can't explain the graded nature of coarticulation
- The model:
  - Phonological representations based on binary features
  - Each feature is associated with a "window" that defines the range of possible values
    - Narrow windows = limited contextual variation
    - Wide windows = unspecified features allows for greater variation

EXAMPLE

Keating, 1988:

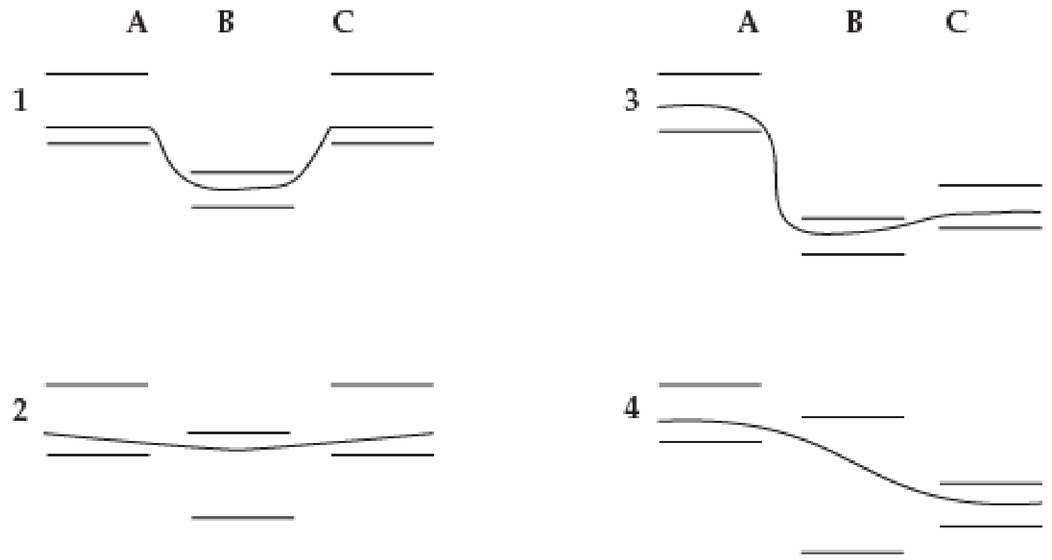


Figure 9.7 Windows and paths modeling articulator movements in three-segment sequences (selected from Keating, 1988a). The effects of narrow vs. wide windows on the interpolation contours can be observed in both the symmetric (1, 2) and the asymmetric (3, 4) sequences.

THE WINDOW MODEL

- Cross-language differences in coarticulation:
  - Can result from varying phonological assimilatory rules or phonetic interpretations of unspecified features
- Example:
- Cohn (1993): analyzed nasalization in English, French, and Sundanese
  - Found that nasalization behaves differently in these languages due to phonological rules in French and Sundanese and phonetic interpolation in English

THE WINDOW MODEL

- Criticism:
- Boyce et al. (1991): unspecified segments linked to specific articulatory positions challenge underspecification
    - Instead, unspecified features may cause variability across speakers and dialects
- Manuel (1987): not all phonetic changes can be explained by grammatical rules
- Interlanguage differences in V-to-V coarticulation stem from:
    - The interaction between universal motor system characteristics and
    - language-specific phonological factors like vowel inventory and distribution
- Languages with smaller vowel inventories exhibit more coarticulatory variation

COPRODUCTION THEORY

- Aims to account for the kinematics of articulators in speech

1. The nature of phonological units (Fowler)

- Current models require a translation from abstract phonological units and physical movements
- Proposes modifying phonological units to directly represent planned, context-free articulatory actions
- Allows temporal overlap of gestures without interference from adjacent ones

COPRODUCTION THEORY

2. Coarticulation resistance
   - Coordinative structures: articulators are functionally linked to ensure the invariance of phonetic goals
   - Variations in coarticulation arise from the degree of spatial overlap between gestures
   - Blending strength: stronger gestures suppress weaker ones
   - Consonants exhibit higher blending strength compared to vowels
   - Cross-language differences: attributed to distinct gestural setups learned during speech development

COPRODUCTION THEORY

3. Labial and velar coarticulation

- Coproduction theory: articulatory gestures have intrinsic durations
- Time-locked model: articulatory movements start a fixed time before the acoustic onset of the segment, independent of preceding segments
  - Several studies support the look-ahead model
- Timing and amplitude of movements are influenced by language-specific phonetic structures

COPRODUCTION THEORY

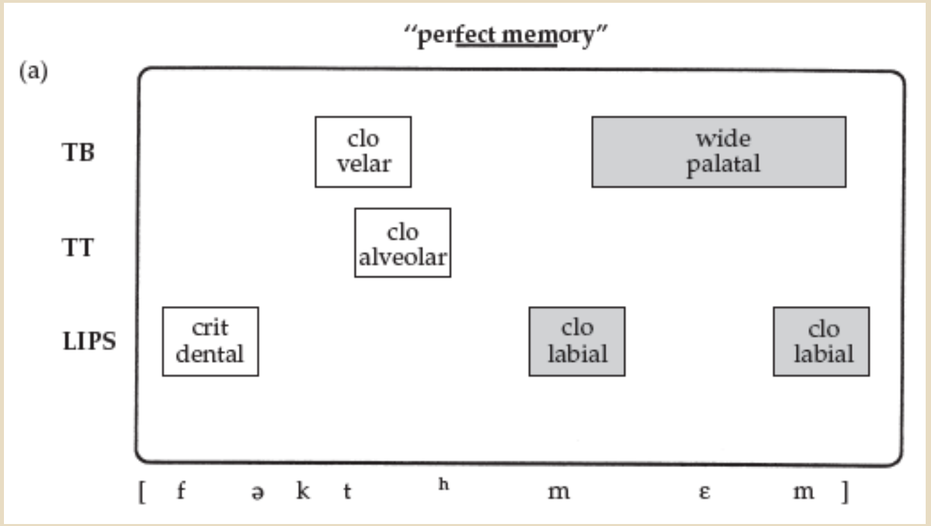
4. The DAC model
   - Size, temporal extent, and direction of coarticulation depend on tongue articulatory demands
     - Assignment of specific DAC values to vowels and consonants
   - Coarticulatory resistance: increases with greater articulatory constraints, affecting segment influence
   - Anticipatory effects are not uniformly timed: they begin earlier when preceding consonants or vowels are less constrained
     - Contrast with carryover effects

CONNECTED SPEECH PROCESSES

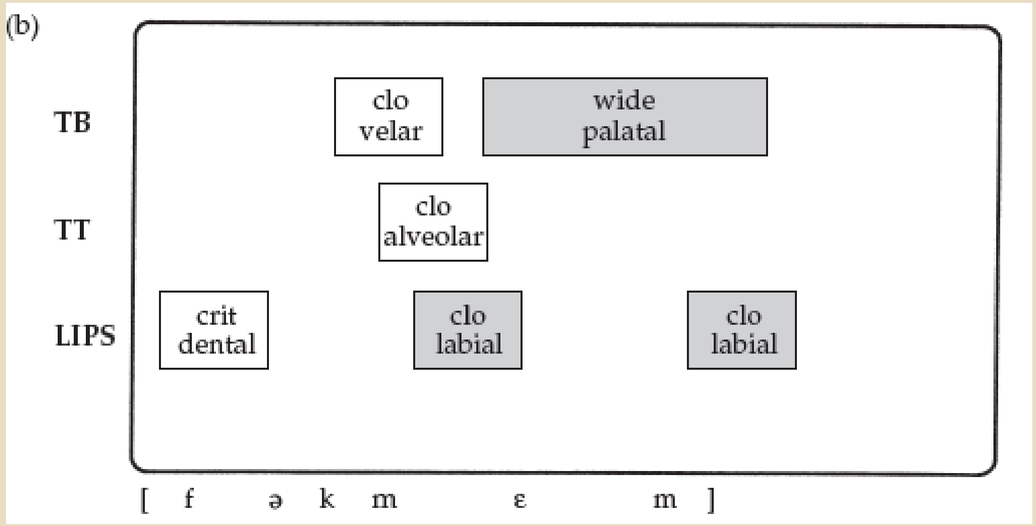
- Browman and Goldstein's gestural phonology:
- Phonological structure of speech represented as overlapping gestures across different tiers
  - Variations in gesture overlap and parameters reveal allophonic changes due to stress and position
- Connected speech processes arise from increased gestural overlap and decreased amplitude
- Coarticulatory processes can vary significantly across languages and contexts

EXAMPLE

Browman & Goldstein, 1989:



ISOLATION



CONTINUOUS SPEECH

CONCLUSION

- Generative phonology: assimilations and connected speech processes as distinct steps linking competence and performance
- "Adaptive variability" and gestural phonology theories: attribute the origins of coarticulation to speech itself
    - Speech production shapes linguistic morpho-phonological rules
- Economy and output constraints
- Connected speech processes are continuous and not fundamentally different from coarticulation

CONCLUSION

- No current model explains different results across languages
- Differences in anticipatory strategies:
  - Different articulators, like the lips and velum, show varying anticipatory strategies
  - Languages like English and Swedish exhibit differences in lip-rounding anticipation
- Differences in results for vowel nasalization in American English may stem from different experimental methods
  - These discrepancies could point to regional variants or ongoing phonetic changes needing further study

THANK YOU FOR YOUR ATTENTION!