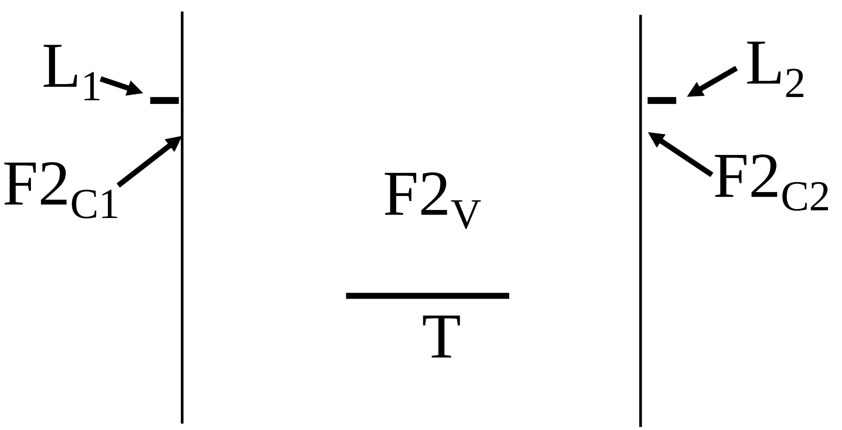
24.914

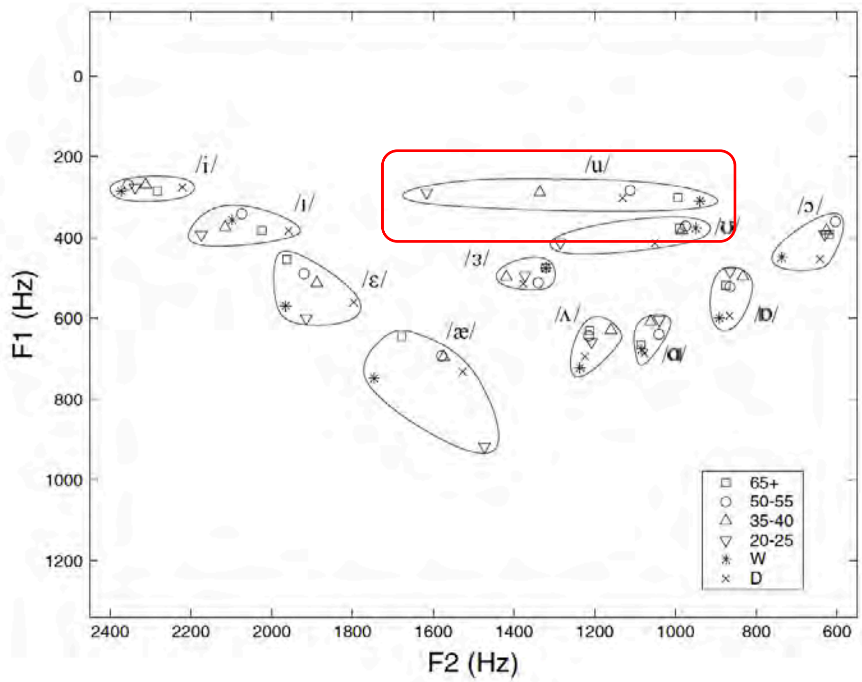
Language Variation and Change

Phonetic grammar and gradual change



Analyzing gradual phonetic change as grammar change

- As discussed earlier, if sound change is grammar change, it follows that sound change is regular
  - Phonology and phonetics govern the pronunciation of all words.
- But we didn't spell out how to analyze gradual phonetic change as grammar change.
  - E.g. gradual fronting of [u] before coronals



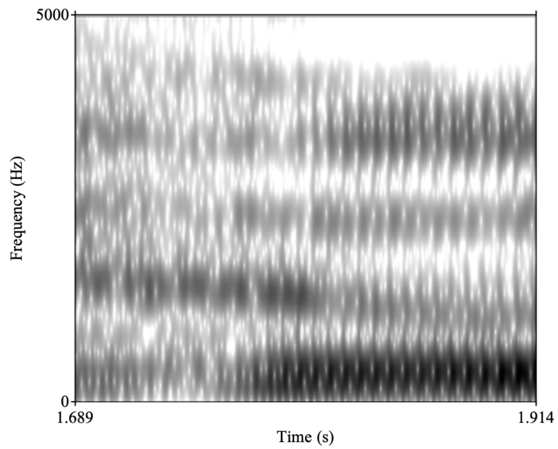
Hawkins & Midgeley 2005, JIPA

Analyzing gradual phonetic change as grammar change

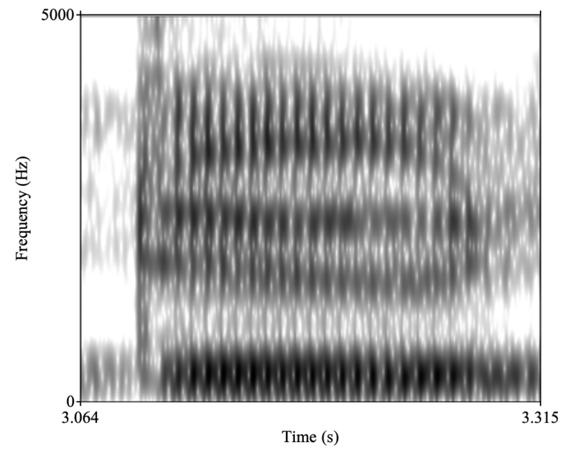
- As discussed earlier, if sound change is grammar change, it follows that sound change is regular.
  - Phonology and phonetics govern the pronunciation of all words.
- But we didn’t spell out how to analyze gradual phonetic change as grammar change.
  - E.g. gradual fronting of [u] before coronals.
- Gradual fronting of [u] cannot be analyzed as re-ranking Ident(back) with respect to *[+back][coronal].
  - It must be a result of a change in phonetic grammar.
- What does phonetic grammar look like?

Fronting of /u/ between coronals

- /u/ has a higher F2 (is fronter) between coronal consonants /dud/ than in a neutral context, e.g. /hu/.



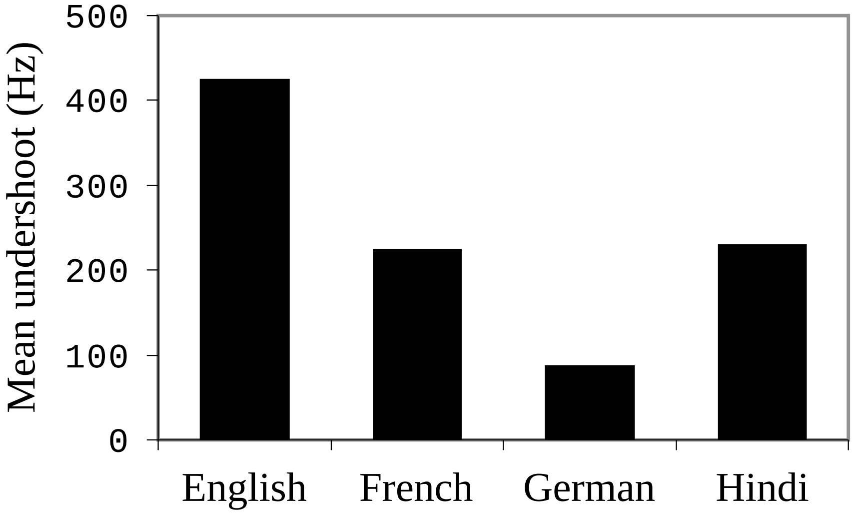
hu



dud

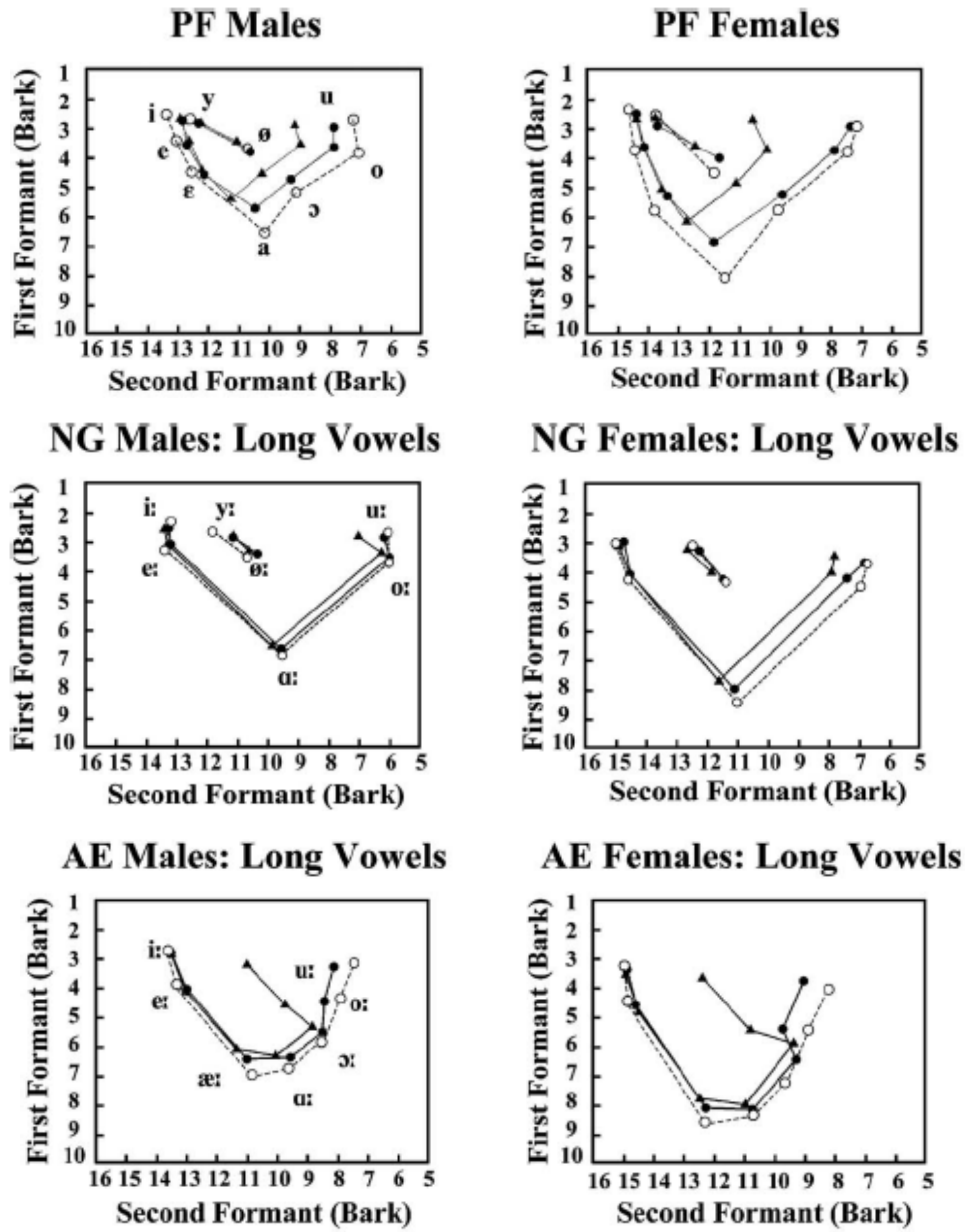
Fronting of /u/ between coronals

- The magnitude of this fronting effect varies between languages
  - F2 in /dud/ - F2 in /(h)u/
- 4 speakers of each language, 2 male, 2 female.
- Also recorded words with /i/ between coronals (e.g. /tit/).
- All word spoken in segmentally matched carrier phrases.
- What is the difference between the phonetic grammars of these languages?



Vowel fronting by coronals

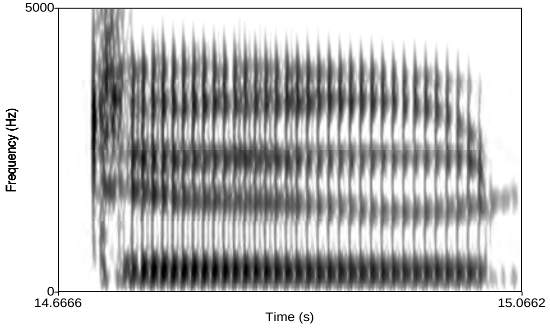
- Similar results on English, French, German from Strange et al (2007).

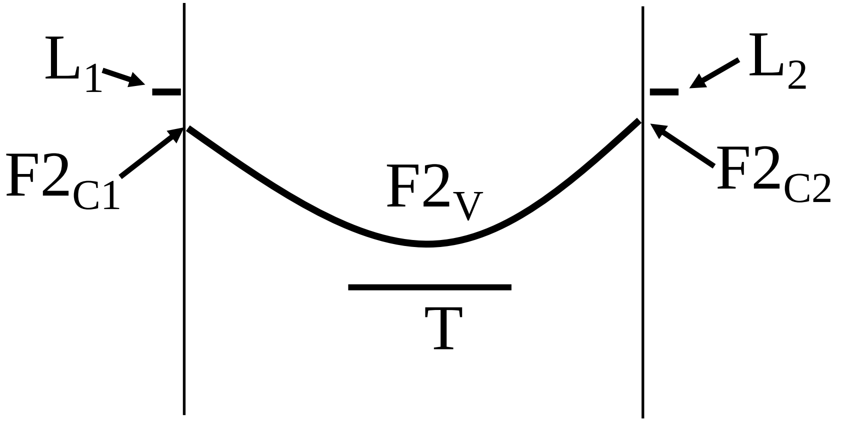


vowels produced in labial (closed circles) and alveolar (closed triangles) consonant contexts in sentence materials. Average values for long (top) and short (bottom) vowels for male (left) and female (right) speakers are plotted separately. For comparison, average values for citation utterances (open circles) are also shown (same as Fig. 2).

Consonant-Vowel coarticulation

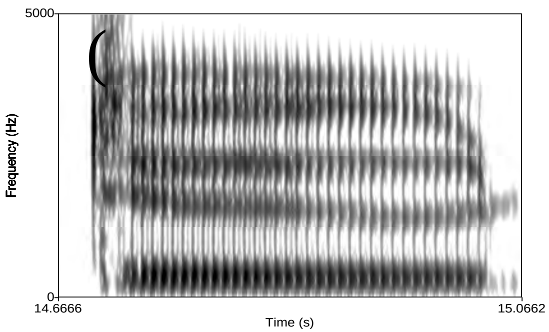
- F2 trajectory in a CVC sequence is a compromise between
  - achieving the F2 targets for consonants (L_1, L_2) and vowel (T)
  - avoiding fast movement between the two.
- Minimization of effort: movements with higher peak velocity are more effortful, other things being equal (Nelson 1983, Perkell 1997).
  - Peak velocity is proportional to displacement (e.g. Kent & Moll 1972)
  - Constraint: $F2_C = F2_V$
    - For convenience, this constraint is formulated in acoustic terms

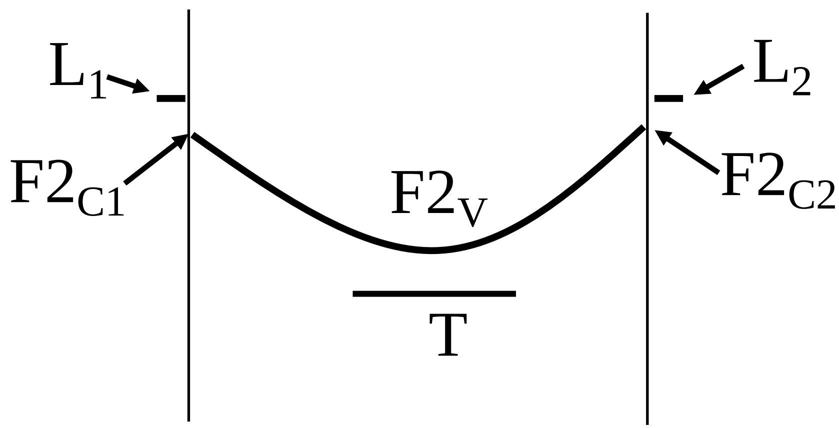




Consonant-Vowel coarticulation

- The tongue body moves forward in anterior coronals (alveolars, dentals) to facilitate formation of the tongue tip constriction (Manuel & Stevens 1995, Öhman 1966).
  - Alveolar stops have high values for *L*
- So in a coronal-back V sequence the tongue body has to move from front to back.
  - High *L* to low *T*
- Can result in undershoot of the target for the back vowel.



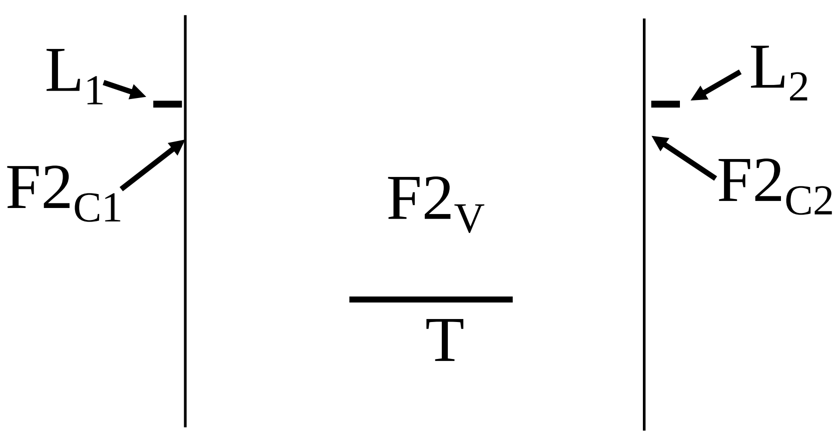


Consonant-Vowel coarticulation

- Given T and L_2, select $F2_V$ and $F2_{C2}$ so as to minimize violation of the following constraints (Flemming 2001):

MINEFFORT:	$F2_{C1} = F2_V$, $F2_V = F2_{C2}$	$w_E(F2_V - F2_{Cn})^2$
IDENTV:	$F2_V = T$	$w_V(T - F2_V)^2$
IDENTC(REL):	$F2_{C1} = L_1$	$w_{C1}(L_1 - F2_{C1})^2$
IDENTC(CLO):	$F2_{C2} = L_2$	$w_{C2}(L_2 - F2_{C2})^2$

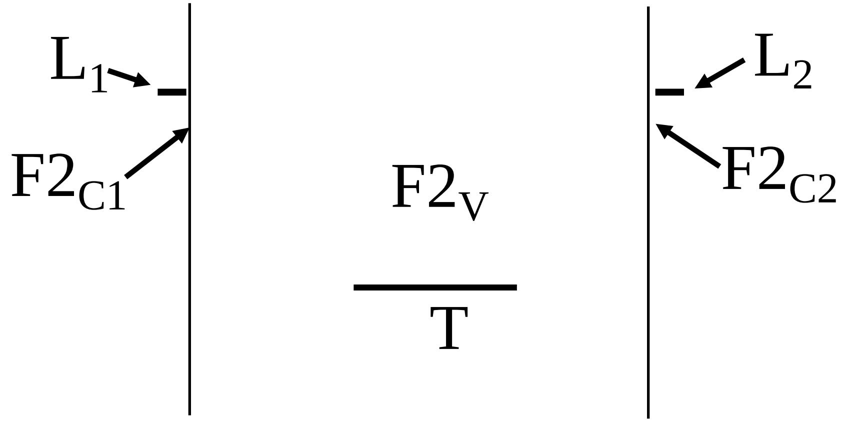
  – $F2_{C2}$ is F2 measured at the *closure* of C2



Consonant-Vowel coarticulation

- Unfortunately we could not make comparable measurements of $F2_{C1}$ across languages because C1 differed in VOT, so we will model the VC transition, using just three constraints
  - Or equivalently: we will assume $L_1 = L_2$ and $w_{C1} = w_{C2}$

MINEFFORT:	$F2_V = F2_{C2}$	$w_E(F2_V - F2_{C2})^2$
IDENTV:	$F2_V = T$	$w_V(T - F2_V)^2$
IDENTC(CLO):	$F2_{C2} = L_2$	$w_{C2}(L_2 - F2_{C2})^2$



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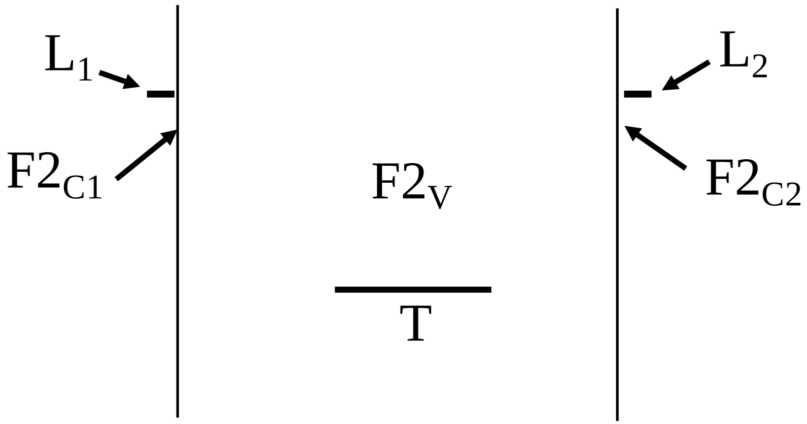
IDENTV:	$F2_V = T$	$w_V(T - F2_V)^2$
IDENTC(CLO):	$F2_{C2} = L_2$	$w_{C2}(L_2 - F2_{C2})^2$

- These constraints conflict where T and L differ
- Resolving conflict: minimize summed constraint violations

$$H = w_E(F2_V - F2_{C2})^2 + w_V(T - F2_V)^2 + w_{C2}(L_2 - F2_{C2})^2$$

  – w_i are positive weights



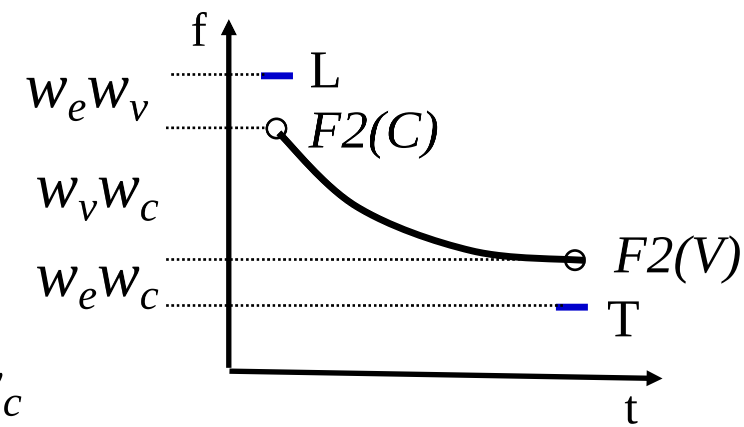
CV coarticulation - analysis

- Optimal values for $F2_C$, $F2_V$ as a function of L, T:

$$F2_C = -u_c(L - T) + L \qquad u_c = \frac{w_e w_v}{w_e w_c + w_v w_c + w_e w_v}$$

$$F2_V = u_v(L - T) + T \qquad u_v = \frac{w_e w_c}{w_e w_c + w_v w_c + w_e w_v}$$

- The interval between L and T is divided into three parts by $F2_C$ and $F2_V$
  - C undershoot
  - V undershoot
  - transition
- In the proportions $w_e w_v$: $w_e w_c$: $w_v w_c$



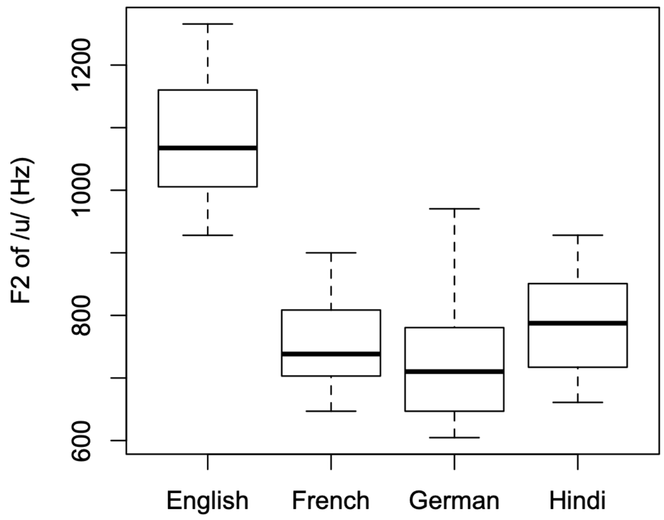
Typological variation

- The constraints are universal, but their relative weights may vary.
- *L* and *T* may vary across languages.
  – Assume that these require an independent analysis - e.g. optimization of inventory of contrasting segments.
- Apply this line of analysis to the differences between the languages in the study.
  – Need to estimate T, L_2 and the constraint weights for each language

Applying this analysis to the /u/-fronting data

- Estimate vowel target *T* from realization of /u/ in the 'neutral' context (e.g. [hu], [u]).
- *T* for /u/ is substantially higher in English than in the other languages:

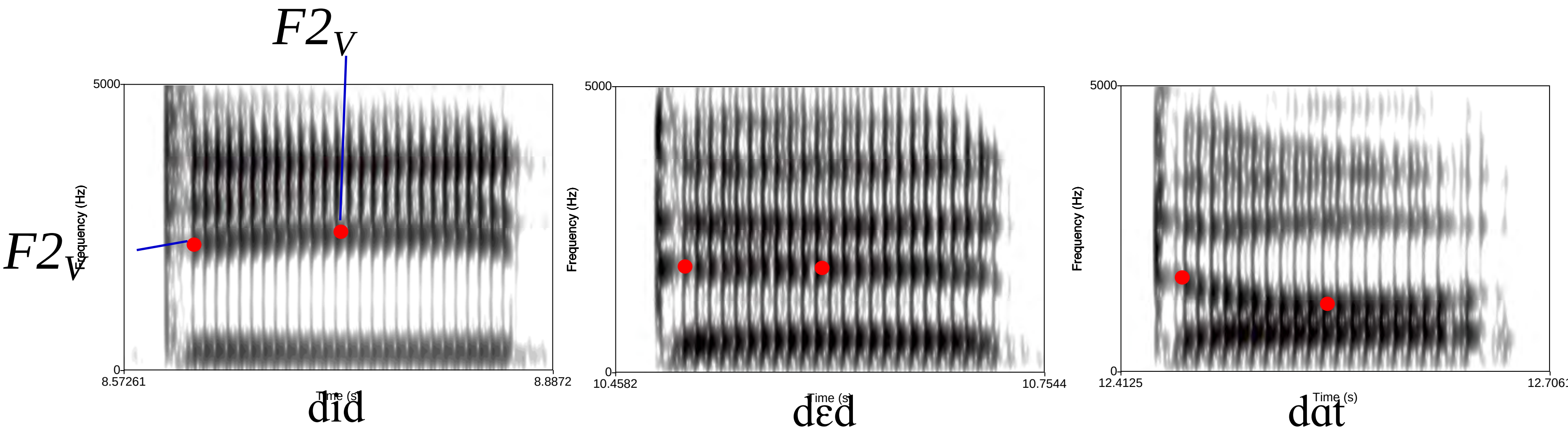
	English	French	German	Hindi
Target of /u/ (Hz)	1079	786	755	736



Estimating L

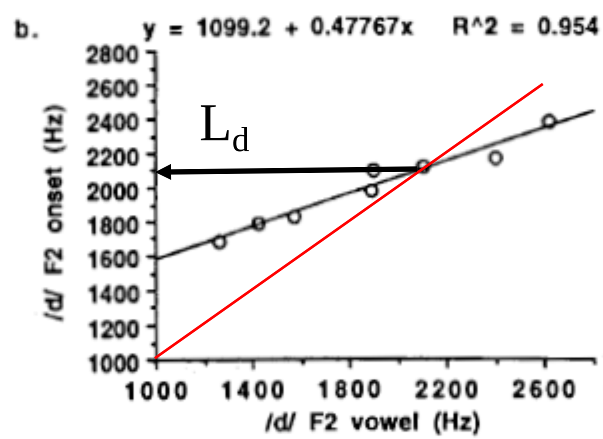
- The model correctly derives the generalization that, for a given C, $F2_C$ is a linear function of $F2_V$

$$F2_C = \frac{w_E}{w_C+w_E} F2_V + \frac{w_C}{w_C+w_E} L$$



- L is the value of $F2_C$ where it equals $F2_V$

[d]



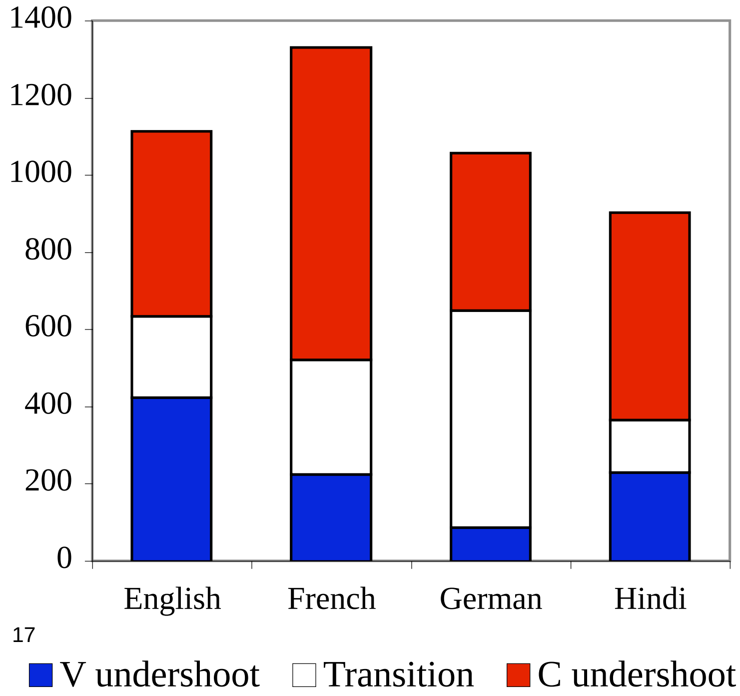
Estimating *L*

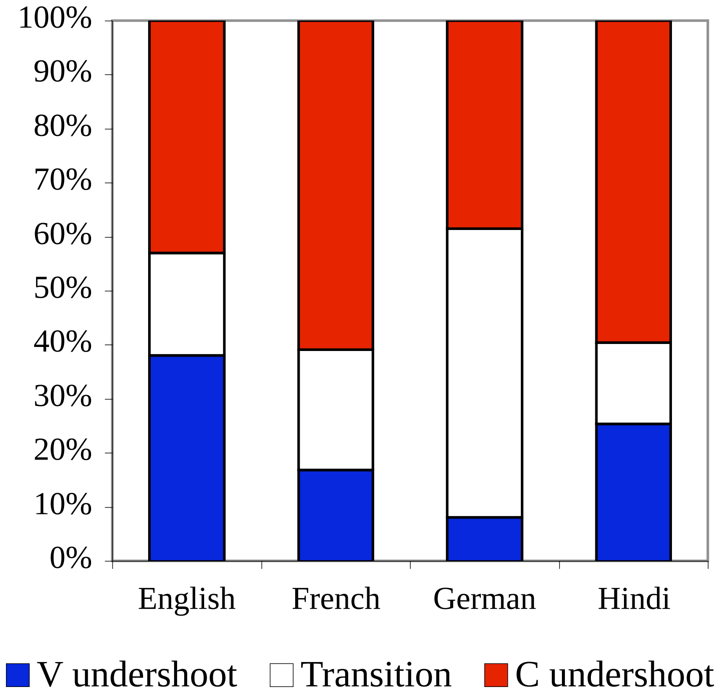
- Locus of coronal C2 differs substantially between the languages:

	English	French	German	Hindi
Locus of C2 (Hz)	2192	2086	1793	1690

Estimating constraint weights

- Given L we can calculate C undershoot.
- Languages differ in the absolute and proportional values of C2 undershoot, V undershoot and size of F2 transition from V to C2.
- In terms of the constraint-based analysis, the differences in proportions correspond to differences in the constraint weights.
- C undershoot $w_V w_E$: Transition $w_C w_V$: V undershoot $w_C w_E$





Cross-linguistic variation in constraint weights

	w_V	w_C	w_E
English	0.26	0.22	0.52
French	0.50	0.14	0.37
German	0.74	0.15	0.10
Hindi	0.32	0.14	0.54

- It is the ratios of the weights that matter.
  - Set $w_V+w_C+w_E = 1$ to create a unique solution.
- These weights are calculated ignoring the contribution of C1, so w_C and w_E are overestimated.

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- French and German have higher values for w_V - these languages contrast front [y] with back [u], English and Hindi do not.
  - Note that this difference is not apparent in the V undershoot measures.
  - According to the analysis, V undershoot $= \dfrac{w_E w_C}{w_E w_C + w_E w_V + w_C w_V}(L - T)$
  - Hindi has low V undershoot because L is low in Hindi compared to the other languages.
  - The system of vowel contrasts relates to w_V, not raw undershoot.

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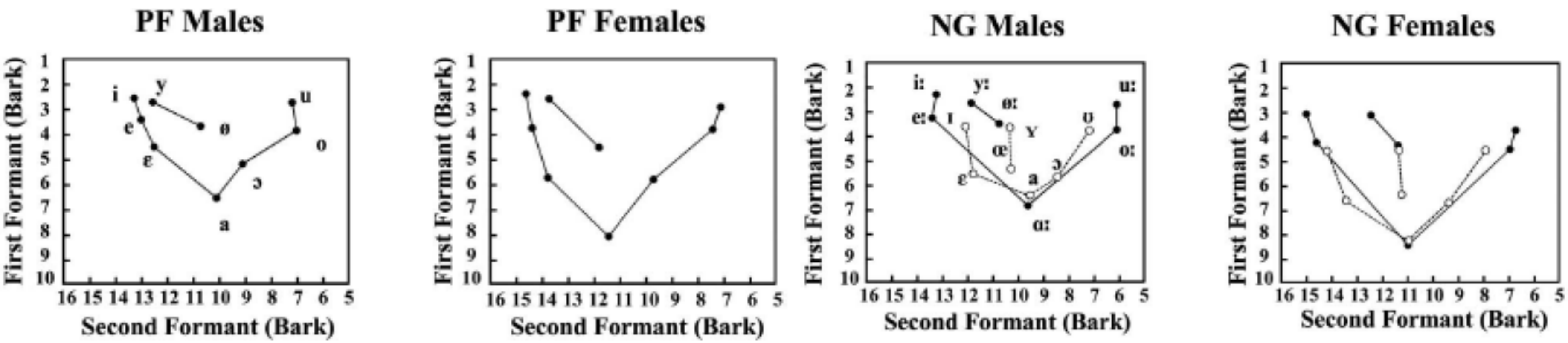
- German has a higher value for w_V than French. German /y/ seems to have lower F2 than French /y/ (Strange et al 2007) - i.e. closer to /u/.
  - In our data: French 2124 Hz, German 1725 Hz



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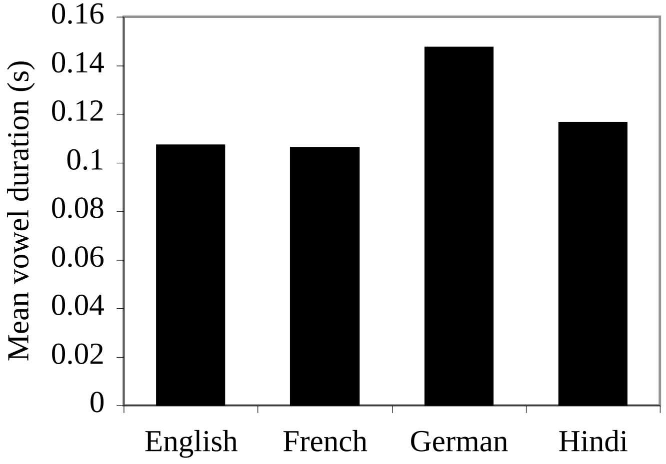
Possible reasons for weight differences:

- German has a much lower value of w_E than other languages, but German /u/ was longer.
- For a given magnitude of movement, peak velocity is lower if movement duration is longer.



Sound change as grammar change

- Gradual change in the magnitude of vowel fronting can be analyzed as gradual change in constraint weights.
- But why do constraint weights change?

- Can word frequency effects arise if sound change is grammar change?