Implications of [i] vowels for the theory of vowel inventories

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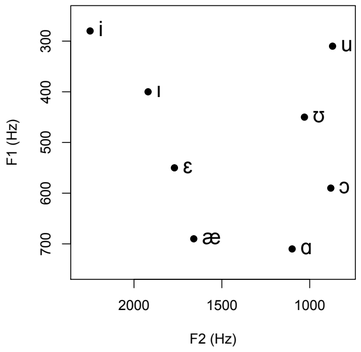
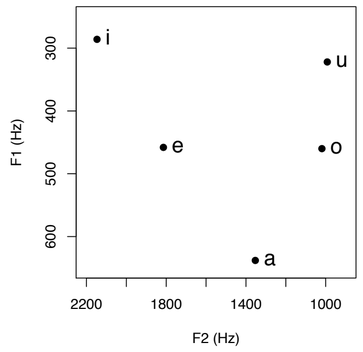
[i] as the vowel with maximal F2

- Most languages have a high front [i] vowel
- In most of those languages, it is the vowel with highest F2



Selected American English vowels
(Ladefoged & Johnson 2011)

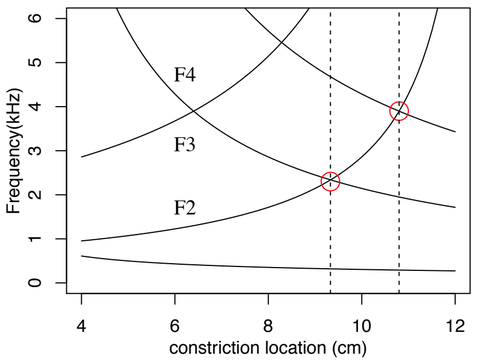


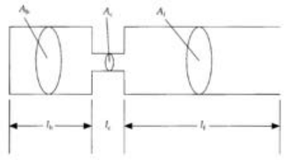
Spanish vowels
(Bradley 1995)

- An account based on the Theory of Adaptive Dispersion:
  - ➢ Languages favor vowels that are maximally dispersed in perceptual space
  - ➢ F2 is a dimension of perceptual vowel space
- Then dispersion favors vowels with extreme values of F2
  - ➢ [i] should be the vowel that maximizes F2

Maximizing F2

- Analysis of vowel acoustics in terms of simple tube models or the more complex model in Fant (1960) implies that F2 is maximized by bringing it as close as possible to F3.
  - achieved by a narrow constriction 2/3 of the way between the glottis and the lips
  - Textbooks such as Johnson (2012), Harrington & Cassidy (1999:45) present this as a model of [i]





Total vocal tract length 15 cm, constriction length 4 cm

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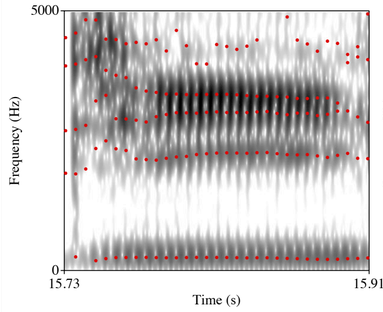
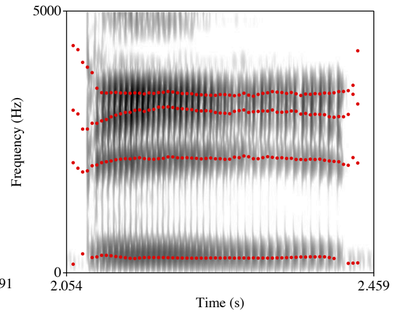
The problem: F3-F4 [i]

- Realizations of [i] with F2 close to F3 (F2-F3[i]) are attested, but realizations with F3 closer to F4 are also widely attested (Gendrot et al 2008, Vaissière 2007)
  - F3-F4[i] is the canonical realization in French and Swedish, and is attested in English.



French [i] in *dit*



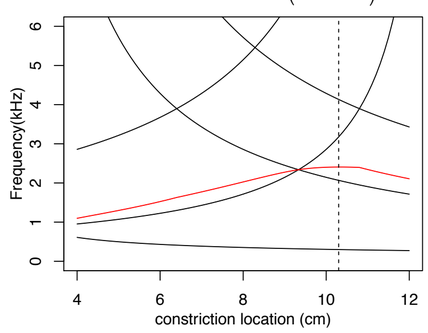
English [i] in *bead*

- F3-F4[i] appears inconsistent with the hypothesis that [i] is the vowel with maximal F2 because nomograms indicate that a vowel with F3 close to F4 should have sub-maximal F2
  - ➢ **why is F3-F4[i] preferred in some languages?**

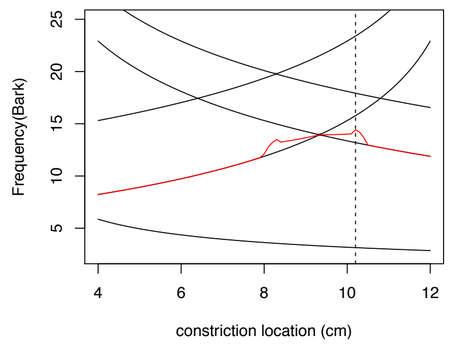
Does F3-F4[i] maximize F2′?

- Liljencrants & Lindblom (1972) proposed that the dimensions of the perceptual vowel space are F1 and F2′ ('the effective second formant')
  - ➢ When F2 is close to F3, F2′ is essentially a weighted average of F2 and higher formants, so it can be increased by raising F3
  - ➢ Perhaps this compensates for the reduction in F2 in F3-F4[i]
- Applying formulae for F2′ to the 3-tube nomogram predicts that the vowel that maximizes F2′ lies between F2-F3[i] and F3-F4[i]
  - F2′ in red

Fant (1959) $$F2' = F2 + \frac{(F3-F2)(F2-F1)}{(F3-F1)}$$

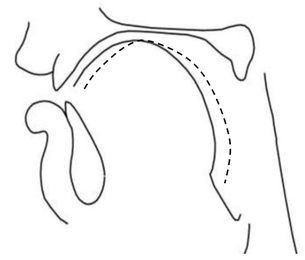


Schwartz et al (1997): If F2 is close enough to F3, F2′ is a weighted average of F2 and F3 or F3 and F4, depending on the spacing of these formants on the Bark scale.

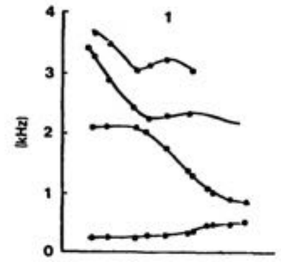


Constriction length

- According to the 3-tube nomogram, F3-F4[i] does not maximize F2′, but that nomogram does not represent variation in constriction length
  - ➢ Increasing constriction length can shorten both front and back cavities, raising all formants, and thus raising F2′.
- A palatal constriction can be lengthened into the front cavity by raising the tongue blade towards the palato-alveolar region.
  - ➢ Raises F3 without lowering F2
- The back cavity can only be shortened by retracting the tongue body, which results in a shorter constriction as the tongue moves away from the curve of the palate.
  - ➢ It is not possible to raise F2 further by lengthening the constriction into the back cavity
- Ladefoged & Bladon (1982) found in their attempts to reproduce Fant's nomograms that constriction lengthening was an automatic consequence of shifting a vowel constriction forward from the palatal region.

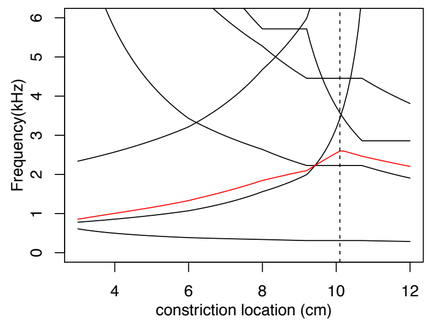


French [i] (Bothorel et al 1986)



Ladefoged & Bladon (1982)

- So contrary to the nomogram above (and Fant's nomograms), maximal F2 can be produced at a range of constriction locations by varying constriction length.
  - ➢ F2′ is maximized by maximizing F2 and F3, yielding F3-F4[i]



- So a preference for F3-F4[i] follows from a preference to maximize F2′
- F3-F4[i] requires more extreme and precise articulations than F2-F3[i], so variation in the extent of F3 raising plausibly follows from variation in the balance between maximizing dispersion and minimizing effort.
  - In French [i], F3 is higher when [i] is longer (Gendrot et al 2008).

Quantal Theory

- If F3-F4[i] were a preferred vowel because the convergence of F3 and F4 yields a quantal vowel then we would expect languages to contrast F2-F3[i] with F3-F4[i].

Conclusions

- F2′ is the perceptual dimension corresponding to vowel backness, not F2
- Articulatory constraints have to be imposed on tube models to make them useful tools for reasoning about the space of possible vowels.

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