Reconsidering Vowels as Mathematical and Statistical Entities

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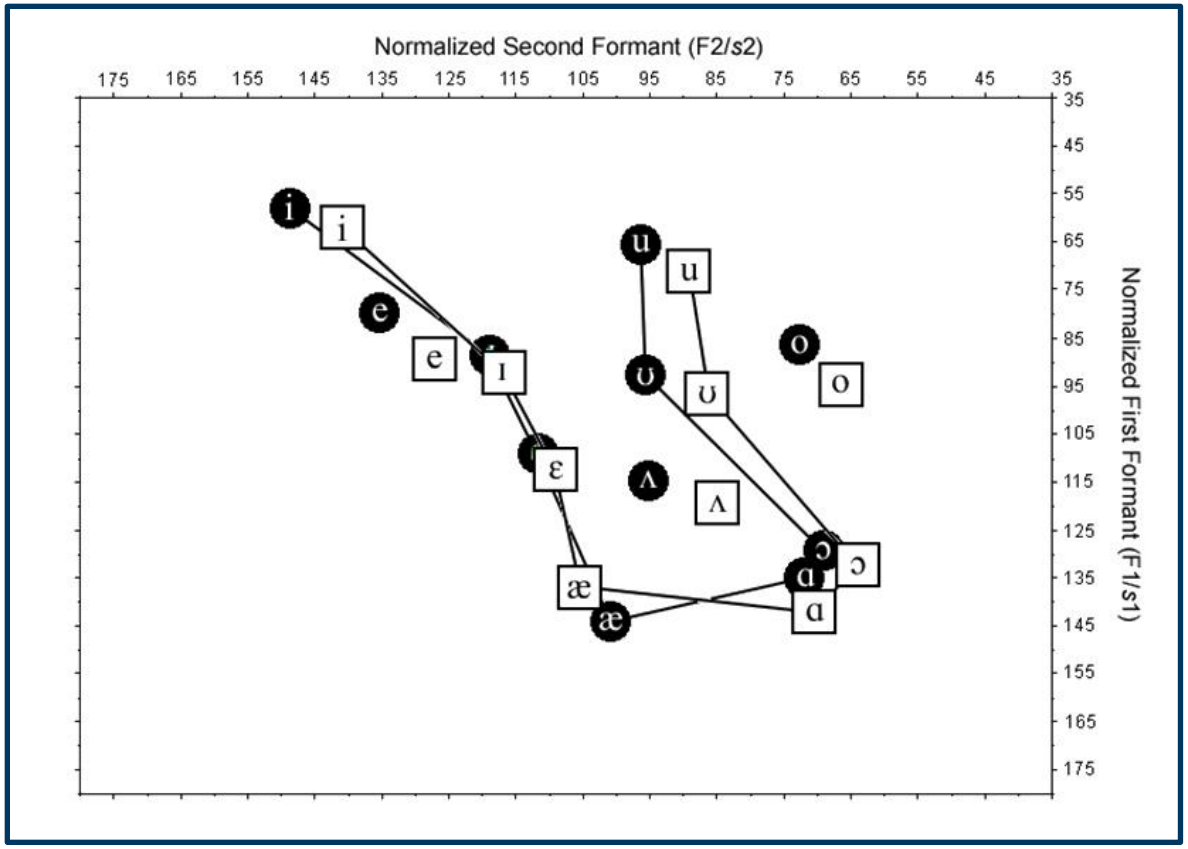
A Return to First Principles

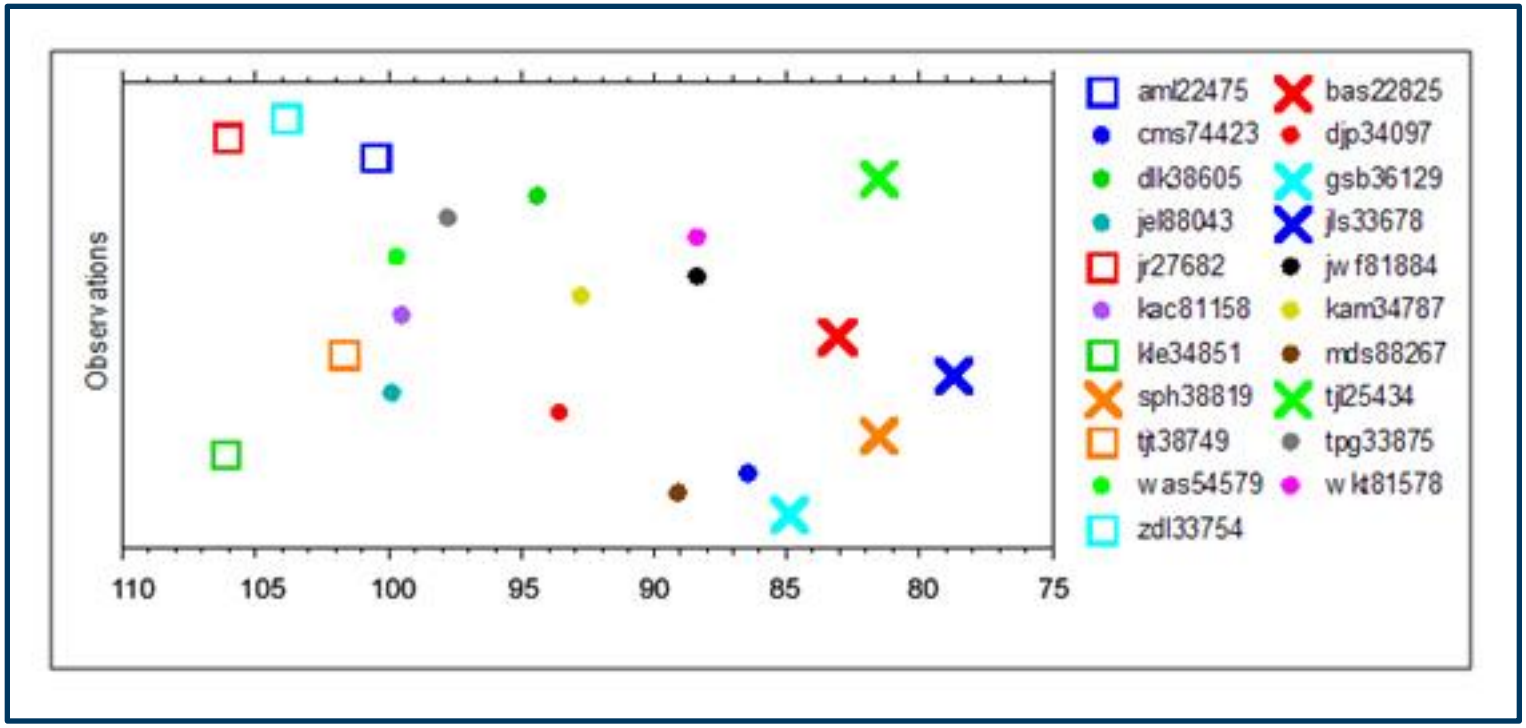
- What are VOWELS?
  - perceptual entities
  - contrastive items for the perception of DIALECTS
  - contextually determined entities
  - non-meaningful linguistic atoms
- How do we investigate VOWELS?
  - Sampling TOKENS from SPEAKERS of DIALECTS
  - Measuring FORMANTS
  - Comparing FORMANT values using STATISTICS
- We must reconsider these methods.

SAMPLING TOKENS FROM SPEAKERS

- What and How Much information can we lose?
  - GOOSE – averaged across tokens and speakers



GOOSE — INDIVIDUAL SPEAKERS, TOKENS



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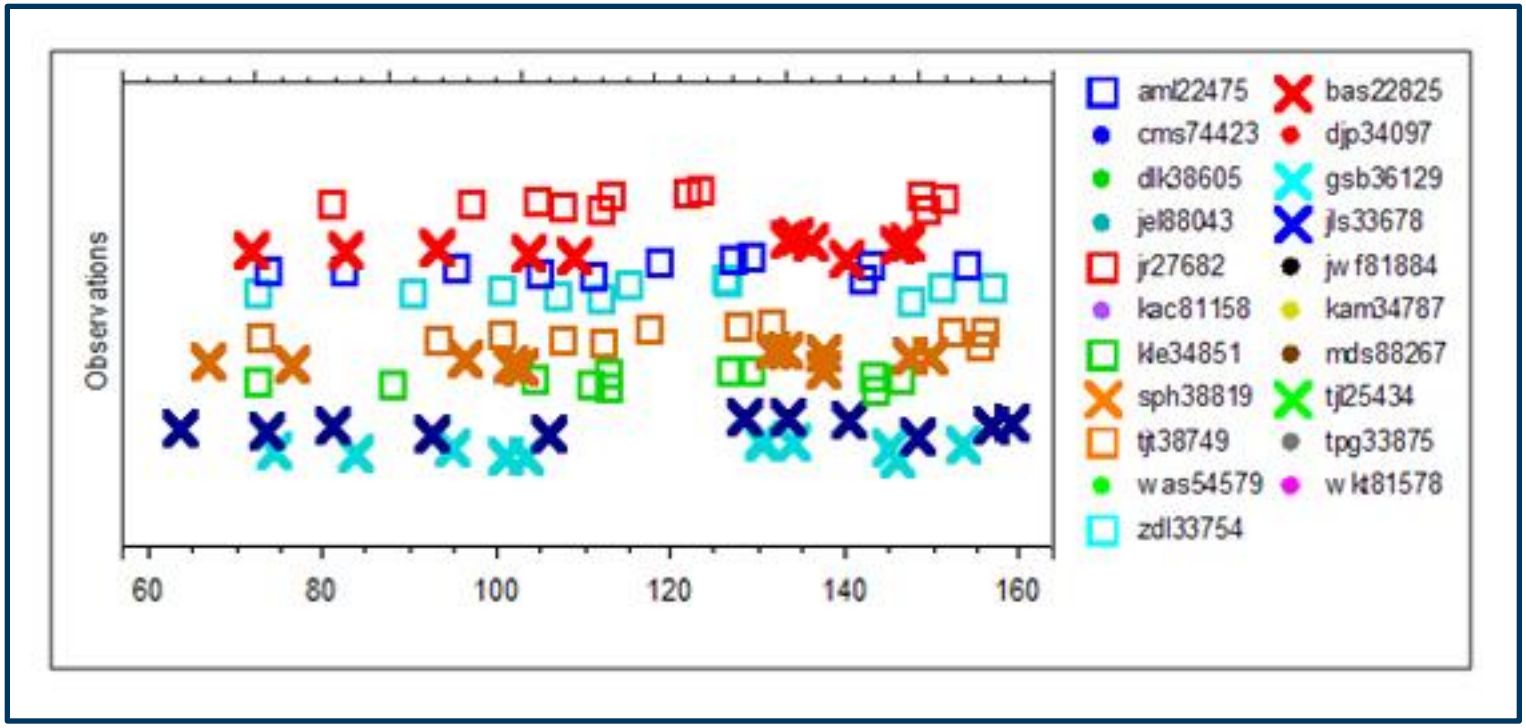
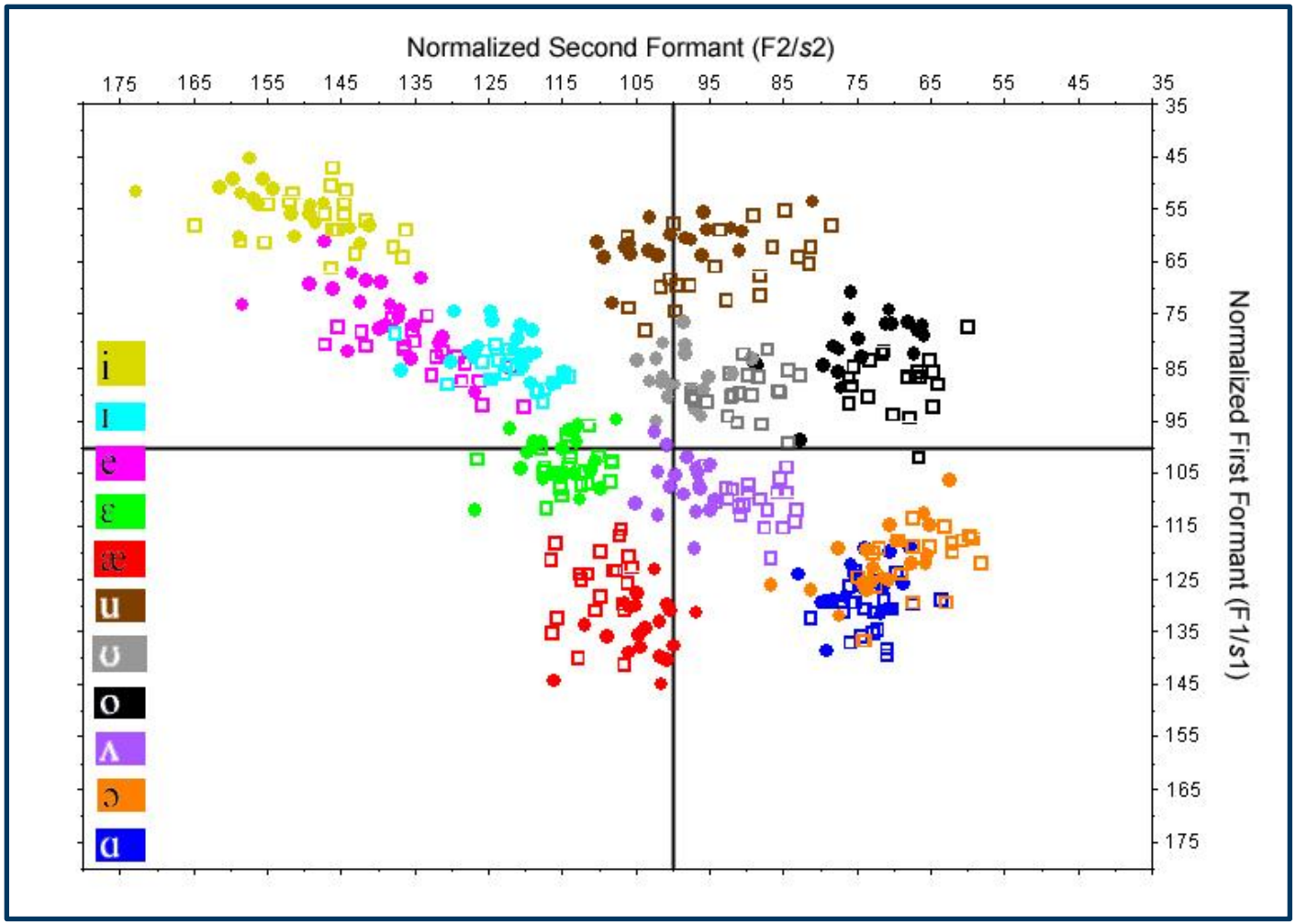


Different Ways of Varying



What Information Do We Need?

- GOOSE varies from fully back to fully central
  - Variation is both WITHIN and BETWEEN individuals
  - Which form of variation is more important?
- GOOSE varies differently than other vowels
- Do these patterns of variation have meaning?

- What does it *mean* to average a percept?

- Is there an appropriate N for TOKENS or SPEAKERS?
  - A linguistics-driven statistical methodology…

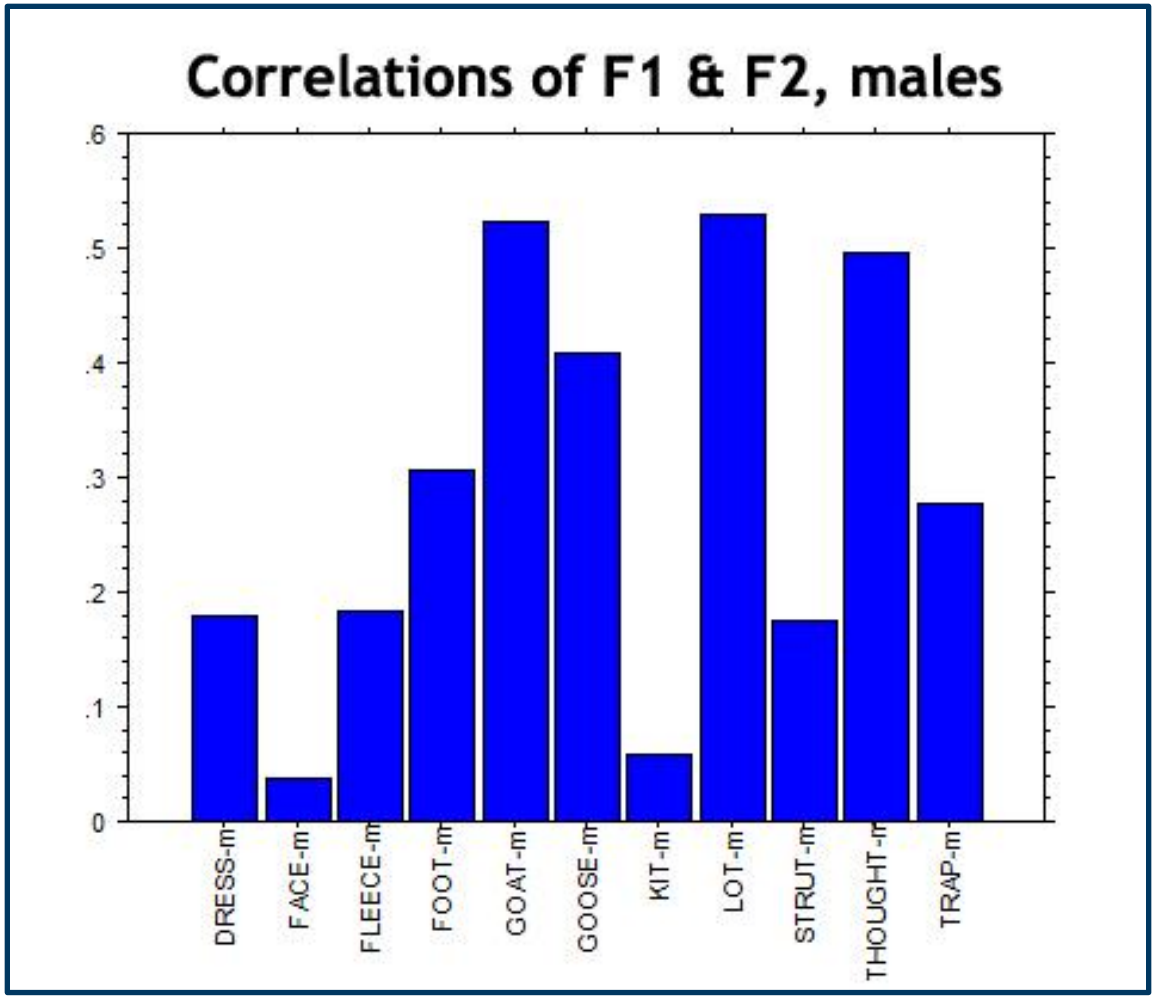
Can a VOWEL Be Reduced to F1xF2?

- Why do we use F1xF2?
  - Labov, Yaeger, Steiner (1972)
- DeLattre, Liberman, Cooper, & Gerstman (1952)
    - An Experimental Study of the Acoustic Determinants of Vowel Color; Observations on One- and Two-Formant Vowels Synthesized from Spectrographic Patterns
  - DLCG were measuring perception via Hz values
  - Modern sociophonetics measures Hz values…
- FORMANTS are continuous; VOWELS are discrete
  - DLCG used 120Hz chunks of F2

Additional Issues with the F1xF2 Model

- Should F1 and F2 be measured on the same scale?
  - F1 has less freedom for variation (space) than F2
  - F1 ~800Hz ; F2 ~ 1600Hz
  - jnd discrimination threshold = ~25Hz (Snodgrass, 1975)
- In F1, there are only about 800/25 or **32** possible distinct regions of perception; F2 = ~64
  - Yet we report values like 816Hz x 1507Hz…
- F1xF2 always co-varies for VOWELS in vowel-space
  - But not to the same extent for all vowels…
  - …or for all speakers

F1xF2 Correlations for Different VOWELS



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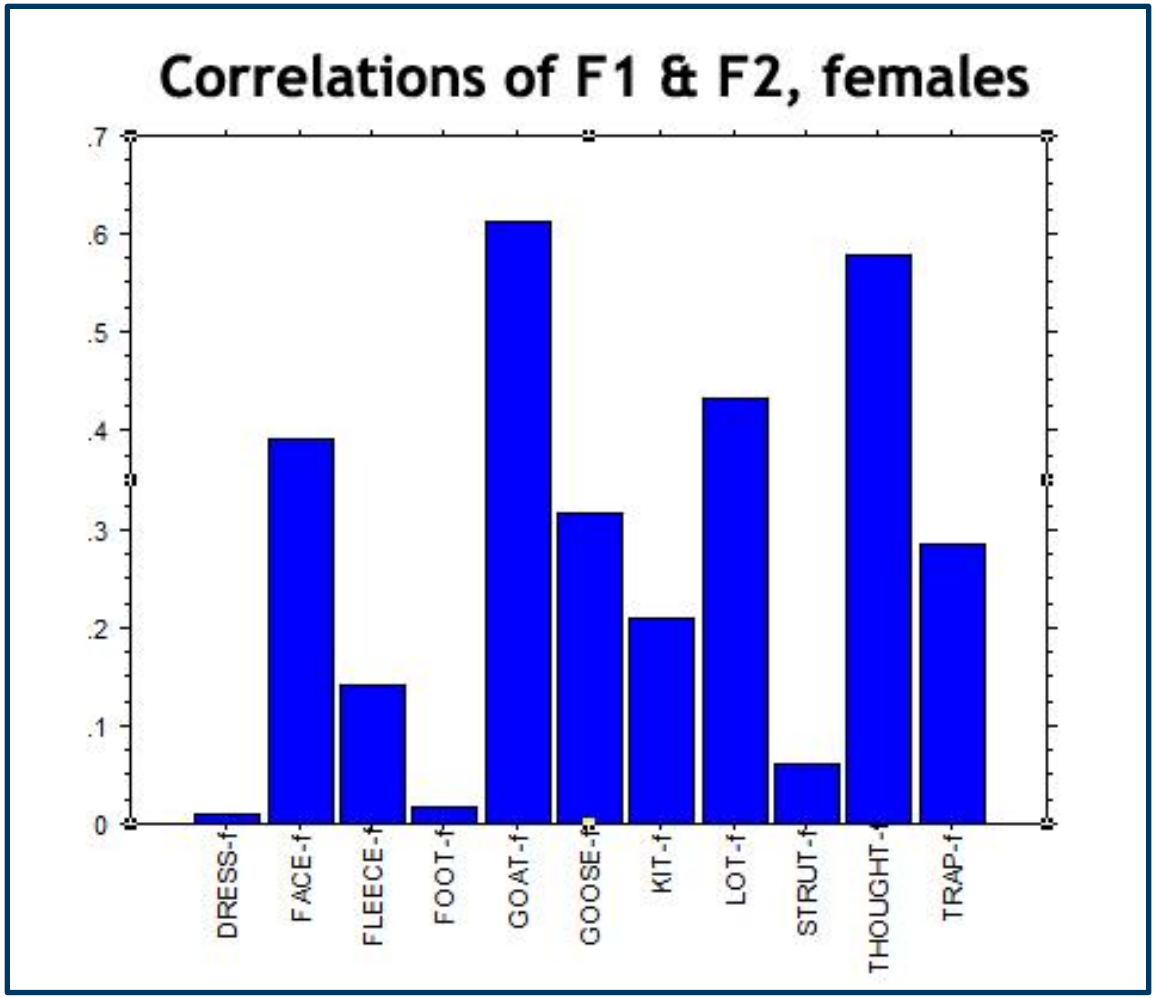


Are VOWELS Statistical?

- Taleb, 2008 – Limits of Statistics

	Simple (Yes/No)	Complex (How much?)
Thin-tailed, known distributions	Robust	Robust
Fat-tailed & unknown distributions	Robust	FRAGILE! DO NOT STATISTIZE!

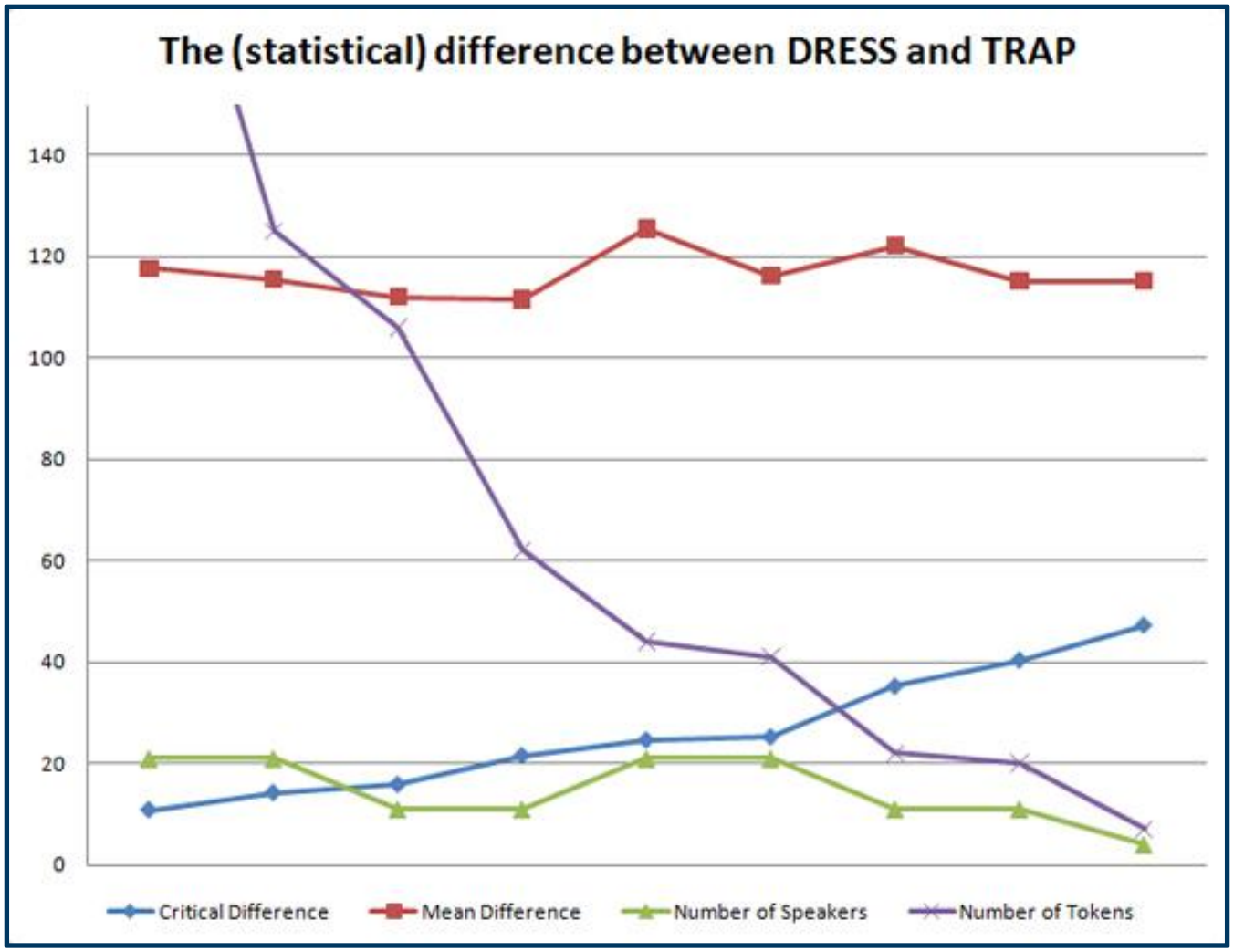
- What quadrant are VOWELS in?

The Power of N in Sociophonetics

- As N (sample size) increases, so does the chance of finding a significant difference
- Is there an appropriate N for TOKENS or SPEAKERS?
- How many SPEAKERS, VOWELS, and TOKENS are enough? Is it possible to have too many?
- Comparing DRESS and TRAP using a basic *t*-Test
- Note "Critical Difference"…

  … below 25Hz is below jnd!

Difference Between DRESS and TRAP



Summary

- Reconsider our underlying principles
  - VOWELS are perceptual objects
  - Perceptual constraints must drive investigation
- Reconsider our methods
  - When can we use averages and when not? (GOOSE)
  - Do the same methods work for all VOWELS?
    - cf. diphthongs & monophthongs ; front & back vowels
  - If we continue using F1xF2 we must establish a significance value (20Hz in F1 ; 40Hz in F2?)
- Reconsider our statistics
  - We need a linguistically-driven statistical method
  - Fewer speakers & tokens may be better than more

Thank You!

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