Linguistics 251 — Hayes/Schuh
Metrics — Spring 2015

Class 15, 5/18/15: The Phonetics of Rajaz Singing in Hausa

1. Readings and assignments

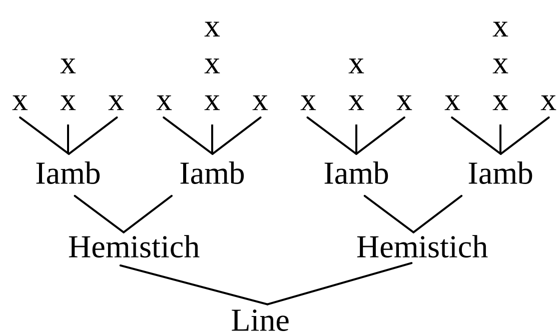
- Read in preparation for next week: Bruce Hayes and Claire Moore-Cantwell. Gerard Manley Hopkins's sprung rhythm: corpus study and stochastic grammar. *Phonology* 28:235-282. On course web site.
- Class presentations now scheduled for 10th week.

2. Overall purpose of our rajaz project

- Study a sung metrical tradition all the way up and down (albeit with a thin slice)
  - ➢ meter
  - ➢ sung rhythm
  - ➢ phonetic realization of sung rhythm
- Today: cover the second two, building on our earlier work on pure meter (Classes 6 and 7).

METRICS OF THE RAJAZ: REVIEW

3. Metrical pattern



Levels of grid strength
superstrong
strong
weak

4. Five predominant types of realization for hemistichs

v - v -	**iambic**	1362	- v - -	6	ignore
- - -	**hemiola**	871	- v v v	5	ignore
- v v -	**medial vv**	687	v v - v -	5	ignore
- - v -	**heptamoraic**	600	- - - -	2	ignore
v v - -	**initial vv**	417	v v - v	2	ignore
v - v v	ignore	35	- v - v -	1	ignore
v v v -	ignore	24	- v v - -	1	ignore
v - -	ignore	19	- v v v v	1	ignore
v v v v -	ignore	19	v v -	1	ignore

v - - -	ignore	16	v v v - -	1	ignore
- v -	ignore	10	v v v v -	1	ignore
- - v v	ignore	6	v v v v v	1	ignore

5. How the five types line up against the grid

- Iambic (default foot type)

```
                x
    x           x
x   x   x   x   x   x
|   |__/    |   |__/
v   —       v   —
```

- Heptamoraic

```
                x
    x           x
x   x   x   x   x   x
|   |__/    |   |__/
—   —       v   —
```

- Initial v v

```
                x
    x           x
x   x   x   x   x   x
|   |   |__/    |__/
v   v   —       —
```

- Medial v v

```
                x
    x           x
x   x   x   x   x   x
|__/    |   |   |__/
—       v   v   —
```

- Hemiola

```
                x
    x           x
x   x   x   x   x   x
|__/    |__/    |__/
—       —       —
```

6. There are various ways to sing the rajaz

- You can sing it “straight”, in 6/8 time, so the grids of meter and song are the same.
- We will examine a rather different rendering:
  - Performance of “Tutocin Shehu” by Abubakar Ladan

7. Abubakar Ladan’s sung grid

- This is rather straightforwardly related to the grid of the meter:
  - add two more positions per hemistich (6 → 8)
  - these get associated with the last heavy of each hemistich, which thus gets a total of four grid slots — perhaps SUPERSTRONG IS LONG
  - Following Lerdahl/Jackendovian principles, we’ll assume pervasive binarity for the sung grid — meaning that the syncopation is distributed differently than in the meter.

8. The Five Feet in AL’s sung grid

- Iambic

```
                x
x               x
x       x       x       x
x   x   x   x   x   x   x   x
|   |       |   |
v   —       v   —
```

- Heptamoraic

```
                x
x               x
x       x       x       x
x   x   x   x   x   x   x   x
|   |       |   |
—   —       v   —
```

- Initial v v

```
                x
x               x
x       x       x       x
x   x   x   x   x   x   x   x
|   |   |       |
v   v   —       —
```

- Medial v v

```
                x
x               x
x       x       x       x
x   x   x   x   x   x   x   x

—       v   v   —
```

- Hemiola

```
                x
x               x
x       x       x       x
x   x   x   x   x   x   x   x

—       —       —
```

9. Let us listen

- Caution: text is from a published source, and does not reflect the corrections Russ made upon listening.

Kanoo ta Abdu shaa yaboo	v — v — / v — v —
Duk wanda kee bidxar raboo	— — v — / v — v —
Akwai shi can zuboo-zuboo	v — v — / v — v —
Ka tabbataa fa Maddibo	v — v — / v — v —
Doomin fadxaa ta gaskiya	— — v — / v — v —
Sai zuuciyar Niijeeriyaa	— — v — / v — v —
Sakkwato birnin manyaa	— v v — / — — —
Koo daa a yau koo a jiya	— — v — / — v v —
Suu muka bi da gaskyaa	— v v — / v — v —
Garin da baabu tooshiyaa	v — v — / v — v —
Barno bulaakaa birnii	— — v — / — — —
Ta Sheehu gun Kxuuraani	v — v — / — — —
Tsohon garin addiinii	v — v — / — — —
Koo zaamanii yai zaamanii	v — v — / v — v —
Ba zaa su kauce gaskiyaa	v — v — / v — v —
Gwandu ta Maalam Haruuna	— v v — / — v — —
Garin da baa maasu zinaa	v — v — / — v v —
Baa maasu almudanhanaa	v — v — / — v v —
Dukan tafarkin bxarnaa	v — v — / — — —
Yaa hana yii gabaa dxaya	— v v — / v — v —
Babban garii Hadxeejiya	v — v — / v — v —

Garin da baa a shan giyaa	v — v — / v — v —
Baa sansanin magaajiyaa	v — v — / v — v —
Baa kxaryaa da faariyaa	— — — / v — v —
Sai hanyaa ta gaskiyaa	— — — / v — v —
Mun zoo ga Birnin Katsina	v — v — / — v v —
Garin mazaa Usmaana	v — v — / — — —
Garin Walii Dxam marinaa	v — v — / — v v —
Yai shaharaa a koo inaa	— v v — / v — v —
Kan ilmi da gaskiyaa	— — — / v — v —
Mu gangaraa Adamaawaa	v — v — / v v — —
Garin dxiya baa baawaa	v — v — / — — —
Wurin gyadxaa gun daawaa	v — v — / — — —
Abinci naa nan da yawaa	v — v — / — v v —
Da arziki na saaniyaa	v — v — / v — v —
Da arziki da abinci	v — v — / v — v —
Da gaskiyaa da mutuncii	v — v — / v v — —
Da tattalii da zumuncii	v — v — / v v — —
An san mutaanen Bauci	v — v — / — — —
Bin sharixaa ta gaskiya	— v v — / v — v —
Zaariya babban birnii	— v v — / — — —
Garii da maasu sukuunii	v — v — / v v — —
Da maasu aikii da sanii	v — v — / — v v —
Nan aka cee wa sansani	— v v — / v — v —
Areewa baabu saakiyaa	v — v — / v — v —
Gumel garin Muhammadu	v — v — / v — v —
Na-sooro dxam Muhammadu	v — v — / v — v —
Garin da baabu faasiduu	v — v — / v — v —
Baa nakxasi da ziyaaduu	— v v — / v v — —
Kan kxaulii na gaskiyaa	— — — / v — v —

THEORY AND ANALYSIS

10. A really simple theory (qualitative)

- Primary premise: what we see in phonetics is always a quantitative compromise between conflicting ends.
    - ➢ Flemming's treatment of the "locus effect" (readings) is a classic case.
- Second premise: not hard to implement this with maxent grammars; which give you a freebie learning angle
    - ➢ Flemming's is a harmonic grammar, though non-stochastic and not learned.

11. Laying out the basis for constraints (qualitative)

- Moras like to be isochronous.
- Syllables like to be isochronous.

→ Consequence so far: a heavy syllable is not really twice as long a light (true in Hausa and many other languages).
  - ➢ I.e. light syllables are chubby moras.

- Grid columns like to be isochronous.

→ So crowding a heavy into one grid column, as in (8)-heptamoraic, will squeeze the heavy.

- Hemistichs like to be isochronous

→ several implications, below

12. What happens when the hemistichs try to be isochronous

- — — — : — can be quite long, since they need not share with chubby moras.
- Heptamoraic feet: non-initial syllables have to get shorter to compensate.

13. The foot taxonomy

- Heptamoraic

  — — v —

  - ➢ All are squeezed by the extra mora.
  - ➢ All are lightly squeezed by the presence of the single chubby mora v.
  - ➢ Initial — is especially squeezed by having just one grid slot.

- Iambic, Initial vv, Medial vv

  v — v —, v v — —, — v v —

  - ➢ All are somewhat squeezed by the presence of two fat moras v v.

- Hemiola

  — — —

  - ➢ Sitting pretty, no compression effects

EMPIRICAL STUDY OF DURATION IN ABUBAKAR LADAN'S TUTOCIN SHEHU

14. We[1] measured the syllables in stanzas

- First twenty stanzas
- Actually syllable boundaries
  - Eventually, I think we'll need to use Donca Steriade's *intervals* instead (Ryan)
- We did the usual procedure nowadays: play recording in Praat, set textgrids, measure the durations with a downloadable script.

15. Skipped data

- Last syllable in each hemistich — these varied hugely, and often faded out into a pause; unmeasurable really.

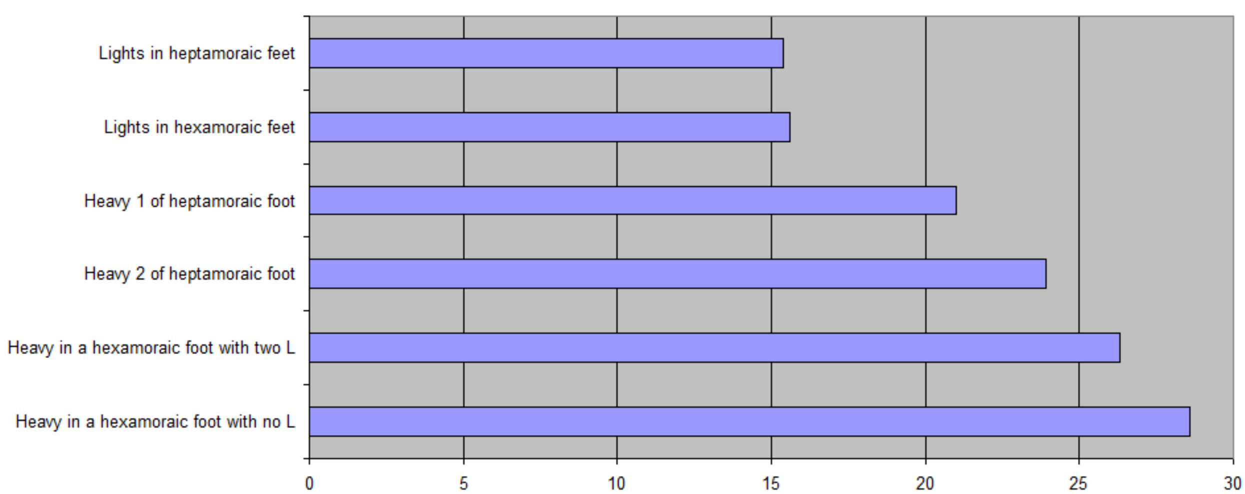
16. Averages

- We need to find a sensible taxonomy

Shortest

Lights in hepamoraic feet	15.4
Lights in hexamoraic feet	15.6
Heavy 1 of heptamoraic foot	21.0
Heavy 2 of heptamoraic foot	23.9
Heavy in a hexamoraic foot with two L	26.3
Heavy in a hexamoraic foot with no L	28.6

Longest



[1] Well, gee … it was Russ, really. I tended to hear allophones instead of phonemes and was naïve in various other ways.

17. Significance testing

- We can do significance testing by making factors be *cutoff points* in this hierarchy, and doing a linear model (lm() in R).

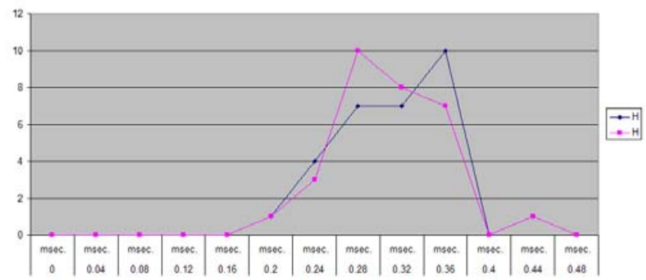
```
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               0.153855   0.007707  19.963  < 2e-16 ***
At Least L Of Hexa        0.001747   0.008009   0.218  0.82742
At Least Heavy            0.054124   0.008009   6.758 3.51e-11 ***
At Least Heavy2 Of Hepta  0.029517   0.010900   2.708  0.00697 **
At Least Heavy Of Hexa    0.023966   0.008288   2.892  0.00398 **
At Least Heavy Of HHH     0.023512   0.005535   4.247 2.53e-05 ***

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

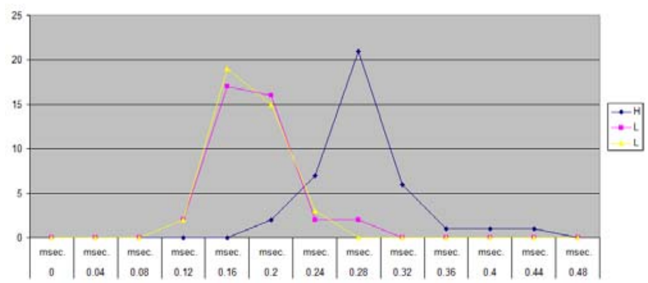
- Every distinction is coming out significant except the tiniest one ; i.e. lights in hepta vs. hexamoraic feet.
- I followed up and did the more professional version (a linear mixed-effects model, using lmer(), and got pretty much the same result.

18. Histograms (sort of) of the duration distributions

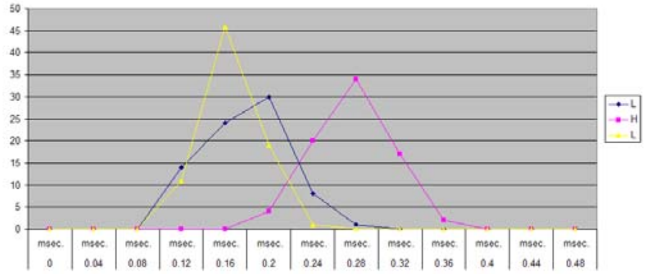
HHH:



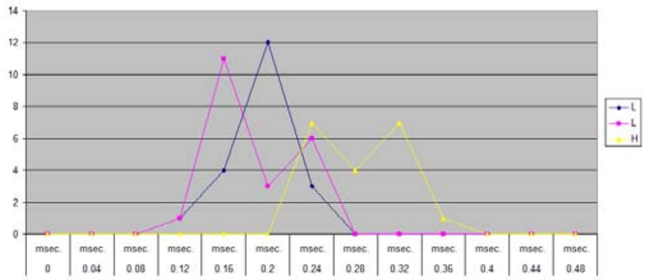
HLLH:



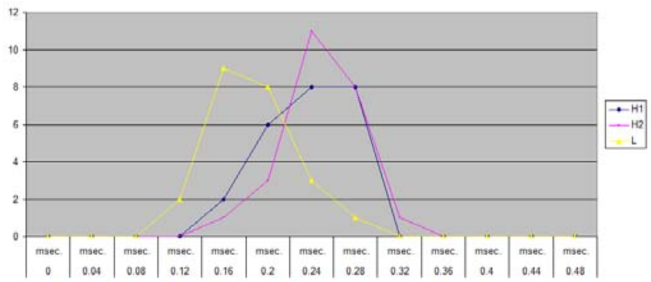
LHLH:



LLHH:



HHLH:



THEORY

19. What we did

- Blend of
  - Flemming-style Harmonic Grammar generative phonetics (readings)
  - … generalized with Maxent to get an actual spread of predicted values
  - … implemented with maxent training regimen to match data
  - … facilitated computationally by measuring time in 10 msec. intervals rather than as a continuum (countable number of candidates)
- This is rather similar to what Michael Lefkowitz is pursuing for his dissertation

20. Generative phonetics

- See e.g. early work of Keating:
  - P. A. Keating: "Universal phonetics and the organization of grammars", Phonetic Linguistics, ed. V. Fromkin, Academic Press, 115-132 (1985)
  - P. A. Keating: "The window model of coarticulation: articulatory evidence", in Papers in Laboratory Phonology I, ed. J. Kingston & M. Beckman, Cambridge University Press, pp. 451-470 (1990)

- Parameters of sound categories have *targets* (idealized perfect values).
- A grammar creates quantitative representations, guided by the abstract targets.

- Let's suppose as a wild approximation that the target is simply the *mean* across all tokens.
  - ➢ We can probably do better: median, or smoothed mode

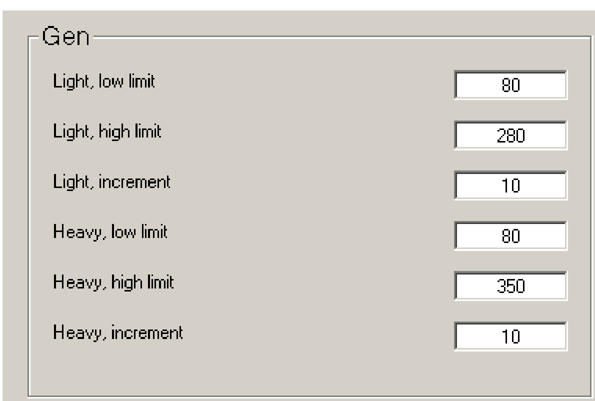
21. Doing this with constraint-based grammars

- GEN consists of all possible phonetic representations
- The weights and math of Harmonic Grammar interface naturally with the quantitative representations.
- They let us pick the best phonetic representation, or (in maxent) a probability distribution across phonetic representations.

22. GEN

- We'll ignore the greatly lengthened final syllable of each hemistich — vast variation; too hard to measure — and just do the first "demihemistich".
  - ➢ e.g. v — v of the iambic hemistich, etc.
- Find a suitable range for the duration of the two or three syllables of this demihemistich.
- Categorize at intervals of 10 msec., creating a fine grid of candidates.
  - ➢ This is pushing the limits of convenient file size and Maxent Grammar Tool run-time.

23. Part of the program interface (values in msec.)



24. Eight Constraints for Hausa Recitation

again, values are measured in milliseconds

- SQUEEZE MORA
  - ➢ Assess a penalty of the square of the degree to which candidate mora duration exceeds the mean.

- STRETCH MORA
    - Assess a penalty of the square of the degree to which candidate mora duration falls short of the mean.
- SQUEEZE SYLLABLE
    - Assess a penalty of the square of the degree to which candidate syllable duration exceeds the mean.
- STRETCH SYLLABLE
    - Assess a penalty of the square of the degree to which candidate syllable duration falls short of the mean.
- SQUEEZE GRID COLUMN
    - Assess a penalty of the square of the degree to which candidate grid column duration exceeds the mean.
- STRETCH GRID COLUMN
    - Assess a penalty of the square of the degree to which candidate grid column duration falls short of the mean.
- SQUEEZE DEMIHEMISTICH
    - Assess a penalty of the square of the degree to which candidate demihemistich duration exceeds the mean.
- STRETCH DEMIHEMISTICH
    - Assess a penalty of the square of the degree to which candidate demihemistich duration falls short of the mean.

25. A few of the training data (Schuh measurements by demihemistich)

```
v - v -    0.108001       0.2832495      0.1379933
v - v -    0.201906       0.270291       0.1939169
- - v -    0.1818279      0.2785149      0.137179
v - v -    0.1903456      0.3092762      0.1321906
v - v -    0.0889996      0.2963731      0.1869171
v - v -    0.1797749      0.2519127      0.191127
v - v -    0.0950104      0.2935951      0.1408302
v - v -    0.1550768      0.3015516      0.1607214
- - v -    0.2171749      0.2410821      0.159706
v - v -    0.1847428      0.2347169      0.1177563
- - v -    0.2458428      0.2373107      0.2167177
- - v -    0.2621213      0.2833985      0.1522181
```

26. The targets (crude means)

	Mora	*Syllable*	*Position*	*Demihemistich*
Mean	153	203	144	577
Median	136	190	139	572
Smoothed mode[2]	128	154	131	572

27. A bit of the OT-Format candidate file[3]

- This demihemistich is — —, i.e. from a hemiola hemistich — — —.

[2] Replace each value with the average of itself and 20 tokens above and below it in the sorted distribution.

[3] Reformatted for clarity on this handout.

		Winner	SqueezeMora	StretchMora	SqueezeSyllable	StretchSyllable	SqueezePosition	StretchPosition	SqueezeMeter	StretchMeter
HHH+296+346	HH0H+80+80		0.00	4.02	0.00	3.05	0.00	4.36	0.00	17.43
	HH0H+80+90		0.00	3.83	0.00	2.81	0.00	4.15	0.00	16.60
	HH0H+80+100		0.00	3.64	0.00	2.59	0.00	3.96	0.00	15.80
	HH0H+80+110		0.00	3.47	0.00	2.40	0.00	3.78	0.00	15.01
	HH0H+80+120		0.00	3.30	0.00	2.22	0.00	3.60	0.00	14.25
	HH0H+80+130		0.00	3.15	0.00	2.06	0.00	3.44	0.00	13.50
	HH0H+80+140		0.00	3.00	0.00	1.93	0.00	3.28	0.00	12.78
	HH0H+80+150		0.00	2.86	0.00	1.81	0.00	3.14	0.00	12.07
	HH0H+80+160		0.00	2.74	0.00	1.71	0.00	3.01	0.00	11.39
	HH0H+80+170		0.00	2.62	0.00	1.64	0.00	2.88	0.00	10.72
	HH0H+80+180		0.00	2.52	0.00	1.58	0.00	2.77	0.00	10.08
	HH0H+80+190		0.00	2.42	0.00	1.54	0.00	2.67	0.00	9.45
	HH0H+80+200		0.00	2.34	0.00	1.53	0.00	2.57	0.00	8.85
	HH0H+80+210		0.00	2.26	0.00	1.52	0.00	2.49	0.00	8.26
	HH0H+80+220		0.00	2.20	0.03	1.52	0.00	2.41	0.00	7.70
	HH0H+80+230		0.00	2.14	0.07	1.52	0.00	2.35	0.00	7.15
	HH0H+80+240		0.00	2.09	0.13	1.52	0.00	2.30	0.00	6.63
	HH0H+80+250		0.00	2.06	0.22	1.52	0.00	2.25	0.00	6.12
	HH0H+80+260		0.00	2.03	0.32	1.52	0.00	2.22	0.00	5.64
	HH0H+80+270		0.00	2.02	0.44	1.52	0.00	2.20	0.00	5.17
	HH0H+80+280		0.00	2.01	0.59	1.52	0.00	2.18	0.00	4.73
	HH0H+80+290		0.00	2.01	0.75	1.52	0.00	2.18	0.00	4.30
	HH0H+80+300		0.02	2.01	0.93	1.52	0.01	2.18	0.00	3.90
	HH0H+80+310		0.04	2.01	1.14	1.52	0.02	2.18	0.00	3.51
	HH0H+80+320		0.08	2.01	1.36	1.52	0.05	2.18	0.00	3.15
	HH0H+80+330		0.12	2.01	1.60	1.52	0.09	2.18	0.00	2.80
	HH0H+80+340		0.18	2.01	1.86	1.52	0.13	2.18	0.00	2.48
	HH0H+80+350		0.24	2.01	2.15	1.52	0.19	2.18	0.00	2.17
	HH0H+90+80		0.00	3.83	0.00	2.81	0.00	4.15	0.00	16.60
	HH0H+90+90		0.00	3.63	0.00	2.57	0.00	3.95	0.00	15.80
	HH0H+90+100		0.00	3.45	0.00	2.36	0.00	3.76	0.00	15.01
	HH0H+90+110		0.00	3.27	0.00	2.16	0.00	3.57	0.00	14.25
	HH0H+90+120		0.00	3.11	0.00	1.98	0.00	3.40	0.00	13.50
	HH0H+300+320		0.10	0.00	2.29	0.00	0.06	0.00	0.18	0.00
	HH0H+300+330		0.14	0.00	2.53	0.00	0.09	0.00	0.28	0.00
	HH0H+300+340		0.20	0.00	2.80	0.00	0.14	0.00	0.39	0.00
	HH0H+300+350	1	0.26	0.00	3.08	0.00	0.19	0.00	0.53	0.00
	HH0H+310+80		0.04	2.01	1.14	1.52	0.02	2.18	0.00	3.51
	HH0H+310+90		0.04	1.82	1.14	1.29	0.02	1.97	0.00	3.15

28. Weights obtained

SQUEEZE MORA	3.43
STRETCH MORA	1.93
SQUEEZE SYLLABLE	0.90
STRETCH SYLLABLE	0.66
SQUEEZE POSITION	1.12
STRETCH POSITION	1.66
SQUEEZE DEMIHEMISTICH	0.48
STRETCH DEMIHEMISTICH	0.48

29. Best candidates for each foot type, with probability

Foot type	*Quantities*	*Syl1*	*Syl2*	*Syl3*	*Probability of this candidate*
Hemiola	— — —	270	270		0.01032
Heptamoraic	— — v —	210	260	150	0.001308
Medial v v	— v v —	270	160	160	0.001649
Iambic	v — v —	160	270	160	0.001649
Initial v v	v v — —	160	160	270	0.001649

30. Comparison with empirical data

Shortest	*True average*	*Model Prediction*
Lights in heptamoraic feet	154	150
Lights in hexamoraic feet	156	160
Heavy 1 of heptamoraic foot	210	210
Heavy 2 of heptamoraic foot	239	260
Heavy in a hexamoraic foot with two L	263	270
Heavy in a hexamoraic foot with no L	286	270

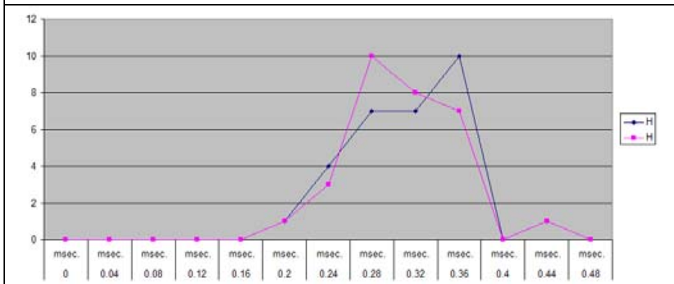
Longest

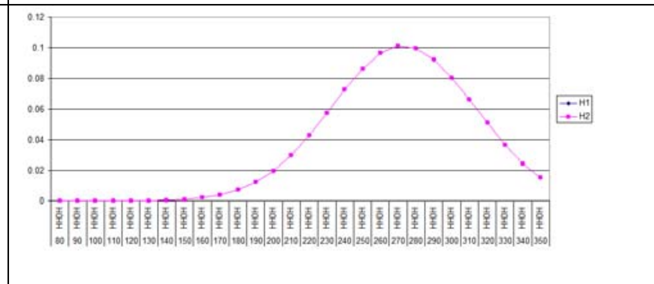
31. The model creates probability distributions

- We can do a "cross section" of candidates, summing all those with a particular value for a particular syllable.
- This creates histograms that can be compared with the empirical ones given earlier.

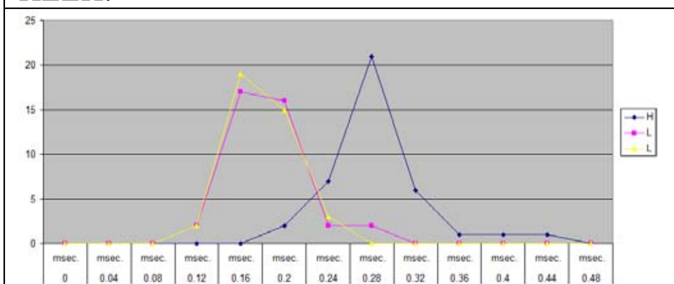
32. Histograms Comparison: Real on left, theory on right

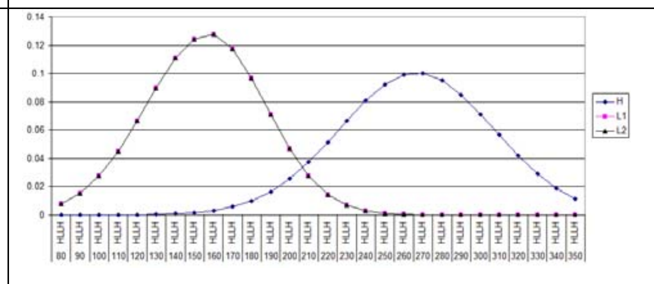
HHH:





HLLH:





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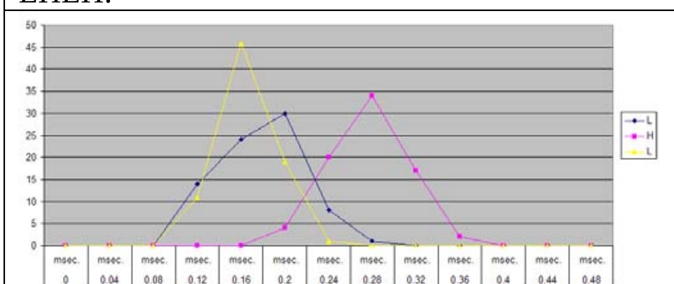

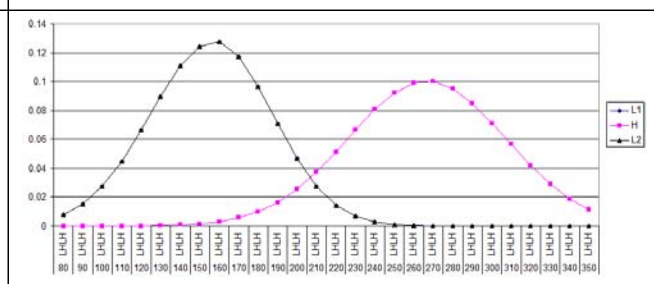

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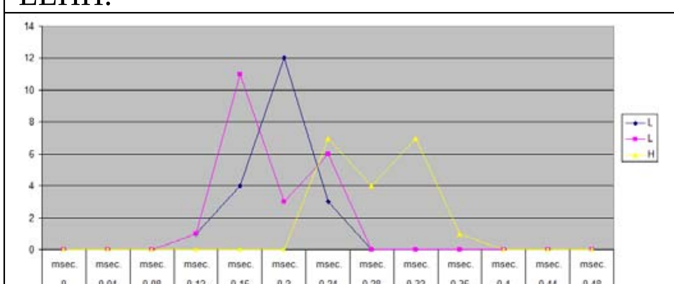

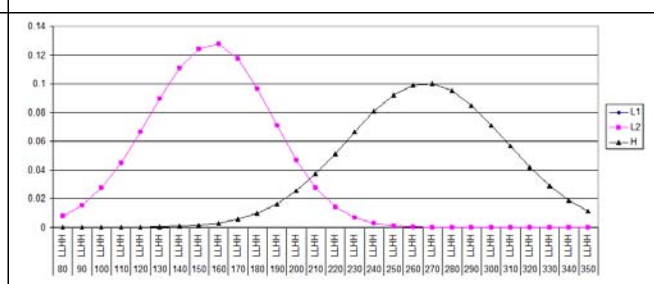

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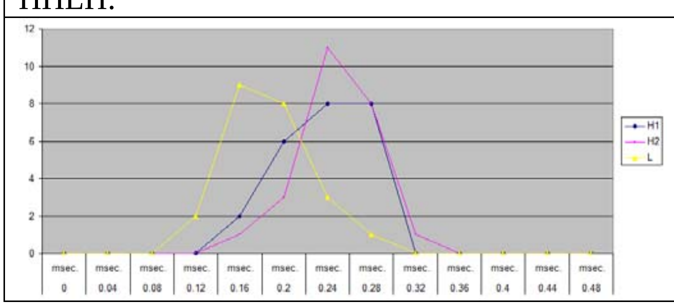

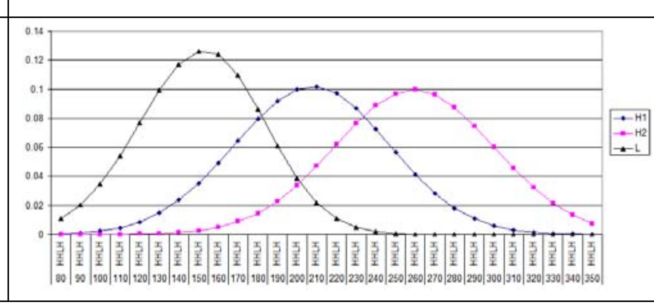

33. Is this ready for prime time?

- I think not, though I'm encouraged by the qualitative behavior.
- I think the next thing to work on is to improve the estimated targets of the contraints — I haven't tried smoothed modes; but intuitively, this ought to be the right target.