Complex world of PHONEMES

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"Sound systems of the world's languages show remarkable regularities"
What are these? Why are they here? How did they evolve?

That we knew

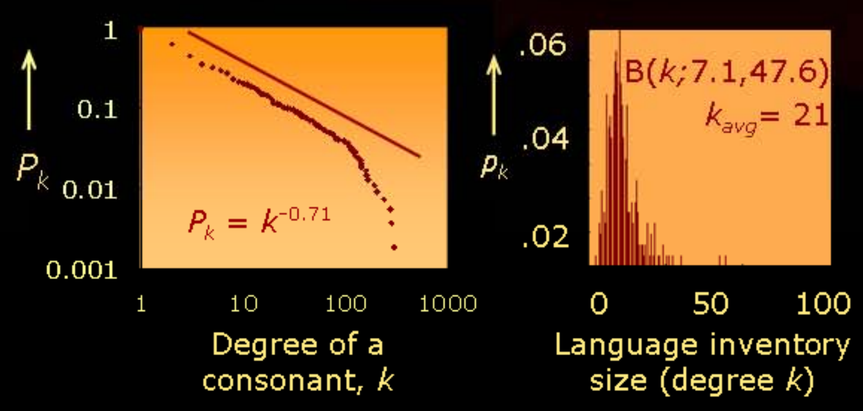
Consonants, vowels & diphthongs are the basic units of language that are combined to form words, phrases, sentences ...

Regularity across sound systems is due to a complex interplay of

- Acoustic Distinctiveness
- Ease of Articulation
- Ease of Learnability

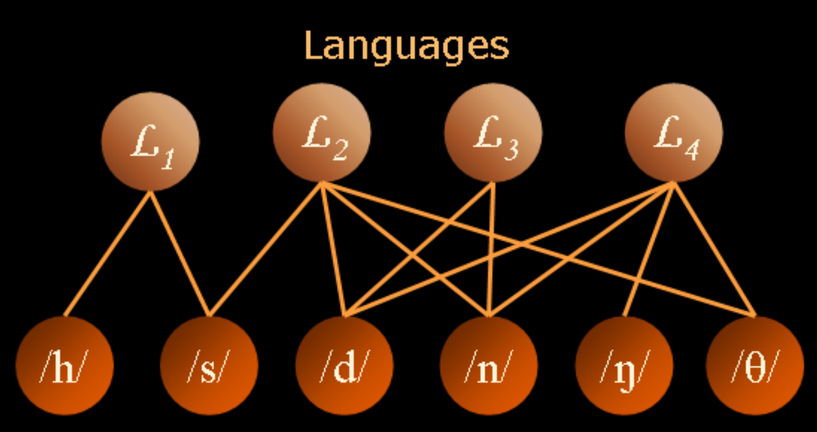
Regularity of vowel systems are known to be an outcome of acoustic distinctiveness.

Organization of the consonant inventories lacks a holistic explanation though several regular patterns have been reported since 1929.



PlaNet

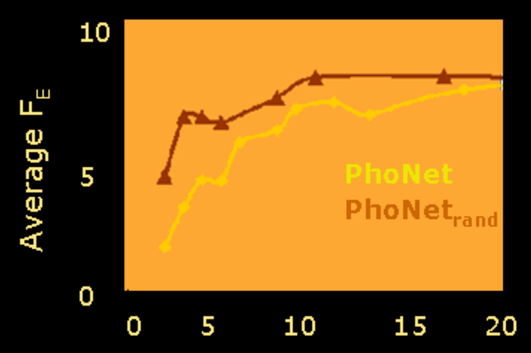
Phoneme-Language Network



Understanding nature

We find community structures in PhoNet by the modified Radicchi *et al.* algorithm

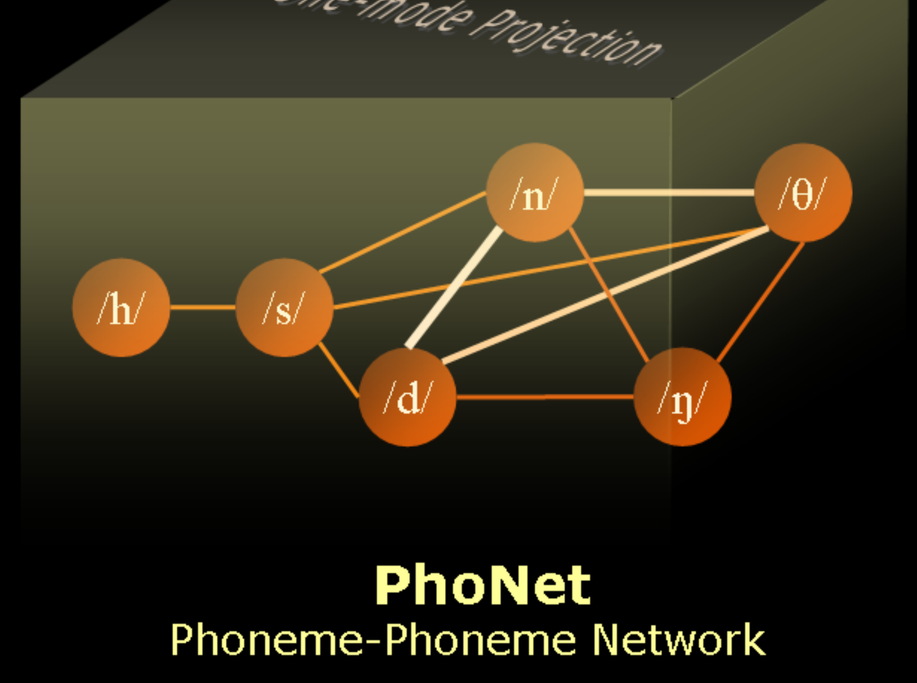
$$S = \frac{w_{uv}}{\sqrt{\sum_{i \in V_C - \{u,v\}} (w_{ui} - w_{vi})^2}}$$



The binding force of these communities is feature economy – tendency to maximize their combinatorial possibilities of a few distinctive features.

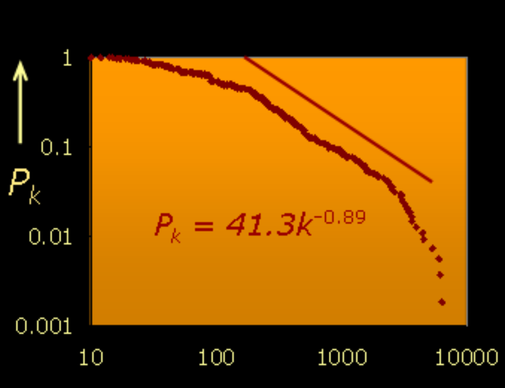
Feature entropy - an information theoretic definition of feature economy as follows

$$F_E = \sum_{F \in f} (-(p_f/N)\log(p_f/N) - (q_f/N)\log(q_f/N))$$



PhoNet

Phoneme-Phoneme Network



Data Source	UPSID
No. of Languages	317
No. of Consonants	541
Edges in PhoNet	34012
CC. of PhoNet	0.89

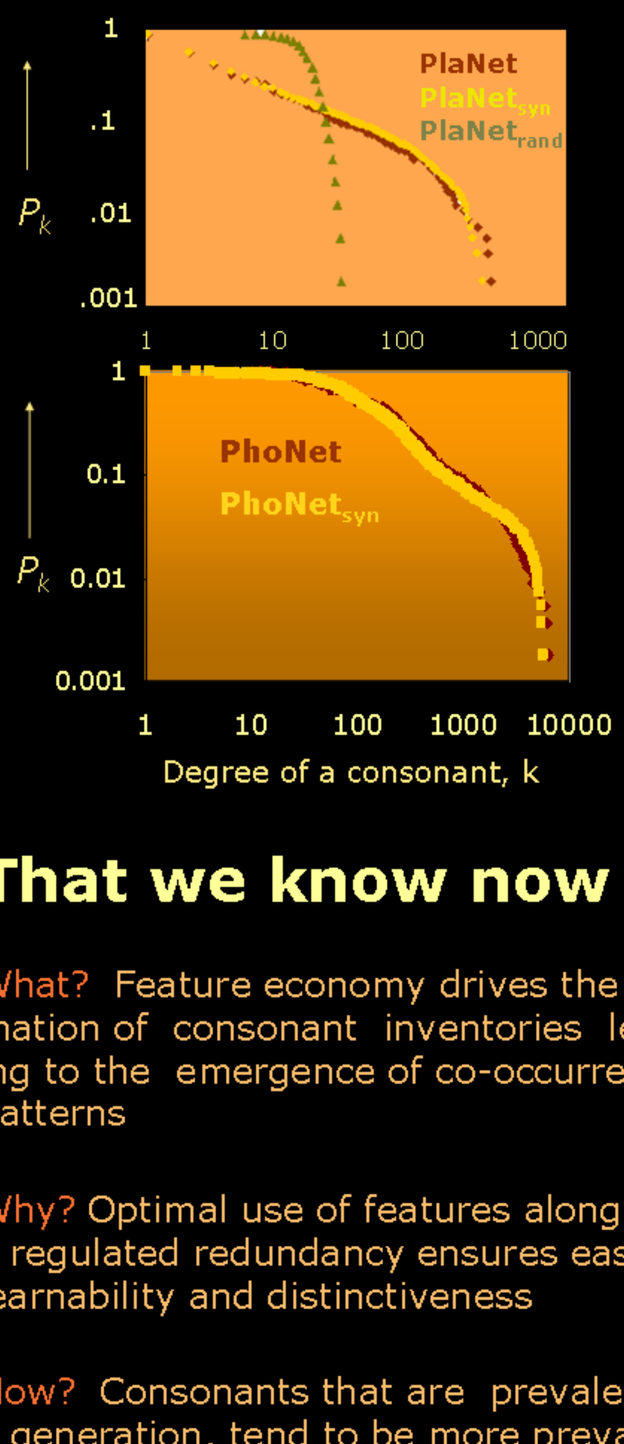
Recreating nature

Random Model:
Language nodes randomly attach themselves to the consonant nodes.

Occurrence based Synthesis Model:
Preferential attachment. Language nodes connect to consonant nodes following

$$Pr(C_i) = \frac{d_i^{\alpha} + \varepsilon}{\sum_{x \in V^*} (d_x^{\alpha} + \varepsilon)}$$

Co-occurrence based Synthesis Model:
Along with the preferential attachment, the model also allows formation of triads among nodes with certain probability.



That we know now

What? Feature economy drives the formation of consonant inventories leading to the emergence of co-occurrence patterns

Why? Optimal use of features along with a regulated redundancy ensures ease of learnability and distinctiveness

How? Consonants that are prevalent in a generation, tend to be more prevalent in the subsequent generations – a manifestation of preferential attachment

"Sound systems self-organize themselves through the process of language evolution and change"

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