“Markedness” is an epiphenomenon of random phonetically grounded sound change

Ollie Sayeed and Andrea Ceolin

sayeedo@sas.upenn.edu, ceolin@sas.upenn.edu

Annual Meeting on Phonology, October 2018, UC San Diego

Penn
UNIVERSITY of PENNSYLVANIA

Introduction

Jakobson (1941) and Haspelmath (2006) list ‘marked’ segments as having a cluster of internal and external properties:

- Marked segments have low frequency within a language.
- Marked segments have low crosslinguistic frequency.
- Marked segments have a restricted distribution within a language.
- Marked segments are acquired later in infancy.
- Marked segments are more likely to be impaired in cases of aphasia.

From Trubetzkoy (1939) onwards, most phonological theories from SPE to OT have encoded markedness in the grammar. A different approach (Blevins 2004, Hale and Reiss 2008, Samuels 2017) treats it as emergent from diachrony. Can we derive these synchronic facts from a simple model of sound change?

Evolutionary Phonology

Our model is a formalization of Evolutionary Phonology (Blevins 2004), where generalizations about sound patterns are reduced to generalizations about how those sound patterns came into existence. We define two new properties of ‘splitwise’ and ‘mergerwise’ markedness:

- **Splitwise marked** segments have a low probability of being created by sound change.
- **Mergerwise marked** segments have a high probability of being destroyed by sound change.

In EP, x is splitwise marked if it’s hard to misperceive another sound as x; and x is mergerwise marked if it’s easy to misperceive x as another sound.

The informal use of ‘marked’ here is fundamentally different from linguistic markedness. For a given pair of segments, this misperception probability will come from non-linguistic properties of articulation and perception, ultimately grounded in physics and psychology - not in theories of the grammar.

A mathematical model

Our model is a variant of a class of random fragmentation and aggregation models (Banavar et al. 2004), which have power-law distributions as their fixed points. We see these power-law distributions in attested type and token frequencies of phonemes within a language (Yule-Simon, Simon 1955, Tambovtsev and Martindale 2007, Martin 2007).

Following the traditional typology in historical linguistics, we treat sound changes as a sequence of splits and mergers. We start with a frequency distribution over phonemes, and randomly apply a split or a merger with equal probability:

- To apply a split, pick a random pair of segments x_i, x_j with $i \neq j$. Take away half of x_i’s probability mass and add it to the probability mass of x_j.

$$p_i^{t+1} := \frac{p_i^t}{2} \qquad p_j^{t+1} := \frac{p_i^t}{2} + p_j^t$$

- To apply a merger, transfer *all* of x_i’s probability mass to x_j.

$$p_i^{t+1} := 0 \qquad p_j^{t+1} := p_i^t + p_j^t$$

To encode biases in the actuation of sound change, we define the (inverse) splitwise markedness $P_S(x_j)$ and mergerwise markedness $P_M(x_i)$ as probability distributions over segments. In applying a split, we bias the choice of x_j according to $P_S(x_j)$, and in applying a merger, we bias the choice of x_i according to $P_M(x_i)$.

A computational implementation

We ran 1,000 simulations of the model for 100 generations, each with the same starting conditions:

- 20 phonemes, arbitrarily labelled $\{a,\ b,\ c\ \ldots\ldots\ t\}$;
- Uniform initial frequency in the language (0.05);
- Six phonemes $\{u,\ v,\ w,\ x,\ y,\ z\}$ with frequency 0 (i.e. don’t exist yet, but can be created through a split).

As a very simple example of mergerwise markedness, we implemented two evolutionary biases, one positive and one negative:

- Whenever a is selected for a merger, it will survive.
- Whenever b is selected for a merger, it will disappear.

Some simulation results

Figure 1 shows a skewed distribution within a typical run, emerging by random sound change from an initial uniform distribution. As we’d expect intuitively, the mergerwise unmarked a is frequent both across runs and within most runs; the mergerwise marked b is infrequent across runs and disappears in most runs. But this behaviour is statistical, not absolute: figure 2 shows that there are cases in which a disappears and cases in which b ends up higher than the starting frequency, despite evolutionary biases.

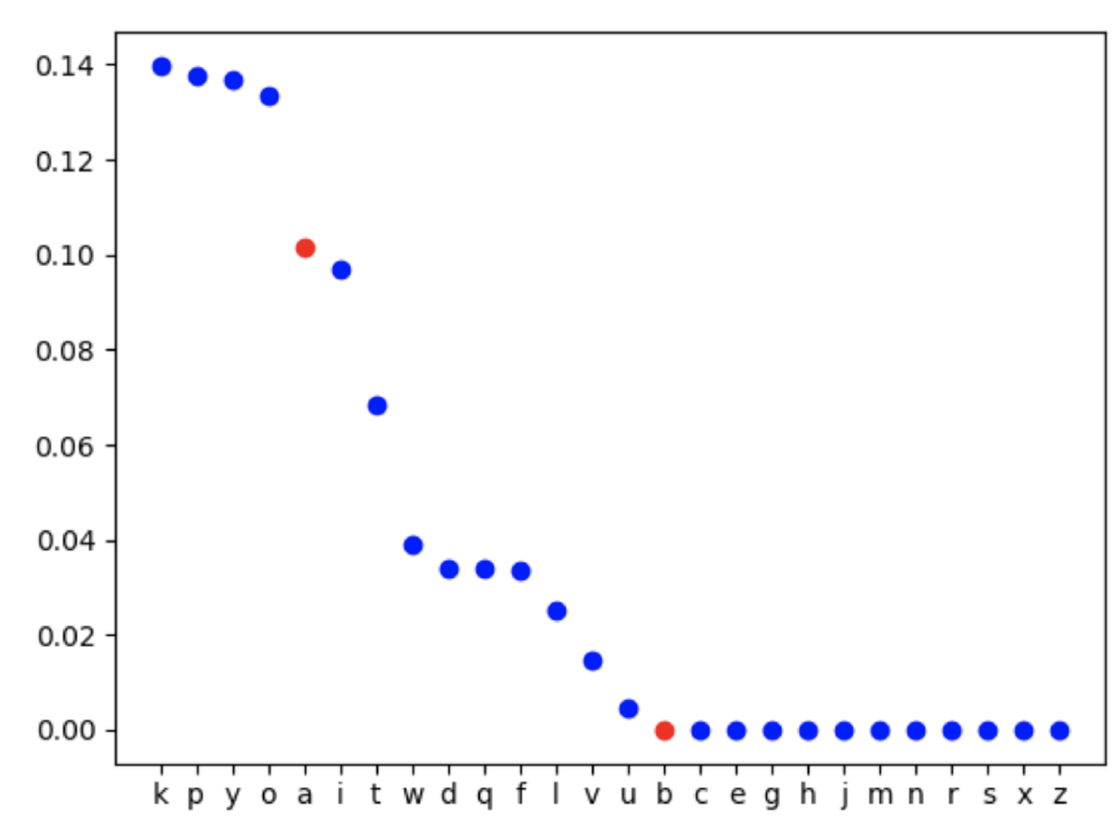

Figure 1: A typical run of our simulation after 100 iterations.

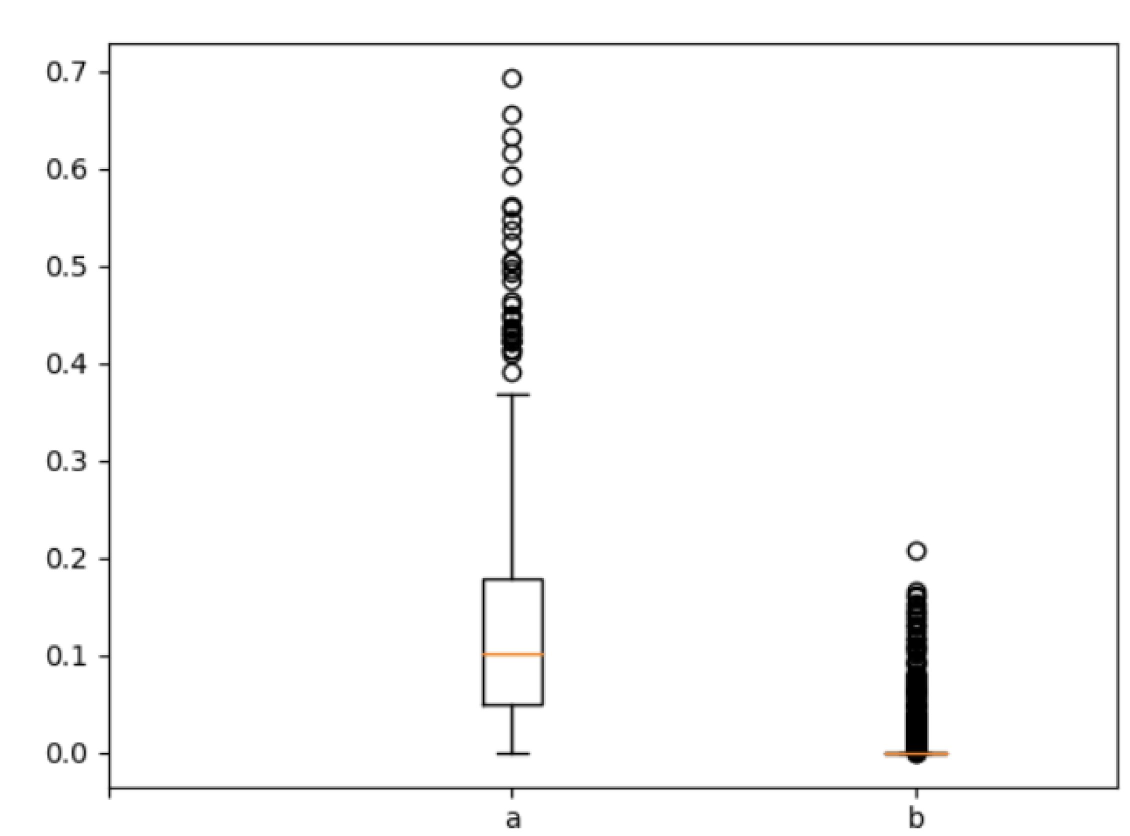

Figure 2: Summary of the final frequencies of a and b after 1000 parallel runs.

Some mathematical results

We derived expressions for the expected frequency $\mathbb{E}(p_i^{t+1})$ of a segment x_i at time $t+1$ - both i) across runs and ii) within the average run - as a function of its frequency at time t and the dynamics of the model. Both frequencies are decreasing functions of both types of markedness, giving a mathematical explanation for the empirical correlation between crosslinguistic frequency and within-language frequency (Gordon 2016).

Correlates of markedness

Romani et al. (2017) find that the last two correlates of markedness - age of acquisition and probability of impairment in aphasia - are correlated with crosslinguistic frequency independently of within-language frequency.

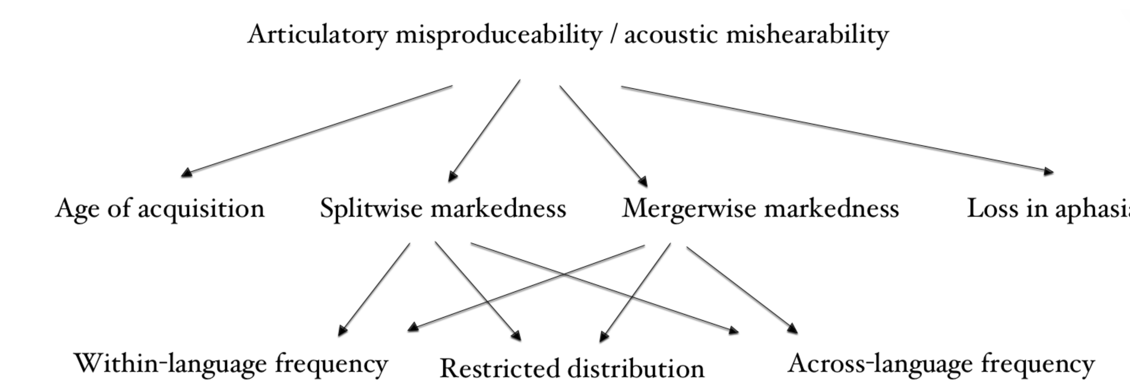

Figure 3: Dependencies between correlates of markedness.

This means these external senses of ‘markedness’ aren’t reducible to frequency within the language, but share some common source with both types of frequency. Romani et al. propose this common source is phonetic difficulty, of the type that also underlies splitwise and mergerwise markedness in an EP view of sound change.

Conclusions

A very simple model of sound change as a process of random splitting and merging of phonetic categories gives us:

- a skewed distribution of phoneme frequencies within the lexicon;
- a correlation between the crosslinguistic frequency and within-language frequency of a segment, ultimately derived from the probability of its being created or destroyed by sound change.

If the properties that cluster together as ‘markedness’ are actually emergent from sound change, synchronic theories don’t need to make reference to markedness.

Directions for further work:

- extend the model to strings, allowing conditioned sound changes;
- add a miniature lexicon and bias changes according to functional load;
- allow multiple segments to change at once, either through feature-based natural classes or through a chain shift.

References

Banavar, J. R. et al. (2004). Scale-free behavior and universality in random fragmentation and aggregation. **Blevins, J.** (2004). Evolutionary phonology: The emergence of sound patterns. **Gordon, M. K.** (2016). Phonological typology. **Hale, M., & Reiss, C.** (2008). The phonological enterprise. **Haspelmath, M.** (2006). Against markedness (and what to replace it with). **Jakobson, R.** (1941). Child language, aphasia and phonological universals. **Martin, A. T.** (2007). The evolving lexicon. **Romani, C. et al.** (2017). Comparing phoneme frequency, age of acquisition, and loss in aphasia: Implications for phonological universals. **Samuels, B.** (ed.) (2017). Beyond markedness in formal phonology. **Tambovtsev, Y., & Martindale, C.** (2007). Phoneme frequencies follow a Yule distribution. **Trubetzkoy, N. S.** (1939). Principles of phonology.