LI 308: Computational models of sound change

Monday, Thursday 1.10–3.00, Harper 140

James Kirby (j.kirby@ed.ac.uk)

Morgan Sonderegger (morgan.sonderegger@mcgill.ca)

Office hours: By appointment

Aims and objectives

Decades of empirical research have led to an increasingly nuanced picture of the nature of phonetic and phonological change, incorporating insights from speech production and perception, cognitive biases, and social factors. However, there remains a significant gap between observed patterns and proposed mechanisms, in part due to the difficulty of conducting the type of controlled studies necessary to test hypotheses about historical change.

Computational and mathematical models provide an alternative means by which such hypotheses can be fruitfully explored. Keeping in mind Box's dictum (all models are wrong, but some are useful), computational models can be a useful tool to help us understand the process of phonetic and phonological change.

In this course, students will be introduced to the growing literature on computational modeling of sound change, with special attention to modeling phonetic change and exploring the influence of community structure on change. In addition to seminars and discussion, the course will provide extensive hands-on experience with computational models through several case studies. Throughout, we will emphasize good modeling practice, especially with regards to the design, interpretation, and evaluation of computational models.

Prerequisities

Some background in programming (especially in R) or mathematics (e.g. probability theory, single-variable calculus, or linear algebra) is helpful, but not required.

Electronic logistics

We have set up a course Piazza site at https://piazza.com/lsa_linguistic_institute/summer2015/li308/, which will contain course materials (code, readings) as well as provide a forum to discuss readings and results.

Please include "LI 308" in the subject line of emails to the instructors.

Course structure

The first day of the course will provide background and a general outline of computational modeling and how it can be used to study sound change.

Each of the following three sessions will be centered around one type of computational model of sound change which has been proposed in the literature. These classes will begin with seminar-style lecture/discussions, where we will discuss the assigned readings on some topic(s), as well as related work, at a relatively high level.

The second half of these days will be labs, with hands-on exploration and extension of a model described in one of the week's readings. The goal is to explore how changes (linguistically-motivated or otherwise) to the model and/or its parameter settings impact the model's behaviour and predictions.

Materials

To participate in the course you will need access to a laptop. If you do not wish to bring your laptop to each class session, it should be possible to work together with one or more other students, but you will need access to a computer with R and Python (2.7) installed. We recommend the RStudio IDE, but vanilla R works fine as well.

The *Readings* will be kept to a minimum, but the Required readings will be assumed background knowledge for the following day, and the seminars will proceed accordingly.

In addition to the readings, we will provide an R Markdown document of a model discussed in one of the readings, that you will be using as a basis for extensions carried out in the lab portion of the next day's class. You should ensure that you have downloaded the code and can execute the examples contained in it before the next day's class. These materials will be distributed via the Piazza site.

Assessment

Participation & Labs: 25%; Project: 75%.

The *Participation* mark will include attendance, as well as in the in-class *Labs* on days 2-4 that will involve hands-on exploration of one or more models (either individually or in small groups) and an associated Piazza post describing your findings.

We would also ask that at some point during the course, each student identify one paper on modeling of sound change (broadly construed) and provide a brief (1 paragraph) summary of it (posted to the Piazza site). Ideally, this paper would *not* be featured in our annotated bibliography.

The final *Project* will be an individual extension, and **brief** (max 4 pages) write-up, of one of the labs of your choice.

Schedule

Day 1: Monday, July 20th

- Course logistics; what this course will and will not cover
- Introduction to sound change and computational models in general
  - What is sound change? What are we trying to model?
  - Why computational models? How do we build, use, and evaluate them?
- *Readings* (for 7/23):
  - Required: Garrett (2014), Pierrehumbert (2001)
  - Optional: Wedel (2004); McElreath & Boyd (2007), Chapter 1

Day 2: Thursday, July 23rd

- Exemplar models of phonetic change in individuals
  - Perception, bias, entrenchment
  - Frequency effects, variant trading, lexical displacement
- *Lab:* Extensions to Pierrehumbert (2001)
- *Readings* (for 7/27):
  - Required: de Boer (2000)
  - Optional: Liljencrants & Lindblom (1972); Kirby (2013); McMurray et al. (2009)

Day 3: Monday July 27th

- Dispersion; inventory change as an emergent phenomenon
- Model selection, category merger, multidimensionality
- *Lab:* Extensions to de Boer (2000)
- *Readings* (for 7/30):
  - Required: Kirby & Sonderegger (2015); Stanford & Kenny (2013)
  - Optional: Niyogi (2006), Chapter 6; Blythe & Croft (2009); Pierrehumbert et al. (2014)

Day 4: Thursday July 30th

- Models of change in populations
  - 'Iterated learning' vs. 'social learning'
  - Dynamical systems approaches vs. simulation
  - Social network structure
- *Lab*: Extensions to Kirby & Sonderegger (2015)

Selected bibilography

While the literature on sound change proper is still growing, there is now a significant body of work on modeling language change more generally. Below we have attempted to organize some of the literature we are aware of, to give you some idea of where you might look to continue exploring topics of interest.

Acquisition

A vast field in its own right, but given the crucial role acquisition is thought to play in sound change, computational models of how phonetic/phonological categories are learned or acquired are highly relevant. Some recent works include Cristia et al. (2013); de Boer & Kuhl (2003); Dillon et al. (2013); Feldman et al. (2009); Kirby (2011); Lake et al. (2009); Lin (2005); McMurray et al. (2009); Vallabha et al. (2007); Wilson (2006) and references therein.

Agent-based models

In the linguistic context, agent-based models are those in which individual language learners or users are directly modeled and interact with one another in a virtual environment. Good introductions to agent-based modeling in the social sciences more generally are Gilbert & Terna (2000) and Gilbert (2007). Some models of sound change that explicitly identify themselves as agent-based include Chirkova & Gong (2014), Fagyal et al. (2010), Harrison et al. (2002), Kirby (2014), Mailhot (2013), and Stanford & Kenny (2013).

Catalogues of sound changes

While there is no 'master list' of attested sound changes, many examples have been collected in Blevins (2008) and Kümmel (2007). Grammont (1939) and Hock (1991) are also useful resources.

Corpus linguistics/phonetics

Another huge area we will not touch on at all in this course. Some ongoing projects in this area with a specific focus on sound change include Sounds of the City (Glaswegian English), From Inglis to Scots (inferring sounds from spellings), ONZE (Origins of New Zealand English), and the Philadelphia Neighborhood Corpus. Many other corpora are described in the the recent handbook of Durand et al. (2014). Some recent 'corpus phonetics' papers focused specifically on sound changes include Hay et al. (2015), Kang (2014), Labov et al. (2013), and Zellou & Tamminga (2014). Harrington (2010) is a useful technical resource.

Cultural evolution/'iterated learning'

Much of the research on language from the cultural evolutionary perspective has been concerned with the *initial* evolution of language, i.e. how humans moved from a pre-linguistic to a linguistic state. However, due perhaps in part to the ambiguity of the term 'evolution', it has also attracted the interest of linguists interested in (ongoing) language change, and the underlying mathematical and computational models are highly relevant for the study of sound change. Some important works in this area include Boyd & Richerson (1985); Burkett & Griffiths (2010); Cavalli-Sforza & Feldman (1981); Gong et al. (2012); Griffiths & Kalish (2007); Griffiths et al. (2013); Kirby (1999); Kirby & Hurford (2002); Kirby et al. (2007); McElreath & Boyd (2007); Nettle (1999); Niyogi & Berwick (2009); Nowak et al. (2001); Reali & Griffiths (2009); Smith et al. (2003); Smith (2009); Tavares et al. (2007); and Wang et al. (2004).

Dispersion

The idea that sound systems evolve to implement a kind of optimal auditory dispersion was first modeled by Liljencrants & Lindblom (1972) and has been further explored by Boersma (1998), Boersma & Hamann (2008), de Boer (2000, 2001), ten Bosch (1995), Flemming (2005), and Ke et al. (2003).

Exemplar models

Exemplar models, broadly construed, are those in which categories consist directly of (a large number of) stored percepts. Originally developed as a model of perception and categorization in psychology, exemplar models became increasingly popular in certain areas of linguistics, such as sociophonetics, in the early 2000s. Examples of exemplar models applied to the study of language change include Blevins & Wedel (2009); Ettlinger (2007); Garrett & Johnson (2013); Kirby (2013); Mailhot (2013); Morley (2014); Oudeyer (2006); Pierrehumbert (2001, 2002); Tupper (2014); and Wedel (2004, 2006, 2007).

Note that while exemplar models are often agent-based, the converse is not necessarily true.

Functional load

The concept of functional load, implicitly or explicitly, plays an important role in many models of sound change. Foundational works include Hockett (1967), Martinet (1952), and Wang (1967); the idea has also been revisited more recently by Surendran & Niyogi (2003, 2006), Bouchard-Côté et al. (2013), and Wedel et al. (2013).

Social dynamics

Research in the sociolinguistic tradition, following on from the groundbreaking work of Labov, Trudgill, and the Milroys, has inspired a growing number of quantitative studies, including those by Baker (2008a,b), Baker et al. (2011), Baxter et al. (2009), Blythe & Croft (2009, 2012), Fagyal et al. (2010), Ke (2007), Ke et al. (2008), Pierrehumbert et al. (2014), and Stanford & Kenny (2013). A frequent evaluation metric in much of this work is 'S-shapedness': a modeled change is judged to be realistic (or not) based on the extent to which the change spreads throughout the population in a logistic fashion.

Language change in general

A few, but by no means exhaustive, important works addressing language (but not necessarily sound) change from a quantitative perspective include Clark & Roberts (1993); Croft (2000); Klein (1966); Kroch (1989); Niyogi & Berwick (1995, 1996); Niyogi (2006); Sonderegger & Niyogi (2010); Yang (2000, 2002); and Zuraw (2003).

Quantitative historical linguistics

Quantitative or computational historical linguistics is a huge subfield in its own right. Two very good online bibliographies include

`http://cysouw.de/teaching/2010_quantitative_historical_linguistics.html`

and

`http://quanthistling.info/publications/`

Work in this area is extremely active; a few more recent papers include Bowern & Atkinson (2012), Bouckaert et al. (2012), and Chang et al. (2015). Bouchard-Côté et al. (2013) is notable for including an explicit model of sound change, not usually an aspect of computational reconstructions that is made explicit.

Author attribution

Please note: there are two Kirbys. Be sure to cite the right one. We are not related, but confusingly we do work at the same institution, in the same department, and on related topics.

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