SOCIAL DYNAMICS AND PHONOLOGICAL STRENGTH: POST-NASAL DEVOICING IN TSWANA

Grzegorz Dogil[1], Jagoda Bruni[1], Daniel Duran[1], Justus Roux[1,2], Andries Coetzee[3]

[1] Institute for Natural Language Processing, University of Stuttgart, [2] North-West University, South Africa,
[3] Department of Linguistics, University of Michigan
daniel.duran@ims.uni-stuttgart.de

This study describes the influence of social and political changes in the South African phylum. The socio-political situation in South Africa has changed from very restrictive language policies that characterized the political system of the country for several generations to very liberal language policies that have been introduced at the outset of SA as a "rainbow nation" in 1994. Nine indigenous languages of South Africa, which have been restricted in use and social impact have been assigned a status of official languages along with English and Afrikaans. Code switching among languages of South Africa firmly exploded after the revolutionary change in the social dynamics of the country. One of the languages influenced by this new social dynamics is Tswana, a Bantu language of the Sotho group. Tswana has a phonetically marked post-nasal strengthening process which has been described in great detail by Zsiga et al. [2006] and Coetzee and Pretorius [2010].

It has been well-documented that post-nasal devoicing is a phonetically unintuitive phenomenon requiring more articulatory effort than producing sequences of a nasal followed by a voiced stop [Westbury and Keating, 1986]. Moreover, Pater [1999] argues for the *NT constraint, claiming that many languages demonstrate existence of prenasalized voiced stops but lack prenasalized voiceless stops. Typological data, as well as phonetic evidence argue for a universal but violable *NC̥ constraint. Coetzee and Pretorius [2010] show, however, that post-nasal devoicing prevails in eighty percent of productions of post-nasal stops in their data systematically collected from twelve speakers. Moreover, twenty-five percent of those voiceless plosives are produced as an ejective, an even stronger type of plosive. The remaining twenty percent of post-nasal stops are classified as voiced, i.e. they contain an expected, weak plosive variant.

In the present study we use computational simulations in order to test the predictions about the direction of a sound change apparently happening in Tswana. We built our simulations on the laboratory corpus of Coetzee and Pretorius [2010] and are testing it on the less canonical acoustic Tswana data from the NCHLT_tsn corpus [Barnard et al., 2014]. We use this real-life speech recordings as a society sample and put the two speech varieties (*Tswana 1*—speakers with a voiced stop variety, and *Tswana 2*—speakers with strong post-nasal devoicing) through several simulation settings incorporating Social Impact Theory [Nettle, 1999] to model social dynamics, and Exemplar Theory [Wedel, 2006] to model speech production–perception and memory organization at the individual level. Over several *epochs*, agents interact by producing speech items and transmitting them from speaker to listener. Various factors like production noise, exemplar selection and production biases, perceptual warping as well as aging and death of individuals introduce variability which promotes change.

We model individuals as agents in a multi-agent simulation. Each agent has its own memory of previously encountered speech items (exemplars) which may serve as templates for future productions. The population of agents is embedded within a *social network*. This network represents social relations between the members of the community. Formally, it is represented as a graph, where nodes correspond to agents and edges between nodes correspond to social relations. We define *social distance* between two given agents as the minimal path length (i.e. the minimum number of edges) between the two corresponding nodes. The particular connection patterns of agents within the social network, i.e. the *network topology*, reflects the social structure of the population to be modeled. In order to reflect the parochial society structure corresponding to largely closed language communities, we use a network with a number of clusters which we refer to as *parishes*. Each cluster is connected to two other clusters by exactly one (randomly chosen) link, such that all clusters together form a closed loop and there exists a path between any given pair of agents. Within each cluster, the network graph has a *small world* topology [Milgram, 1967, Watts and Strogatz, 1998]. This has the effect that the average path length within each parish is relatively small, but across parish boundaries the average path lengths are relatively large. We refer to this setting as the *parochial* *small-world network*. The linguistic situation of Tswana after 1994 (opening to influence of other languages) is modeled by a network which has a small average path length over the entire population. We refer to this setting as the *whole world network*. Based on different networks, different types of speaker–listener interactions can be investigated. Agents may interact, for example, based on social distance or *closeness* (with a bias towards individuals within their social neighborhood), or based on social *status* (with a bias towards more influential individuals). We also include *full* interaction, where everybody talks to everybody else, irrespective of social status or closeness.

Our computational modeling experiments are based on a classical notion of historical phonology which assumes that processes affect sounds along the scales of phonological strength [Hock, 1986, Dogil and Luschützky, 1990]. The devoicing and ejectivization of plosives is considered strengthening of their articulatory and phonatory features. The voicing of stops in post-nasal position is considered as weakening. We feed those complementary phonological notions into our simulations. In particular we model social dynamics of Tswana speakers by assigning them either to the *parochial small-world* communication networks or the *whole world* intensive code switching communication networks typical of the present linguistic situation in South Africa.

Our results show the influence of social and linguistic factors. The model predicts differences in the development of sound change dependent on network topology, social status of agents and their interactions. Figure 1 shows an illustrative outcome of a simulation based on laboratory data where *Tswana 1* variants constitute an initial majority form. Qualitatively different evolutions of the population's productions are possible along the scale from weakening to strengthening. Despite an initial majority of agents assigned to *Tswana 1*, the weighting of individual parameters predicts qualitatively different distributions of the competing variants. We count the ratio of produced items representative of *Tswana 1* out of all produced items in each epoch. The two top lines correspond to a case where after initial competition, the weakening pattern prevails. The two mid lines describe a situation where both variants prevail and the two bottom lines correspond to a situation where strengthening is the optimal outcome. Thus, the simulation of social dynamics alone such as network topology and agent interactions models directions of a sound change.

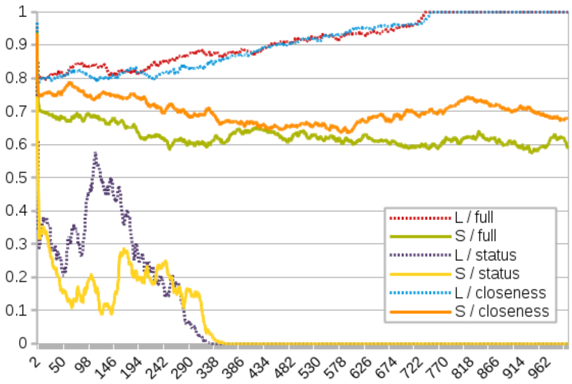

Figure 1: Ratio of *Tswana 1* productions over 1000 epochs. **L** and **S** indicate network topologies with large and small average path lengths, respectively; **full**, **status** and **closeness** indicate speaker-listener interaction types.

REFERENCES

E. Barnard, M. H. Davel, Ch. van Heerden, F. de Wet, and J. Badenhorst. The NCHLT Speech Corpus of the South African languages. In *Proc. of SLTU*, pages 194–200, St. Petersburg, Russia, 2014.

A. W. Coetzee and R. Pretorius. Phonetically grounded phonology and sound change: The case of Tswana labial plosives. *J. of Phonetics*, 38(3): 404–421, July 2010.

G. Dogil and H. Ch. Luschützky. Notes on sonority and segmental strength. *Rivista di Linguistica*, 1 (2):3–54, 1990.

H. H. Hock. *Principles of Historical Linguistics*. Mouton de Gruyter, Berlin, 1986.

S. Milgram. The small-world problem. *Psychology Today*, 1(1):61–67, 1967.

D. Nettle. Using social impact theory to simulate language change. *Lingua*, 108(2-3):95–117, 1999.

J. Pater. Austronesian nasal substitution and other NC̥ effects. In R. Kager, H. van der Hulst, and W. Zonnenveld, editors, *The Prosody-Morphology interface*, pages 310–343. Cambridge University Press, Cambridge, 1999.

D. J. Watts and S. H. Strogatz. Collective dynamics of 'small-world' networks. *Nature*, 393(6684): 440–442, 1998.

A. Wedel. Exemplar models, evolution and language change. *The Linguistic Review*, 23:247–274, 2006.

J. R. Westbury and P. A. Keating. On the naturalness of stop consonant voicing. *Journal of Linguistics*, 22(01):145, 1986.

E. Zsiga, M. Gouskova, and O. Tlale. On the status of voiced stops in Tswana: Against *ND. In C. Davis, A. Deal, and Y. Zabbal, editors, *The Proc. of NELS 36*, pages 721–734, Amherst, MA, 2006. GLSA.