Where does the air pressure come from? The production of ejectives in German and Georgian.

Adrian P. Simpson & Erika Brandt
Friedrich-Schiller-Universität Jena

In German the release of word-final plosives in combination with syllable-onset junctural glottalisation gives rise to stop releases with the auditory and acoustic characteristics of ejectives (Simpson 2007). However, the articulatory ingredients producing such epiphenomenal ejectives lack one important ingredient necessary for the production of textbook ejectives: compression of the supraglottal cavity realised by upward movement of the larynx (Catford 1977). Simpson (2014) has speculated that the air pressure fuelling such plosive releases is in fact brought about by a pulmonic airflow entering the closed oral cavity of an oral stop prior to a subsequent closure of the glottis before the stop closure is released (schematised in fig. 1). Simpson further speculates that this epiphenomenal production mechanism may well be used in the production of ejectives in languages in which they make up part of the phonological inventory.

The present study describes two-stage multi-channel data acquisition of target and control plosives from a sample of 15 German and 13 Georgian female subjects. In the first study, multichannel recordings (sound pressure wave, intraoral pressure, Lx, and LT) were made of target and control plosives in the sentence contexts. Dual channel electrography allows us to observe higher frequency vocal fold activity (Lx) as well as possible vertical movement of the larynx (LT – larynx trace) calculated from the relative intensities of the two larynx conductance signals produced from the two electrode pairs (Rothenberg 1992). In a second study, realtime MRI recordings were made of a subset of the German and Georgian subjects to establish whether any vertical larynx movement or other compression of supraglottal cavities was present. MRI recordings have just been completed and will not be discussed further.

Results from the first study confirm the lack of larynx movement in the production of epiphenomenal ejectives for /t/ and /k/ in German. However, for /p/ LT suggests larynx raising compared to preceding vowel in target condition and condition schwa (<hatte ein>) (see fig. 2). More interestingly, the presence of vocal fold activity and the simultaneous rise in intraoral pressure together with the lack of any obvious larynx movement also provide first confirmation for the hypothesis that many Georgian ejectives, at least in non-initial contexts, exploit a pulmonic airstream to fuel the burst at the release of the ejective (see fig. 3).

Initial results from the German subjects' production of 'pulmonic ejectives' provide a plausible account for the emergence of ejectives in a language prior to a point where speakers may begin to fuel pressure changes by compressing the supraglottal cavity (Ohala 1997). Results from both languages also show that larynx movement may not be used at all to produce the auditory impression of an ejective given a suitable synchrony of glottal activity (open vs. closed) with oral closure, confirming model predictions from Kingston (1985), but also the astute descriptive observations of an early study of Georgian phonetics (Robins & Waterson 1952).

References

Catford, J.C. 1977. *Fundamental Problems in Phonetics*. Edinburgh: Edinburgh University Press.
Kingston, John C. 1985. *The phonetics and phonology of the timing of oral and glottal events*. Ph.D. thesis, University of California, Berkeley.
Ohala, John J. 1997. "Emergent stops". *Proceedings of the 4th Seoul International Conference on Linguistics (SICOL 1997),* Seoul, 11th–15th August 1997. 45–50.

Robins, R. H. & Natalie Waterson. 1952. Notes on the phonetics of the Georgian word. *Bulletin of the School of Oriental and African Studies* **14**, 55–72.
Rothenberg, Martin. 1992. A multi-channel electroglottograph. *Journal of Voice* **6**(1), 36–43.
Simpson, Adrian P. 2007a. Acoustic and auditory correlates of non-pulmonic sound production in German. *Journal of the International Phonetic Association* **37**(2), 173–182.
Simpson, Adrian P. 2014. Ejectives in English and German – linguistic, sociophonetic, interactional, epiphenomenal? In Chiara Celata & Silvia Calamai (eds.), *Advances in sociophonetics*. Amsterdam: Benjamins, 187–202.

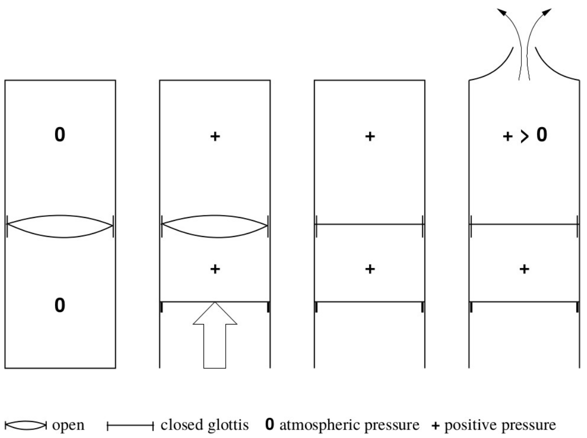

Fig. 1: Representation of production mechanism driving an epiphenomenal ejective release using Catford's (1977) schematisation method.

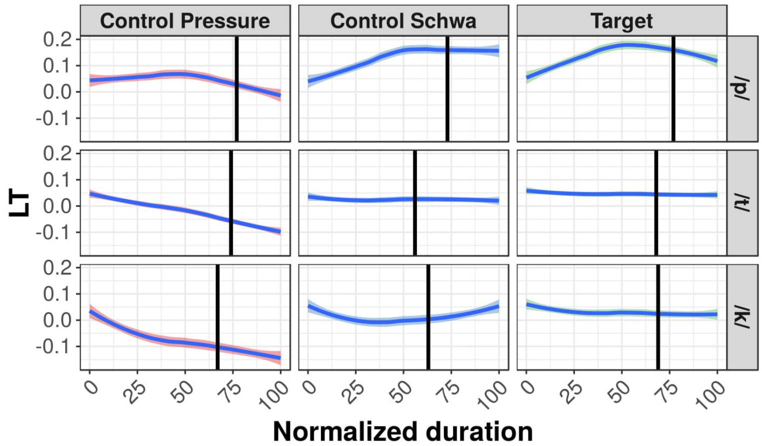

Fig. 2: Time normalized, ensemble averaged LT for German /p, t, k/ in control pressure (<hat nie>), control schwa (<hatte ein>), and target (<hat ein>) with averaged plosive release (vertical line).

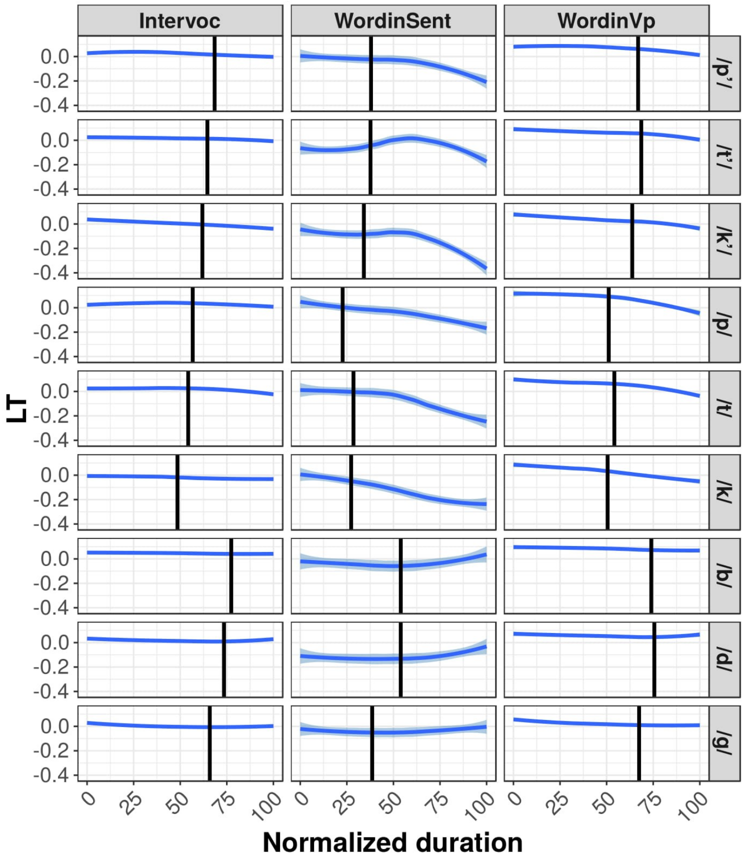

Fig. 3: Time normalized, ensemble averaged LT for Georgian /p', t', k', p, t, k, b, d, g/ in intervocalic (Intervoc), word initial, sentence initial (WordinSent), and word initial with preceding vowel (WordinVp) conditions and added averaged plosive release (vertical line).