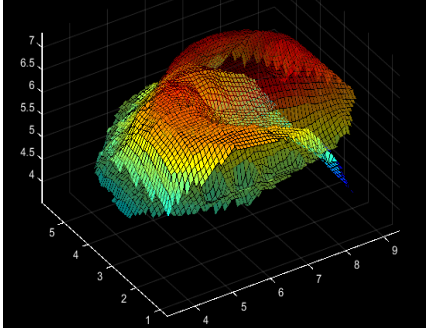# Three-dimensional imaging of tongue shape in Marathi liquids

This study presents three-dimensional articulatory data of the five liquid consonants in Marathi (/l/, /lʱ/ /r/ /rʱ/ /ɭ/) (Dhongde & Wali 2009; Pandharipande 1997). Laterals and rhotics tend to provoke great interest on the part of researchers both because they are articulatorily complex and because they are subject to articulatory and acoustic variation crosslinguistically and across and within speakers (Ladefoged & Maddieson 1996; Proctor 2011; Wiese 2001, 2011). As such, a good body of work has investigated the articulation and the acoustic characteristics of these sounds in languages like English (Dellatre & Freeman 1968; Guenther *et al.* 1998; Sproat & Fujimura 1993; Westbury, Hashi, & Lindstrom 1998; many others). Comparatively little work, meanwhile, has focused on liquids in South Asian languages, which is interesting in that English contains just two liquids while many South Asian languages contain more. This is not to say that such research is nonexistent: recent work, for example, has provided analysis of the acoustic characteristics of liquids in Malayalam (Punnoose, Khattab, & Al-Tamimi 2013), and both imaging (palatography and electropalatography) and acoustic analysis of Tamil liquids exists (McDonough & Johnson 1997). Nor is ultrasound data absent—recent publications have focused on Kannada retroflex geminates (Kochetov *et al.* 2014) and mid-sagittal ultrasound imaging of the five Malayalam liquids (Scobbie, Punnoose, & Khattab 2013).

To date, however, Marathi's five liquids have not been investigated. We utilize recent advances in 3D ultrasonography to provide detailed articulatory data for these complex sounds, combining real-time images of tongue motion, digitized impressions of the palate, and time-aligned acoustic signals. This methodology allows for the creation of images such as that found in Figure (1), included for illustration only: this is the American English rhotic in onset position produced by a female speaker from Indiana (from Lulich *et al.* 2016; used with permission).[1] For the present research, real Marathi words containing the five liquid consonants of interest were elicited. Target words—listed in Table (1)—were embedded in carrier sentences.

Fig. (1) American English /ɹ/, in *'reap'*	**Table (1)** Liquid consonants of Marathi.

Fig. (1) American English /ɹ/, in *'reap'*

From Lulich *et al* 2016. *The speaker's palate is superimposed over the lingual articulation data.*

Table (1) Liquid consonants of Marathi.

	LATERAL	RHOTIC	RETRO-FLEX
PLAIN	**l** [lagu] *applicable*	**r** [radʒa] *king*	**ɭ** [baɭ] *baby*
BREATHY	**lʱ** [lʱasa] *Lhasa, Tibet*	**rʱ** [rʱas] *deterioration*	

We present pilot data from a single female native speaker of Marathi. Three dimensional imaging of the five liquids is presented with a focus on the distinction between the lateral and the rhotic, the tongue root advancement differences that help distinguish the plain from the breathy version of each pair, and the articulatory features of the retroflex approximant.

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[1] Marathi data have been collected and are under analysis, but representative Marathi images are not yet available for this abstract.

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