Palatalization and velarization in Malayalam nasals: a preliminary acoustic study of the dental–alveolar contrast

Sameer ud Dowla Khan
Reed College
skhan@reed.edu

Abstract

The current study builds upon the literature on secondary articulations in Malayalam liquids to investigate whether another set of sonorants, i.e. the nasals, also involve palatalization, velarization, or varying configurations of the tongue root. Specifically, the current study focuses on the anterior nasals, i.e. dental *n* vs. alveolar *n̪*, a marginal contrast which has not been examined phonetically for secondary articulations. What is known about these two nasals is that they stem from different historical sources, they contrast in precise place of articulation, and they have been described impressionistically as distinguishable by velarization on the dental *n* and palatalization on the alveolar *n̪*, although no phonetic evidence has ever been provided to support either claim. Preliminary acoustic results from a single speaker in the current study suggest that these claims are in fact borne out: back vowels are generally fronted when adjacent to geminate alveolar *n̪n̪*, compared to those adjacent to geminate dental *nn*. This suggests palatalization on the former and/or velarization on the latter, in line with the acoustic results for liquids in previous studies. These acoustic results thus suggest that Malayalam speakers can use secondary articulations to exaggerate the differences between otherwise very similar nasals, in the same ways that they use those articulations to distinguish the "clear" and "dark" classes of liquids.

1 Background

Malayalam is famous for its large number of contrastive places of articulation (Mohanan & Mohanan (1984)), which extend not just to obstruents, which have strong place cues (Jun (2004)) in their formant transitions and especially the loud aperiodic noise in their burst and frication, but also to sonorants, which do not have strong place cues. Without a burst or frication to provide aperiodic noise, the place cues of sonorants are more limited. Specifically, sonorants (like all consonants) have formant transitions that can convey their place of articulation, and among the sonorants, the liquids and glides have internal formant structure much like vowels (although with lower amplitude overall). Nasals, however, are particularly notorious for their poor place cues (Malécot (1956)), as they do not have reliable place cues internally, and thus have only formant transitions to aid their place perception. It is thus not surprising that nasals often have fewer place contrasts than corresponding stops or even liquids in a given language. And yet, Malayalam maintains a contrast of five liquids (Table 1) and seven nasals (Table 2), with a nasal consonant for every stop consonant place of articulation (Bouavichith et al. (2018)).

Liquid	Example
dentialveolar *l* /l/	*kali* ‘anger’
retroflex *ḷ* /ɭ/	*kaḷi* ‘game’
dentialveolar *r* /ɾ̪ ~ r̪/	*kari* ‘soot’
postalveolar *r̲* /ɾ̠ ~ r̠/	*kar̲i* ‘curry’
retroflex *ṛ* /ɻ/	*kaṛiccu* ‘ate’

Table 1: Five Malayalam liquids.

Nasal	Example
labial *m* /m/	*kammi* ‘shortage’
dental *n* /n̪/	*panni* ‘pig’
alveolar *n̲* /n/	*kan̲n̲i* ‘(a month)’
retroflex *ṇ* /ɳ/	*kaṇṇi* ‘link’
palatoalveolar *ñ* /ɲ/	*kañña* ‘rice porridge’
pre-velar *ṅ’* /ŋ̟/	*tēṅṅ’a* ‘coconut’
velar *ṅ* /ŋ/	*tēṅṅal* ‘wailing’

Table 2: Seven Malayalam nasals.

From the existing literature, one can see three ways in which Malayalam speakers arguably compensate for the weak place cues of sonorants. First, sonorants in Malayalam are restricted by **position**, as most sonorant place contrasts are only found intervocalically, where formant transitions are available on both sides of the consonant (see Table 3). Second, sonorants generally have more restrictions on **duration** contrasts, especially for nasals: while all seven places of articulation for nasals are contrastive when intervocalic and long (i.e. geminate), speakers only contrast up to three nasals when short (i.e. singleton). Lastly, the liquids are reported to have **secondary articulations**, e.g. palatalization, velarization, tongue root retraction, in which otherwise similar sounds (e.g. *r* vs. *r̲*) are distinguished through overall tongue shape or position.

For example, acoustic analysis by Punnoose (2010) and Punnoose & Khattab (2011) as well as ultrasound investigation by Scobbie et al. (2013) (see Figure 1) demonstrated that dentialveolar *l* and *r*, and the so-called “fifth liquid” *ẓ* are “clear”, involving palatalization and an advanced tongue root, while retroflex *ḷ* and postalveolar *r̲* are their “dark” counterparts, involving a retracted tongue root or pharyngealization, helping to distinguish between two sets of otherwise very similar liquids. To explicitly represent these secondary articulations, a very fine phonetic transcription of the Malayalam laterals might show a velarization diacritic on retroflex *ḷ* [ɭˠ] and postalveolar *r̲* [ɾ̠ˠ ~ r̠ˠ], and a palatalization diacritic on dentialveolars *l* [lʲ] and dentialveolar *r* [ɾ̪ʲ ~ r̪ʲ] and the “fifth liquid” *ẓ* [ɻʲ].

Place	Initial	Med. singleton	Med. geminate	Final
labial	*māṉ* 'deer'	*āma* 'turtle'	*kammi* 'shortage'	*āẓam* 'depth'
dental	*nālŭ* 'four'	*	*panni* 'pig'	*
alveolar	*	*āna* 'elephant'	*kaṉṉi* '(a month)'	*ñāṉ* 'I'
retroflex	*	*āṇŭ* 'be'	*kaṇṇi* 'link'	*
pal.-alv.	*ñāṉ* 'I'	*	*kaññi* 'rice stew'	*
pre-velar	*	*	*tēṅṅ'a* 'coconut'	*
velar	*	*	*tēṅṅal* 'wailing'	*

Table 3: Seven Malayalam nasals, across four word positions. The * represents a systematic gap in the lexicon.

Furthermore, acoustic work by Local & Simpson (1999) confirmed that these secondary articulations on liquids are measurable both in the formant frequencies of the consonants themselves as well as in the surrounding vowels, and that these articulations are exaggerated in and around the geminate versions of these consonants. This suggests that the place of the liquid consonant can be cued well into the preceding and following vowels, characteristic of secondary articulations such as palatalization and velarization.

Study	Methods	"Clear"	"Dark"
Local & Simpson (1999)	acoustic	*l*	*l̪*
Punnoose (2010)	acoustic	*l r ẓ*	*l̪ r̪*
Punnoose & Khattab (2011)	acoustic	*l r ẓ*	*l̪ r̪*
Scobbie et al. (2013)	ultrasound	*l r ẓ*	*l̪ r̪ (ẓ)*
Srikumar & Reddy (1988)	x-ray, palatography	*r*	*r̪*

Table 4: Malayalam liquids classified by secondary articulation, across studies.

2 Research question

The current study builds upon the literature on secondary articulations in Malayalam liquids to ask: **do nasals also involve palatalized ("clear") or velarized/ pharyngealized ("dark") articulations?** Specifically, the current study focuses on the acoustics of the two anterior nasals, i.e. dental *n* and alveolar *n̪*, which have not previously been examined phonetically for secondary articulations.

As discussed in Asher & Kumari (1997), the contrast between the two anterior nasals *n* and *n̪* is marginal: in most positions, their distribution is in fact totally predictable (Table 2), with dental *n* occurring word-initially, medially when adjacent to dental stops, and as an intervocalic geminate, and alveolar *n̪* occurring elsewhere: word-finally, word-medially when intervocalic or adjacent to non-dental stops, and as an intervocalic gemi-

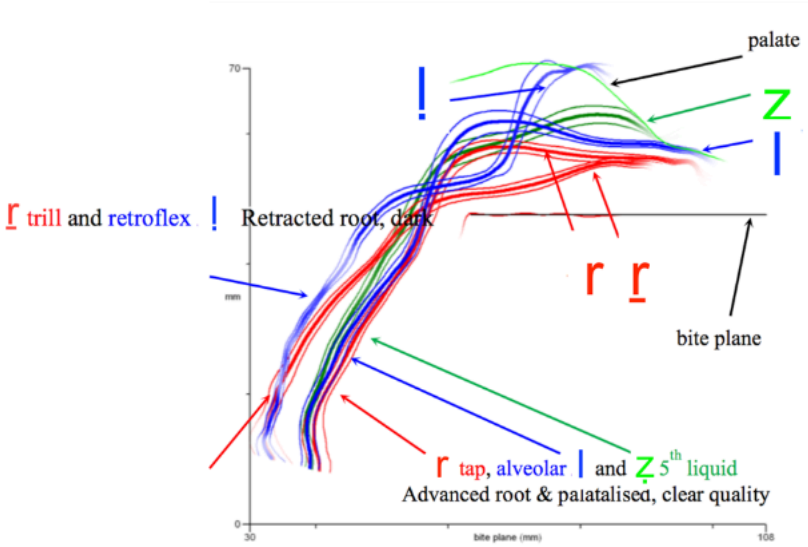

Figure 1: Ultrasound tracings from Scobbie et al. (2013). The tongue blade points to the right.

nate. Thus, the *n* vs. *n̪* contrast is effectively only available medially as a geminate *nn* vs. *n̪n̪*, and even in this position, the contrast has extremely low functional load; for many speakers (including the speaker recorded in the current study) there are no minimal pairs. (Kumaraswami Raja (1980) offers *ninnāl* 'stand-CND' vs. *niṉn̪āl* '2SG-INS' as such a pair, which our speaker rejected.) This situation is compounded by the fact that both nasals are represented identically in the orthography.

Despite the marginal status of their contrast, these two anterior nasals do stem from different historical sources: the geminate dental *nn* of Malayalam derives from three separate Proto-Dravidian sources (i.e. **nn*, **nt*, **n̪ṟ*) while the geminate alveolar *n̪n̪* derives from a single historical source (i.e. **n̪n̪*), often arising from the metrically-motivated lengthening of a singleton nasal (Kumaraswami Raja (1980)). Furthermore, palatographic data demonstrates that the two anterior nasals are articulatorily distinct in terms of their precise place of articulation (Dart & Nihalani (1999)), with the dental *nn* involving a more anterior contact than the alveolar *n̪n̪*. Lastly, and most importantly for the current study, the two anterior nasals have been described impressionistically as involving secondary articulations; specifcally, (McAlpin, 1998, p. 402) states that "Malayalam's dental *n* is strongly velarized", while (Asher & Kumari, 1997, p. 443) note that "medial *n̪*/*n̪n̪* have a distinctly palatal tamber". Note that there has been no phonetic evidence provided to support either claim of velarization or palatalization in any previous study to my knowledge. The current study seeks to find phonetic evidence of these secondary articulations.

3 Methods

To determine whether *n* and *n̪* can be acoustically distinguished by the secondary articulations suggested in the literature, formant frequencies were measured during vowels preceding and following dental and alveolar nasals, in intervocalic geminate position (i.e. *nn* and *n̪n̪*). Recordings were made of a single speaker, as part of a preliminary study to be expanded to a larger sample. The speaker is a man in his 20s, who has lived his whole life in Thrissur, Kerala, India until coming to Oregon, USA, for college. He was recorded at the Lab of Linguistics (LoL) at Reed College, where he was also employed as the primary language consultant in an undergraduate field methods course.

F1 and F2 frequencies of vowels preceding and following target geminate nasals were measured at their midpoint, in line with the methods described in Local & Simpson (1999). Target words (shown in Table 5) were chosen based on transcriptions provided in previous studies which consistently distinguish the two anterior nasals (Asher & Kumari (1997), Kumaraswami Raja (1980), Mohanan & Mohanan (1984), Namboodiripad & Garellek (2017)). These words were recorded in isolation by eliciting Malayalam translations of English words provided by the investigator, to mitigate the effects of hearing the Malayalam word produced by the investigator or of reading the orthographic form. Vowels adjacent to liquids (i.e. *l*, *l̪*, *r*, *r̪*, *ẓ*) were excluded to prevent any conflation of the possible effects of palatalization and velarization from the nasals with the well-documented effects of palatalization and velarization from the liquids.

Dental *nn* /n̪ː/		**Alveolar *n̪n̪* /nː/**
ennŭ ‘CMP’	*ninnŭ* ‘from’	*en̪n̪āl* ‘1SG-INS’
onnŭ ‘one’	*panni* ‘pig’	*en̪n̪e* ‘1SG-ACC’
uẓunnŭ ‘black gram’	*paranna* ‘broad’	*kan̪n̪i* ‘(a month)’
kunnŭ ‘mountain’	*porunnuga* ‘be joined-INF’	*tan̪n̪e* ‘indeed/self-ACC’
cuvanna ‘red’	*marunnŭ* ‘medicine’	*tin̪n̪um* ‘eat-FUT’ ~ *tinnum*
tannu ‘give-PST’	*munnūr̪ŭ* ‘three hundred’	*tun̪n̪akkāran* ‘seamster’
tannāl ‘give-CND’	*mūnnŭ* ‘three’	*tun̪n̪akkāri* ‘seamstress’
tinnu ‘eat-PST’	*vannu* ‘come-PST’	*nin̪n̪e* ‘2SG-ACC’
naḍannu ‘walk-PST’	*virunnŭ* ‘visit’	*pin̪n̪e* ‘later’
ninnāl ‘stand-CND’	*-unnu* ‘PRS’	*pen̪n̪ŭ* ‘pen’

Table 5: Target words with dental *nn* and alveolar *n̪n̪*.

As is suggested from the wordlist, the dental nasal has a far higher type frequency than the alveolar nasal in intervocalic geminate position. However, some of the alveolar nasal examples do have extremely high token frequency, as they include several forms of the pronominal system. The alveolar nasal is also used for more recent loans from English (e.g. *pen̪n̪ŭ* ‘pen’). All stimulus items recorded and used in the subsequent analysis were familiar to the subject, although one word (‘eat-FUT’) had two variant pronunciations:

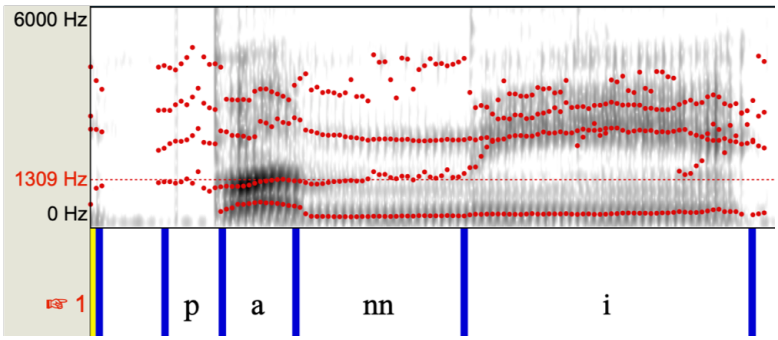

Figure 2: Spectrogram of *panni* 'pig', showing F2 lowered adjacent to the dental nasal *nn*.

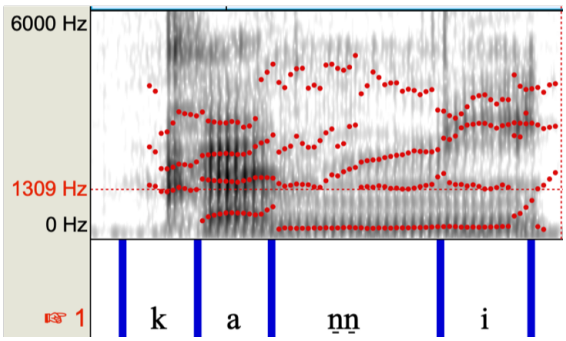

Figure 3: Spectrogram of *kaṉṉi* '(a month)', showing F2 raised adjacent to the alveolar nasal *ṉṉ*. (Note that the actual F2 is mistracked as F3 in the final vowel *i*.)

tiṉṉum ~ *tinnum*. The speaker suggested that the former variant, with the alveolar nasal, was considered standard, while the latter variant, with the dental nasal, was more natural for his variety. Both variants were included in the results and kept separate from one another. Many other words suggested by the literature — especially the presumably more archaic and/or infrequent words in Kumaraswami Raja (1980) — were not known by the speaker, e.g. *puṉṉa* 'Calophyllum inophyllum', *saṉṉi* 'epileptic fit', and *kuḍanna* 'both handsful', among others. These were not recorded.

Example spectrograms of two target words are provided in Figures 2 (*panni*) and 3 (*kaṉṉi*).

4 Results and discussion

Results indicate that back vowels *u*, *ŭ* (*eu* in the image), and *a* are generally fronted when preceding (Figure 4) or following (Figure 5) an alveolar *ṉṉ*, compared to those adjacent to dental *nn*, suggesting palatalization on the former and/or velarization on the latter. (In these same contexts, it is unclear if front vowels *i* and *e* are fronted, raised, or have no

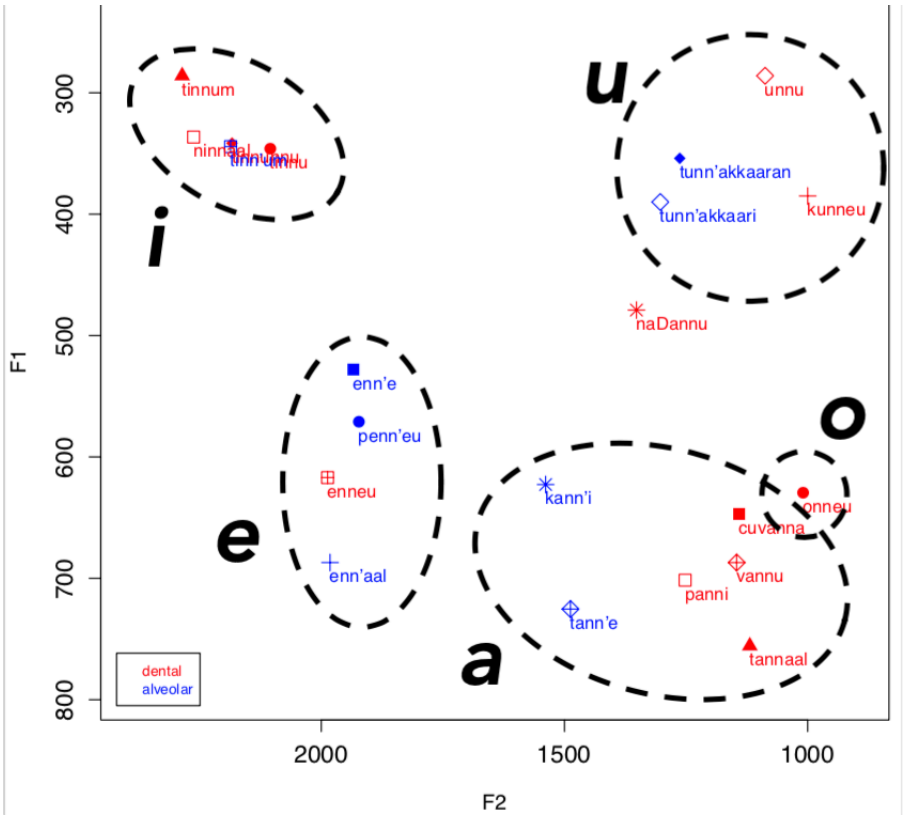

Figure 4: F1xF2 plots for the midpoint of the vowel **preceding** dental *nn* (in red) and alveolar *n̪n̪* (*nn'* below, in blue), averaged by word.

effect. This is partially due to an incomplete data set.) This pattern strongly resembles the results for liquids in the published literature. Furthermore, the backing and fronting of the 'enunciative' vowel *ŭ* (transcribed *eu* in the vowel plots below) following dental *nn* and alveolar *n̪n̪*, respectively, resemble what is seen following other consonants described as dark and light, respectively, in the literature (Namboodiripad & Garellek (2017)).

These acoustic results thus suggest that Malayalam speakers use secondary articulations to exaggerate the differences between otherwise very similar nasals, in the same ways that they use those articulations to distinguish the clear and dark liquids. If indeed these vocalic effects are due to palatalization and velarization, the two anterior nasals could be more finely transcribed *nn* [n̪ˠ:] and *n̪n̪* [nʲ:]. It is worth noting that this palatalization on the alveolar nasal must be subtle enough to not facilitate a full merger with the truly palatoalveolar nasal *ñ* [ɲ], with which it maintains a contrast for both our speaker and for the published descriptions of the standard language, e.g. *kan̪n̪i* '(a month)' vs. *kañña* 'rice porridge'.

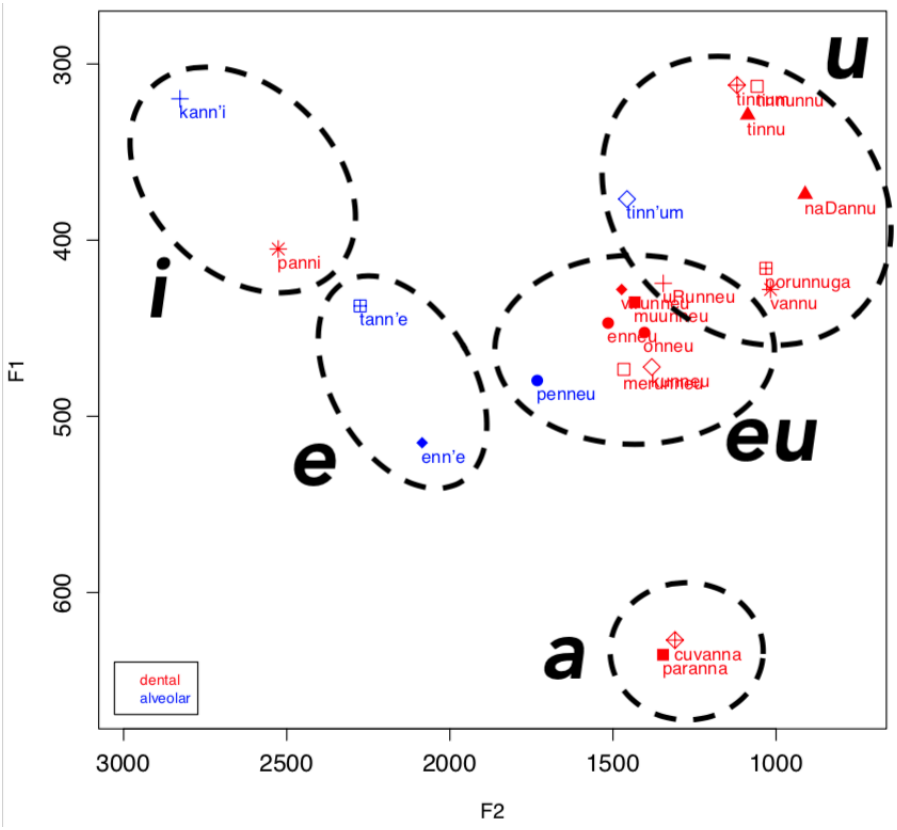

Figure 5: F1xF2 plots for the midpoint of the vowel **following** dental *nn* (in red) and alveolar *n̪n̪* (*nn'* below, in blue), averaged by word.

Conclusions

In line with previous work on Malayalam liquids *l*, *r*, *ɻ*, *l̪*, and *r̪*, the current acoustic analysis of vowels surrounding anterior nasals finds evidence of velarization and palatalization as secondary articulations on dental *nn* and alveolar *n̪n̪*, respectively. Specifically, back vowels are acoustically fronter when adjacent to alveolar *n̪n̪*, compared to when adjacent to dental *nn*, suggesting that these two geminate anterior nasals can be narrowly transcribed *nn* [n̪^{ˠ}ː] and *n̪n̪* [n^{ʲ}ː]. These secondary articulations presumably serve to enhance the tenuous phonetic contrast between the two consonants, which by virtue of their sonorant nature would not be expected to maintain a dental vs. alveolar place contrast. In fact, while laterals and rhotics generally have some internal formant structure to help convey their place of articulation, nasals are notoriously poor in place cues, further supporting the claim that such sounds are in the greatest need for acoustic/perceptual exaggeration of their contrast through these secondary articulations.

The current analysis is based on a small set of data collected from a single speaker of Malayalam, and naturally the study will need to be expanded to back up these claims. In addition to adding a larger number of speakers, the set of nasals examined could be broadened to include retroflex *ɳ*, palatoalveolar *ñ*, pre-velar *ṅ'*, and velar *ṅ*. It would also be informative to connect the current acoustic findings with articulatory findings in the form of ultrasound or palatographic investigation, drawing parallels with current ultrasound work on the dorsal nasals *ɳ*, *ṅ'*, and *ṅ* (Bouavichith et al. (2018)).

Another question worth pursuing involves whether the cues for secondary articulations of the geminate nasals recorded here also appear on their singleton counterparts. While the geminate forms of dental *nn* and alveolar *n̪n̪* can appear in near-minimal pairs, their singleton counterparts are in perfect complementary distribution. Will this reduce the need for secondary articulations to enhance their perceptual contrast, or will the shorter consonant duration be compensated with more extreme articulations nonetheless (cf. Local & Simpson (1999))? By looking further into this marginal contrast as well as the more robust contrasts seen with the other nasals, we can explore how a language can maintain a symmetrical set of nasal places vs. stop places, even when the former set inherently involves poor place cues.

References

Asher, R. E. & T. C. Kumari. 1997. *Malayalam.* Routledge.

Bouavichith, Dominique A., Savithry Namboodiripad & Marc Garellek. 2018. A contrastive place of articulation between palatals and velars: an ultrasound study of malayalam palatal-velar nasals. *Journal of the Acoustical Society of America* 143(3).

Dart, Sara N. & Paroo Nihalani. 1999. The articulation of malayalam coronal stops and nasals. *Journal of the International Phonetic Association* 29(2).

Jun, Jongho. 2004. Place assimilation. In Bruce Hayes, Robert Kirchner & Donca Steriade (eds.), *Phonetically based phonology*, Cambridge: Cambridge University Press.

Kumaraswami Raja, N. 1980. Geminate dental / alveolar nasal in malayalam: a historical study. *Journal of Tamil Studies* 18.

Local, John & Adrian P. Simpson. 1999. Phonetic implementation of geminates in malayalam nouns. In *Proceedings of the 14th international congress of phonetic sciences*, .

Malécot, André. 1956. Acoustic cues for nasal consonants: an experimental study involving tape-splicing technique. *Language* 32.

McAlpin, David W. 1998. Coarticulation and coronals in malayalam. *Journal of the American Oriental Society* 118(3).

Mohanan, K. P. & Tara Mohanan. 1984. Lexical phonology of the consonant system in malayalam. *Linguistic Inquiry* 15(4).

Namboodiripad, Savithry & Marc Garellek. 2017. Malayalam (namboodiri dialect). *Journal of the International Phonetic Association* 47(1).

Punnoose, Reenu. 2010. *An auditory and acoustic study of liquids in malayalam*: Newcastle University dissertation.

Punnoose, Reenu & Ghada Khattab. 2011. Phonetic and phonological investigation of the fifth liquid in malayalam: evidence for rhotic characteristics. In *Proceedings of the 17th international congress of phonetic sciences*, .

Scobbie, James M, Reenu Punnoose & Ghada Khattab. 2013. Articulating five liquids: A single speaker ultrasound study of malayalam. *Rhotics: New data and perspectives* 99–124.

Srikumar, K & N Reddy. 1988. An articulatory and acoustic study of trills in malayalam. *Osmania Papers in Linguistics* 14. 42–54.