Assamese Vowels: The Role of the Linguist

Diana Archangeli
University of Arizona & University of Hong Kong

1 Introduction

An over-arching goal for linguists is to understand what can and cannot be a natural human language, understood in the myriad ways that humans use language. The illustration in this contribution is drawn from an articulatory and phonological study of the vowels of Assamese. The discussion exemplifies two key roles that linguists take in understanding language, extending our knowledge of languages and exploring the implications of that knowledge.

Types of work that linguists do to extend our basic knowledge of human languages include the careful description of existing languages. Descriptions may focus on sentence structure or word structure, on how meaning is expressed, on the ways that language is used in society, etc. The focus here is on the sounds of language. Traditionally, language sounds have been documented based on an impressionistic understanding of what the linguist hears; with technological advances, this understanding is increasingly based on careful detailing of acoustic and articulatory properties of language, often carried out by data collection in the field (Gick 2002; Bird 2011; Whalen & McDonough 2015).

In order to understand the implications of our knowledge of language properties, linguists carry out careful analysis of the symmetries and asymmetries they find in the data. Such research typically is done within the terms of a particular theory, and the analysis of novel data often results in proposed innovations to a theory. In some cases, such innovations lead to a significant reassessment of how we view the phonological system, for example, the shift from linear (Chomsky & Halle 1968) to nonlinear representations in the 1970s (Kahn 1980; Goldsmith 1979; McCarthy 1982), the shift from fully specified to underspecified representations in the 1980s (Kiparsky 1982; Archangeli 1984), the shift from rule-based to constraint-based grammars in the 1990s (Prince & Smolensky 1993; McCarthy & Prince 1993, 1995). This paper continues the tradition, challenging the degree of influence of an innate human language faculty in developing phonological grammars.

In this paper, both aspects of a linguist's work are illustrated with data from Assamese. Assamese is classed as ISO 639-3 asm, Indo-European, Indo-Iranian; Indo-Aryan, Outer Languages; Eastern, Bengali-Assamese (Simons & Fennig 2017). It is spoken primarily in the state of Assam, in north-eastern India, where there are around 12,800,000 speakers; worldwide, there are estimated to be 12,828,220 speakers.

The Assamese language is described as having CV or CVC syllables, and 8 vowels (Mahanta 2007, 2012). These vowels have an intriguing asymmetry in the distribution of tongue root position, with a low retracted vowel [a], a high front advanced vowel [i], and all other vowels having advanced and retracted counterparts, [e, ɛ], [o, ɔ], [u, ʊ].

(1) **Assamese vowels**

	Nonround		Round
	Front	Back	Back
High	i		u ʊ
Not high	e ɛ	a	o ɔ

The [atr]/[rtr] vowel pairs have an asymmetric distribution: retracted mid vowels occur before retracted vowels, i.e. [ɛ, ɔ] before [ɛ, a, ɔ, ʊ], and advanced mid vowels occur before advanced vowels, i.e. [e, o] before

*The ultrasound part of the paper reports on work carried out with Jon Yip and the phonological analysis owes much to discussion with Douglas Pulleyblank. Special thanks to Shakuntala Mahanta for her generous support at the Indian Institute of Technology Gujarati, and to the University of Hong Kong Small Projects Scheme for research funding.

[i, e, o, u]. Under suffixation, this can result in alternations, where root vowels are retracted before retracted suffixes and advanced before advanced suffixes, [nomori] 'die' vs. [nɔmɔra] 'die-NEG'.

The work reported here includes both an articulatory investigation to confirm the impressionistic descriptions and a phonological analysis to illustrate Emergent Phonology.

In this report, I cover only the very basic part of Assamese vowel harmony, the general trend for mid vowels to agree with the following vowel in terms of [atr]/[rtr]. There are contexts in which harmony is blocked and in which it is idiosyncratic; see Mahanta (2007, 2012) for details and analysis.

2 Articulatory analysis: Confirming the impressionistic descriptions

In order to determine whether the impressionistic description of Assamese vowels corresponds to their articulation, we carried out an ultrasound study of the vowels of Assamese. The work presented in this section is a summary of a preliminary analysis of part of the data, based on Archangeli & Yip (2016), see Archangeli & Yip (in prep) for the full and final analysis.

Data reported on were collected from 10 subjects, all native speakers between the ages of 23 and 32 who use Assamese in their daily personal lives. Stimuli were presented using Assamese orthography in randomized blocks, giving 6 repetitions. Minimal pairs with labial consonants were used as much as possible (labials reduce coarticulatory effects from consonants). Shakuntala Mahanta checked all items used for appropriateness of items. Examples are given in (2). All items have final Coronal consonants; but it was not possible to match initial and medial Cs throughout. We dealt with the possibility of consonantal effects in two ways: (i) we compared V1 to V1 and V2 to V2 in each minimal pair in order to keep surrounding consonants the same; (ii) in our LMER models we treated Word as a random factor.

(2) **Stimuli examples**

[atr]	[rtr]	gloss
b^{h}emesi	b^{h}ɛmɛsa	crooked (f/m)
p^{h}edeli	p^{h}ɛdɛla	ugly (f/m)
nomori	nɔmɔra	neg-die
nod^{h}ori	nɔd^{h}ɔra	neg-hold

Data were collected in a sound-attenuated room at the Indian Institute of Technology – Guwahati. The set up is shown in the picture to the right. The subject was seated facing a laptop screen where prompts were shown. Three camera arms were used to stabilise the subject's head and the probe, with post-hoc assessment of the degree of head movement. The image shows Jon Yip adjusting the probe for this subject. Data were collected on a dedicated laptop.

The temporal center of each target vowel was identified from the acoustic signal, using Praat (Boersma & Weenink 2015); data points were extracted from the video frame corresponding most closely to this time point using EdgeTrak software (Li *et al.* 2005) and hand-correcting as needed. Further details of data collection and extraction are given in Archangeli & Yip (2016, in prep).

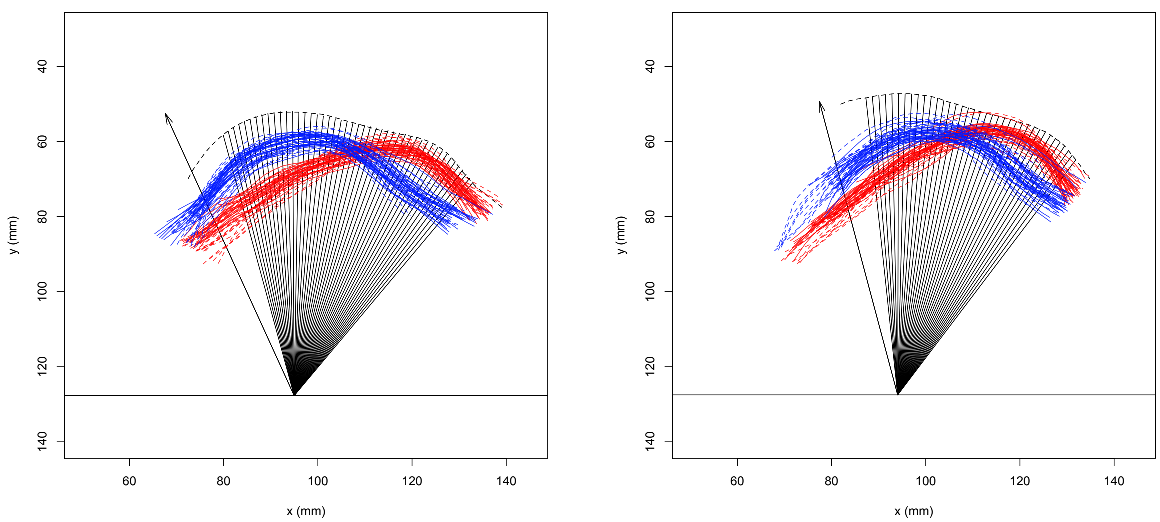
While tongue root advancement/retraction is thought to be the determining factor with the Assamese vowel contrasts, it can be difficult to image using ultrasound because the tongue root is so far back in the mouth. For this reason, we adopted two indirect measures. Because the root of the tongue is closest to the back of the tongue (as opposed to the tip), we identified a Distance measure for the back of the tongue. Because tongue root position may affect the entire position of the tongue (since the tongue cannot compress), we also identified an Angle measure for the point of greatest constriction in the mouth. The Distance measure and the Angle measure were used to test tongue root advancement/retraction in the target vowels. How these measures were made is explained below.

Distance identifies the distance from an arbitrary origin point (the center of the probe for each speaker) to the back of the tongue at the backmost angle where all traces are visible, shown by the arrows in (3). The idea with Distance is that a retracted vowel will be articulated further back in the mouth than a corresponding advanced vowel, so Distance should be greater for retracted vowels.

Angle, on the other hand, measures how great the angle is between the Distance line and the point of greatest constriction (measured in distance from the palate). In advanced vowels, we expect the tongue to be further forward in the mouth so Angle should be greater for advanced vowels; retracted vowels are expected to have a lesser angle.

(3) **Illustration of Distance and Angle calculations, speaker S1 (left) and S5 (right)**

Red and blue lines correspond to tongue traces from two different vowels. Black dotted line shows palate trace. Black straight lines show radians from origin (center of probe). Black arrow shows backmost angle that all tongue traces cross, used for each token to calculate Distance (mm from origin to tongue trace along this radian) and for determining Angle (degrees from this angle to radian with least distance to palate, corresponding to point of greatest constriction).



Distance (mm)	Greater = more retracted.	Length of arrow radian to tongue trace in mm.
Angle (degrees)	Smaller = more retracted	Degrees to radian of greatest constriction.

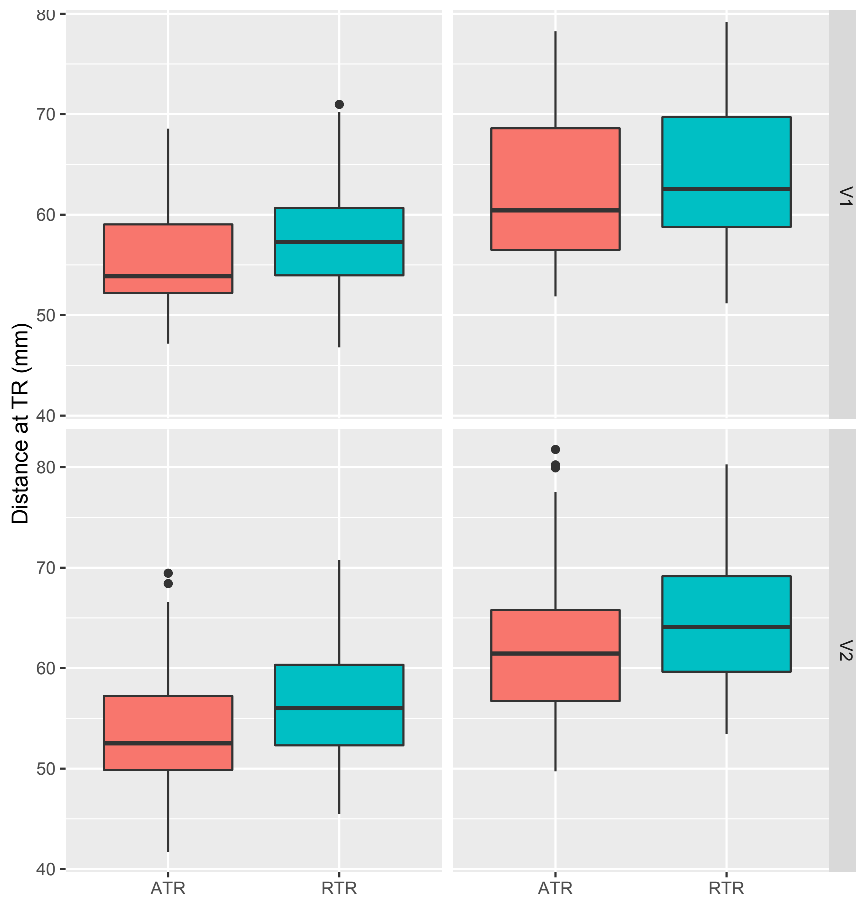
In order to determine whether articulation corresponds to perception, we measured Distance and Angle for minimal pairs and near minimal pairs, differing only in tongue root position and final vowel (since final vowels determine tongue root quality of mid vowels). The prediction is that Distance will be greater and Angle will be lesser for retracted vowels than for advanced vowels. Results are shown in (4–5) for the overall pattern.

The boxplots in (4) show two general trends: (i) back vowels (right side) have greater distances than front vowels (left side), consistent with their being further back in the mouth; and (ii) within each vowel category (front vowels and back vowels), the retracted vowels (blue) have greater distances than the advanced vowels (red), consistent with the prediction of greater distance in retracted vowels.

LMER models were used to test the significance of these trends. As shown in (5), Distance proved to be a useful measure for tongue root differences, showing significance in all four categories of vowel. Angle, on the other hand, showed significance only in V2 with back vowels. We determined that Distance is a more reliable measure than Angle.

(4) **Baseline harmony results – Distance boxplots**

These boxplots show [atr]/[rtr] Distance comparisons for front and back vowels (front vowels [e, ɛ] are shown on the left side are back vowels [o, ɔ] on the right side), separating the first vowel in a word from the second vowel (V1 in a CVCVC word is shown in the upper set and V2 in the lower set). Advanced vowels are shown in red, retracted vowels in blue. Higher boxes correspond to greater distances.



(5) **Baseline harmony results.** Significance with Distance for tongue root position, regardless of vowel type or position in word

	Distance				Angle			
	ɛ > e		ɔ > o		ɛ < e		ɔ < o	
V1	1.36	*	1.94	**	0.37	n.s.	1.28	n.s
V2	2.60	***	1.91	**	0.18	n.s.	2.15	*
	greater Distance *means* greater [rtr]				lesser Angle *means* greater [rtr]			

These results are a preliminary confirmation the impressionistic analysis of the Assamese vowels. (See Archangeli & Yip in prep for the full picture, including discussion of cases where harmony appears to be blocked.) Vowels that are described as retracted have greater Distance than comparable advanced vowels, as expected with retracted vowels: The expected quantifiable contrast in pairs like [nɔmɔra], [nomori] 'NEG-die', shows greater Distance in the vowels where greater retraction is perceived.

The effect of greater Distance for retracted vowels in V2 than in V1 (which is significant for distance), is unexpected and suggests either (i) a consequence of the different flanking consonants or (ii) anticipatory assimilation to the following low, back, retracted vowel [a] which follows. The study as a whole confirms the methodology of **?** in using Distance as a measure for tongue root position.

3 Implications of knowledge: A phonological analysis

Phonological analyses need to account for a variety of properties of phonological systems, such as those laid out in (6). Each of these properties is illustrated with specific properties of Assamese.

(6) **What a phonology needs to account for**

a.	*Sounds*	What sounds are possible in the language?
		[i, e, ɛ, a, ɔ, o, ʊ, u]
b.	*Sequences*:	What sound sequences are possible?
	mid vowels	{ɛ, ɔ}C{ɛ, a, ɔ, ʊ}
		{ɛ, ɔ}CC...
		{ɔ}[nasal]
		{e, o}...{i, e, o, u}
c.	*Alternations*:	What alternations occur in the language?
		Mid vowels typically alternate between [atr] vowels and [rtr] vowels
		{pʰɛdɛl, pʰedel}$_{\text{UGLY}}$; {nɔmɔr, nomor}$_{\text{NEG-DIE}}$
d.	*Contexts*:	What is the context for each alternant?
		[atr] before [atr], [rtr] before [rtr]
		[pʰɛdɛla, pʰedeli], *[pʰɛdɛli, pʰedela]; [nɔmɔra, nomori], *[nɔmɔri, nomora]

Phonological analysis is not simply a description of the patterns that occur (like the list we see in (6)); phonological analysis is an attempt to characterise the abstract knowledge a speaker has of the language in question. As such, phonological analyses exemplify theories of the mental organisation of sounds and sound patterns. A common theoretical assumption is that there is an innate human language faculty driving the form used to express phonological generalisations; this underlies both generative phonology (Chomsky & Halle 1968) and Optimality Theory (Prince & Smolensky 1993).

As an example of how these models shape the expression of phonological knowledge, both models assume that there is a drive to identify a single underlying/input form for each morpheme. What this means for acquisition is that a child learns multiple forms, deduces that some of the forms are related to each other, deduces that some of these relations are phonologically predictable, in those cases deduces a single form (possibly abstract) as the **underlying representation**, and deduces rules or constraint rankings in order to produce the attested surface forms.

An alternative model, which I explore here, is the **Emergentist theory** (Mohanan *et al.* 2010; Archangeli & Pulleyblank 2015, 2016, in press). Under Emergence, acquisition begins the same way: a child learns multiple forms and deduces that some of the forms are related to each other. At this point, the theories begin to differ: under Emergence, the child posits morph sets containing the related morphs. From these morph sets, the child deduces that some of these relations are phonologically predictable and posits a general relation among morph set members. (Compare this to the Innatist model, which assumes that when the learner deduces relations among morph set members, a wholesale reanalysis of morph sets takes place, to create a single underlying representation for each morph along with the critical rules or constraint rankings to result in the correct surface forms.)

In Assamese, observation of the forms in the lefthand columns of (7) results in the morphs sets in the righthand column.

(7) **Alternations and morph sets**

	observed items		glosses	morph sets
a.	p^{h}ɛdɛlɑ	p^{h}edeli	ugly-M/F	{p^{h}ɛdɛl, p^{h}edel}$_{\text{UGLY}}$
b.	gɛrɛlɑ	gereli	fat-M/F	{gɛrɛl, gerel}$_{\text{FAT}}$
c.	t^{h}ʊpʊkɑ	t^{h}upuki	plump-M/F	{t^{h}ʊpʊk, t^{h}upuk}$_{\text{PLUMP}}$
d.	pɑgɔl	pɑgoli	mad-M/F	{pɑgɔl, pɑgol}$_{\text{MAD}}$

Inspection of these morph sets reveals that every morph with a retracted mid vowel also has an advanced counterpart and vice versa. This is formally characterised as a **morph set relation**.

(8) **[Rtr]/[atr] morph relation: [rtr]*] ↔ [atr]*]**

observe	[t^{h}ʊpʊk-]	*relation predicts*	[t^{h}upuk-]
	[p^{h}edel-]		[p^{h}ɛdɛl-] , *etc.*

Morph set relations give a way for the learner to "fill in" morph sets even when only one member of the set has been observed.

The last step in acquiring a pattern is determining when to use each morph. Because there are multiple members within morph sets, the child is driven to identify a way to select when to use each morph. Inspection of words that the different morphs occur in reveals a few general patterns. First, *pɑgɔl* 'mad-M' shows that if there is no suffix, the form appears with retracted vowels: *[atr].

(9) **Sequences: prefer retracted vowels**

a.	*[atr]	Penalise advanced vowels.	
b.	*example*	[pagɔl]	'mad-M'

Second, the advanced morphs only appear before a suffix with an advanced vowel: *[rtr]ˆ[atr].

(10) **Sequences: mid advanced vowels before advanced vowels**

a.	*[rtr]$_{\text{nonlow}}$ˆ[atr]	Penalise sequences of [rtr]$_{\text{nonlow}}$ˆ[atr].			
b.	*examples*	[k^{h}orosi]	prodigal	[p^{h}edeli]	ugly-F

These conditions assess which morph to use in a given context. They can be arrayed in a table very similar to an Optimality Theory tableau, but with some important differences. The conditions ranked across the top of the assessment tables are those that are motivated by morph distribution in the language, not members of a set provided by an innate language faculty. The choices arrayed down the left side of the assessment table are created from the morph sets being combined, the Cartesian product of the members of the relevant morph sets. Three such assessments are shown in (11–13). In (11), there is a high advanced suffix, so the prohibition against [rtr]-[atr] sequences eliminates the retracted root morph, as shown by the "*!" in the cell for the form in (11b). The form with the advanced root morph is selected.

(11) **Selection for {pɑgɔl, pɑgol}-{i}$_{\text{FEM}}$**

	{pɑgɔl, pɑgol}-{i}$_{\text{FEM}}$	*[rtr]$_{\text{nonlow}}$ˆ[atr]	*[atr]
☞	a. pɑgol-i		**
	b. pɑgɔl-i	*!	*

In the next two assessments, there is no advanced suffix. Advanced forms are eliminated by *[atr], and retracted morphs are selected in both cases.

(12) **Selection for {pɑgɔl, pɑgol}-{∅}$_{\text{MASC}}$**

		{pɑgɔl, pɑgol}-{∅}$_{\text{MASC}}$	*[rtr]$_{\text{nonlow}}$ˆ[atr]	*[nonhigh, atr]
	c.	pɑgol		*!
☞	d.	pɑgɔl		

(13) **Selection for {gɛrɛl, gerel}-{ɑ}$_{\text{MASC}}$**

		{gɛrɛl, gerel}-{ɑ}$_{\text{MASC}}$	*[rtr]$_{\text{nonlow}}$ˆ[atr]	*[nonhigh, atr]
☞	a.	gɛrɛl-ɑ		
	b.	gerel-ɑ		*!*

For the basic Assamese harmony pattern, the learner must ascertain that there are two morphs for roots with mid vowels, that the retracted morph is preferred, but if there is a following advanced vowel, the advanced morph is preferred. There is no additional step of deducing a single underlying form. This model also removes one of the puzzles in generative accounts: that the simplest grammar should be the grammar with no rules at all, yet this does not occur. The need to select among morphs in a morph set, once multiple morphs are identified, drives the learner to seek conditions to help make that decision. Additionally, The model also does not suffer from computational challenges like the infinite set of candidates. Furthermore, there is clear motivation for identifying the critical conditions, the need to select among morphs.

To summarize, this discussion explored a key difference between Innatist and Emergentist approaches to phonological systems, the Innatist desideratum of a single underlying representation for each morpheme vs. the Emergentist construction of morph sets labeled with morphosyntactic features to characterize each morpheme. The discussion showed that eliminating the concept of underlying representation does not require giving up on phonological analysis.

4 Conclusion

The work reported on here illustrates two of the key research roles played by a linguist, adding to knowledge and understanding the implications of our knowledge. The research adds to our knowledge of the Assamese vowel system by providing an instrumental, quantitative articulatory analysis which confirms the impressionistic descriptions and acoustic analysis of previous work. Specifically, we see that Distance, a correlate of retracted tongue root, is greater in retracted mid vowels and smaller in advanced mid vowels. The analysis also confirms the methodology in Gick *et al.* (2006), for using distance to the back of the tongue as a metric for determining differences in tongue root position. Thus the work adds not only to our understanding of Assamese, but also to greater confidence in our research methodologies.

This research also adds to our understanding of phonological systems, illustrating **Emergent Phonology**, a model of the sound side of grammar from phonetics to phonology to morphophonology. Emergent Phonology minimizes the appeal to innate linguistic universals in accounting for sound patterns. Despite being surface-oriented, the model is able to account for the complex and sometimes idiosyncratic generalizations found in the distribution of Assamese vowels. The phonological analysis of Assamese includes phonotactics which hold of morph concatenations and a transparent relation between members of morph sets, eliminating the need for abstract underlying representations and a means of manipulating those representations.

References

Archangeli, Diana, 1984. *Underspecification in Yawelmani Phonology and Morphology*. Massachusetts Institute of Technology dissertation. Published 1988: New York: Garland.

——, & Douglas Pulleyblank. 2015. Phonology without universal grammar. *Frontiers in Psychology* 6.

——, & ——. 2016. Emergent morphology. In *Morphological Metatheory*, ed. by Heidi Harley & Daniel Siddiqi, 237–270. Amsterdam: John Benjamins Publishing.

——, & ——. in press. Phonology as an emergent system. In *The Routledge Handbook of Phonological Theory*, ed. by Anna Bosch & S.J. Hannahs. London: Routledge.

——, & Jonathan Yip. 2016. The effect of context on the articulation of harmonic vowels in Assamese. In *Acoustic Society of America 172*, Honolulu, HI.

——, & ——, in prep. The articulation of Assamese vowels. University of Hong Kong & University of Arizona.

Bird, Sonya. 2011. Phonetic fieldwork in the Pacific Northwest. In *Proceedings of the 17th International Congress of Phonetic Sciences*, 76–79.

Boersma, P., & D. Weenink, 2015. Praat: doing phonetics by computer [computer program]. Version 5.4.06. http://www.praat.org. (accessed 21-Feb-15).

Chomsky, Noam, & Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper & Row.

Gick, Bryan. 2002. The use of ultrasound for linguistic phonetic fieldwork. *Journal of the International Phonetic Association* 32.113–121.

——, Douglas Pulleyblank, Fiona Campbell, & Ngessimo Mutaka. 2006. Low vowels and transparency in Kinande vowel harmony. *Phonology* 23.1–20.

Goldsmith, John. 1979. *Autosegmental Phonology*. New York: Garland.

Kahn, D. 1980. *Syllable-based Generalizations in English Phonology*. New York: Garland.

Kiparsky, Paul. 1982. Lexical morphology and phonology. In *Linguistics in the Morning Calm*, ed. by I.-S. Yang, 3–91. Seoul: Hanshin.

Li, Min, Chandra Kambhamettu, & Maureen Stone. 2005. Automatic contour tracking in ultrasound images. *Clinical Linguistics & Phonetics* 19.545–554.

Mahanta, Shakuntala. 2007. *Directionality and Locality in Vowel Harmony with Special Reference to Vowel Harmony in Assamese*. Utrecht: Landelijke Onderzoekschool Taalwetenschap.

——. 2012. Locality in exceptions and derived environments in vowel harmony. *Natural Language and Linguistic Theory* 30.1109–1146.

McCarthy, John, & Alan Prince. 1995. Faithfulness and reduplicative identity. In *University of Massachusetts Occasional Papers in Linguistics [UMOP] 18: Papers in Optimality Theory*, ed. by Jill Beckman, Laura Walsh Dickey, & Suzanne Urbancyzk, 249–384. University of Massachusetts, Amherst: GLSA.

McCarthy, John J. 1982. *Formal Problems in Semitic Phonology and Morphology*. Bloomington: IULC.

——, & Alan Prince. 1993. Generalized alignment. In *Yearbook of Morphology*, ed. by Geert Booij & Jaap van Marle, 79–153. Dordrecht: Kluwer.

Mohanan, K. P., Diana Archangeli, & Douglas Pulleyblank. 2010. The emergence of Optimality Theory. In *Reality Exploration and Discovery: Pattern Interaction in Language and Life*, ed. by Linda Uyechi & Lian-Hee Wee, 143–158. Stanford University: Center for the Study of Language and Information.

Prince, Alan, & Paul Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. Technical Report RuCCS-TR-2. New Brunswick, NJ: Rutgers University Center for Cognitive Science.

Simons, Gary F., & Charles D. Fennig (eds.) 2017. *Ethnologue: Languages of the World, Twentieth edition*. Dallas, Texas: SIL International. Accessed: 2017-04-07.

Whalen, Douglas H, & Joyce McDonough. 2015. Taking the laboratory into the field. *Annual Review of Linguistics* 1.395–415.