Stress and Vowel Harmony in Telugu

by

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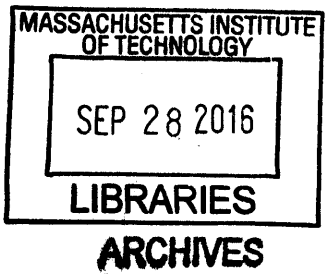

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ABSTRACT

This thesis presents a study of vowel harmony in Telugu, a Dravidian language. Vowel harmony in this language is manifest primarily in the form of vowel alternations in paradigms triggered by suffixes. I present a robust factual generalization that holds true of alternations in different types of nominal and verbal stems- vowels in unstressed syllables change to agree with a suffix vowel, with respect to either backness or height. Stress is the main conditioning environment for blocking of harmony. I show that secondary stress in Telugu can be inferred based on the pattern of vowel harmony. I account for this pattern of stressed vowels resisting harmony using positional faithfulness. Since stress-conditioned harmony is relatively uncommon in natural language, the account of vowel harmony in Telugu presented here helps to fill out the typology of stress-harmony interactions. I also report a production experiment which shows that secondary stress has a significant effect on syllable duration and is therefore, phonetically 'real' in this language.

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1 Introduction

Vowel Harmony refers to the similarity of two or more non-adjacent vowels with respect to some phonological feature(s). The similarity could be either in the form of a static co-occurrence restriction on distribution of vowels in morphemes or in the form of dynamic alternations in morphological paradigms. There are many interesting differences in the patterns of harmony across languages that it is not clear what the motivation for harmony is or even if there is one common mechanism underlying all these patterns. Much research in recent years has focused on expanding the empirical base for studying harmony as a phenomenon in human speech. This thesis is an effort in the same direction and presents a study of vowel harmony in Telugu, a Dravidian language.

Telugu has different kinds of vowel harmony patterns reported in the literature (Subbarao, 1971; Marantz, 1980; Pingali, 1985)[1]. Although there have been interesting suggestions in previous work, there has not been a clearcut account of the different harmony patterns. In this paper, I present a robust factual generalization that holds true of different instances of vowel alternation in Telugu triggered by harmony- vowels in unstressed syllables alternate in nominal and verbal paradigms by assimilating to a suffix vowel. Primary stress in Telugu goes on the heavier of the first two syllables in a word. In addition, secondary stress goes on every alternate mora starting from primary stress unless it is final. Secondary stress can be inferred based on the pattern of resistance to vowel harmony. An alternate statement of stress in this language is that it is assigned based on left-to-right word parsing using the moraic trochee (Hayes, 1995). In addition to stressed vowels, non-high front vowels block harmony. I show that this is due to a ban on distribution of non-high back vowels in stem-final position in the lexicon.

Cross-linguistically, stress-based harmony is relatively uncommon although it is attested in a few languages. Nasal harmony in Guarani, back and rounding harmony in Eastern Cheremis and height harmony in Pasiego Spanish are a few examples of stress-based harmony analysed in the literature. In Telugu, stress on syllables is the main condition for blocking of harmony. I show that this can be predicted straightforwardly in a framework like Optimality Theory (OT) using positional faithfulness- a vowel bearing stress in the derivative must be identical to its counterpart in the base. As such, the stress-based account of harmony in Telugu presented here helps to fill out the typology of stress/harmony interactions.

The structure of this thesis is as follows: I present an account of the pattern of suffix-triggered harmony alternations found in nominal stems in section 2. I present the verbal pattern in section 3 and discuss some preliminaries about the analysis. I discuss a few open problems that are not accounted for by my analysis in section 4. I also report a production experiment (section 5) to discover the phonetic correlates of secondary stress predicted by my analysis. A brief sketch of the phonology of the language is given in the appendix. I also report a corpus-based study of vowel co-occurrences in trisyllabic stems. The information in the appendix is a rich source for future attempts at studying the harmony system in this language.

[1] Wilkinson (1974) reports a left-to-right laxing harmony in Telugu that applies phrase-externally. I do not discuss this pattern in this paper since the facts are very different from the other alternation patterns reported in the language.

2 Nouns

Nouns in Telugu show a pattern of regressive vowel harmony which is triggered by the plural suffix -/lu/. The vowel /i/ in nominal stems alternates with /u/ in plural forms. This is shown in the examples in 1.

(1) /i/-/u/ alternation in nouns

a.	giri	girulu	'hills'
b.	pilli	pillulu	'cats'
c.	ni:ti	ni:tulu	'morals'
d.	kolimi	kolumulu	'forges'
e.	yo:gini	yo:ginulu	'ascetic women'
f.	gumiki:	gumiki:lu	'punches'
g.	tiwa:ci	tiwia:culu	'carpets'
h.	se:na:ni	se:na:nulu	'commanders-in-chief'
i.	parimiti	parimitulu	'limits'

Notice that harmony triggered by the vowel in the plural marker -/lu/ affects some (underlined) but not all instances of /i/ in stems. For example, the plural form of (a) /giri/ 'hill' is /girulu/ and not */gurulu/. The plural form of the trisyllabic stem (d) /kolimi/ 'forge' is /kolumulu/ while that of (e) /yo:gini/ 'female ascetic' is /yo:ginulu/ and not */yo:gunulu/. Previous analysis (Pingali, 1985) ascribed the opacity of the initial vowel in example 1 (a) to stress but treated the alternation of non-initial stem vowels in these examples as unpredictable. The /i/-/u/ alternation is analyzed as a result of under-specification of high stem vowels in nouns. Different lexical classes of nouns are set up to account for the differences in the application of vowel harmony. In this section, I show that the /i/-/u/ alternation in stem vowels is entirely predictable based on word shape. I show that all stem vowels that resist harmony bear stress. Crucially, I show that secondary stress can be inferred based on the pattern of vowel harmony. This pattern of stressed vowels resisting harmony is accounted for using positional faithfulness- a vowel bearing stress in the plural must be identical to its counterpart in the singular.

(2) Stress and alternations in bisyllabic nouns

a.	giri	gíri-lu	girulu	'hills'
	puli	púli-lu	pululu	'tigers'
	cewi	céwi-lu	cewulu	'ears'
	podi	pódi-lu	podulu	'boxes/cases'
	gadi	gádi-lu	gadulu	'rooms'
b.	pilli	pílli-lu	pillulu	'cats'
	gutti	gútti-lu	guttulu	'clusters'
	boppi	bóppi-lu	boppulu	'bumps'
	jerri	jérri-lu	jerrulu	'centipedes'
	katti	kátti-lu	kattulu	'knives'
c.	ni:ti	ní:ti-lu	ni:tulu	'morals'
	su:di	sú:di-lu	su:dulu	'needles'
	sre:ni	sré:ni-lu	sre:nulu	'classes'
	ko:ti	kó:ti-lu	ko:tulu	'monkeys'
	ka:ki	ká:ki-lu	ka:kulu	'crows'

First, I present the stress patterns in different stem types to show that all stem vowels that undergo harmony have one property in common- they are stressless. In bisyllabic nouns consisting of either two light (CV) syllables /LL/ or one heavy (bimoraic CVC, CVV) and one light syllable /HL/, the vowel /i/ in the final syllable changes to /u/ in plural forms. This is shown in the examples in 2. Note that the initial vowel never changes whether it is light or heavy. Previous accounts of stress in Telugu (Sitapati, 1936; Pingali, 1985) report primary stress on the heavier of the first two syllables. Assuming this to be true, the stress pattern in these stem types is- stress on the initial syllable (mora) and no stress on final light syllable (mora), that is, /ĹL/, /H́L/. Note that the final syllable in which the vowel alternates is stressless. These stress patterns can be accounted for using the following rhythmic constraints in OT-

- STRESS-L: stress the syllable at the left edge of the word.
- *MORA LAPSE: no adjacent unstressed moras.
- *SYLL CLASH: no adjacent stressed syllables.
- NONFINALITY: final syllable is unstressed.

The derivations of the stress patterns in /LL/ and /HL/ stems are shown in tableaux 1 and 2. The ranking of constraints is- STRESS-L, NONFINALITY >> *MORA LAPSE, *SYLL CLASH.

Input: /LL/		STRESS-L	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a. ☞	cv́.cv				
b.	cv.cv́	*!	*		
c.	cv́.cv̀		*!		*
e.	cv.cv	*!		*	

Table 1: Stress assignment in bisyllabic stems with two light syllables

Input: /HL/		STRESS-L	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a. ☞	cv́x.cv			*	
b.	cvx.cv́	*!	*	*	
c.	cv́x.cv̀		*!		*
d.	cvx.cv	*!		**	

Table 2: Stress assignment in bisyllabic stems with a heavy initial syllable

(3) Alternations in trisyllabic /LLL/ nouns

a.	mulik̲i̲	múlik̲i̲-lu	mulu̲ku̲lu	'nibs'
b.	guri̲gi̲	gúri̲gi̲-lu	guru̲gu̲lu	'earthen pots'
c.	budi̲pi̲	búdi̲pi̲-lu	budu̲pu̲lu	'bumps/swellings'
d.	teri̲pi̲	téri̲pi̲-lu	teru̲pu̲lu	'intervals'
e.	koli̲mi̲	kóli̲mi̲-lu	kolu̲mu̲lu	'forges'
f.	kori̲wi̲	kóri̲wi̲-lu	koru̲wu̲lu	'firebrands'
g.	mari̲di̲	mári̲di̲-lu	maru̲du̲lu	'brothers-in-law'
h.	kani̲ti̲	káni̲ti̲-lu	kanu̲tu̲lu	'lumps'
i.	mani̲ʃi̲	máni̲ʃi̲-lu	manu̲ʃu̲lu	'humans'

In trisyllabic stems consisting of three light syllables (LLL), both non-initial /i/ change to /u/ in plural forms (shown in example 3). In stems of this type, primary stress goes on the initial syllable and the other two syllables are unstressed- /ĹLL/. There are no native trisyllabic LLL stems that contain an /i/ in the initial syllable. Assuming that this is vowel harmony with respect to backness, a front vowel in initial syllable bearing primary stress, such as in 3 (d.) [teripi] 'interval' resists harmony. Vowels in stressless second and third syllables undergo harmony. To account for the stress pattern in this language, the following constraint is required in addition to the ones previously defined-

- *MORA CLASH: no adjacent stressed moras.

The derivation of the stress pattern is shown in tableau 3. The ranking of constraints is- *MORA CLASH >> STRESS-L, NONFINALITY >> *MORA LAPSE, *SYLL CLASH.

Input: /LLL/	*MORA CLASH	STRESS-L	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a. ☞ cv́.cv.cv				*	
b. cv.cv́.cv		*!			
c. cv.cv.cv́		*!	*	*	
d. cv́.cv.cv̀			*!		
e. cv́.cv̀.cv	*!				*
f. cv.cv́.cv̀	*!	*	*		*

Table 3: Stress assignment in trisyllabic stems consisting of three light syllables

(4) Alternations in trisyllabic /HLL/ nouns

a.	lankiṇi	lánkiṇi-lu	lankiṇulu	'fierce women'
b.	ma:pini	má:pini-lu	ma:pinulu	'measuring instruments'
c.	yo:giṇi	yó:giṇi-lu	yo:giṇulu	'ascetic women'
d.	tommidi	tómmidi-lu	tommidulu	'(sets of) nines'
e.	wa:kili	wá:kili-lu	wa:killu	'entrances'
f.	sandili	sándili-lu	sandillu	'upper arms'
g.	pandiri	pándiri-lu	pandillu	'marquees'
h.	ca:widi	cá:widi-lu	ca:widlu	'porches'
i.	guppiḍi	gúppiḍi-lu	guppiḍlu	'fists'
j.	ma:rpiḍi	má:rpiḍi-lu	ma:rpiḍlu	'alterations'

If the initial syllable in a trisyllabic stem is heavy (HLL), then /i/ in the second syllable does not change to /u/ in plural forms (example 4). According to the stress generalization reported in previous work (Sitapati, 1936; Pingali, 1985), in these stems, initial syllable carries primary stress and the other two syllables do not bear stress. Yet, the vowel in the second syllable resists harmony unlike in LLL stems. In order to account for this contrast, I propose a new hypothesis about stress in this language- the light syllable following the initial heavy syllable in HLL stems also bears stress. In other words, Telugu has secondary stress on every alternate mora after primary stress. This hypothesis predicts that the stress pattern in stems of this type is /HL̀L/[2]. The opacity of the vowel /i/ in the second syllable of the stems in example 4 is therefore, due to its bearing secondary stress. On the other hand, in a trisyllabic LLL stem such as [kolimi]

[2]Another way to describe these patterns is that stress is assigned using left-to-right moraic trochees with a ban on degenerate feet.

'forge' (/ĹLL/), the second syllable does not bear stress since the initial syllable is light. In addition, in LLL stems, secondary stress does not go on the final light syllable (/ĹLL/) since both non-initial stem vowels alternate.

This hypothesis of secondary stress on alternate moras predicts the final syllable in HLL stems to be stressless (/ĹL̀L/). Notice in examples 4 (a)-(d) that the vowel /i/ in the final syllable does change to /u/ in plural forms. This is consistent with the pattern in previous examples- stem vowels alternate only when they are stressless. In examples (e)-(j), the stem-final vowel is syncopated in the plural form for independent reasons[3]. In these stems, there is formation of a retroflex cluster at the morpheme boundary in the plural forms. Previous work (Pingali, 1985) ascribes the non-alternation of /i/ in the second syllable in these stems to blocking by the retroflex consonant cluster[4]. But, examples (a)-(d) show that the stem vowel in the second syllable resists harmony even when the final vowel is not syncopated and undergoes harmony. The stress-based generalization provides a simpler account of the resistance of the vowel following the initial heavy syllable to vowel harmony in all HLL stems.

The stress pattern in HLL stems can be accounted for using the constraints previously defined. The derivation is shown in tableau 4. *MORA LAPSE has to outrank *SYLL CLASH in order to derive alternating secondary stress. Also, since secondary stress does not go on the final syllable in trisyllable LLL (/ĹLL/) stems, NONFINALITY still outranks *MORA LAPSE. Therefore, the ranking of constraints is- *MORA CLASH >> STRESS-L, NONFINALITY >> *MORA LAPSE >> *SYLL CLASH.

Input: /HLL/		*MORA CLASH	STRESS-L	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a.	cv́x.cv.cv				*!*	
b.	cvx.cv́.cv		*!		*	
c.	cvx.cv.cv́		*!	*	**	
d.	cv́x.cv.cv̀			*!	*	
e. ☞	cv́x.cv̀.cv					*
f.	cvx.cv́.cv̀	*!	*	*	*	*

Table 4: Stress assignment in trisyllabic stems with a heavy initial syllable

(5) Alternations in nominal stems containing four light syllables

a.	parimiti	párimìti-lu	parimitulu	'limits'
b.	animiti	ánimìti-lu	animitulu	'inferences'
c.	enimidi	énimìdi-lu	enimidulu	'(sets of) eights'
d.	penimiṭi	pénimìṭi-lu	penimiṭlu	'husbands'
e.	pidikili	píḍikìli-lu	pidikiḷḷu	'fists'

One straight-forward way to test this hypothesis about secondary stress and its interaction with vowel harmony is with nominal stems that are sequences of more than three light syllables.

[3]Syncope of this stressless vowel seems to be related to one of the following reasons: OCP-related ban on sequences, minimizing the length of the suffixed forms, the permissibility of the consonant cluster formed after syncope and perhaps, even the lack of stress on the vowel. Syncope of final vowel is found in stems in which the onset in the final syllable is one of /r l ṭ ḍ/

[4]A brief summary of her account is as follows- the lateral in the plural marker -/lu/ assimilates to the retroflex consonant in the final syllable of these stems by associating with an autosegment [+B]. VH cannot apply to stem-final vowel since association lines cross. Since this vowel is incompletely specified at the end of the derivation, it is dropped. Vowel in second syllable is fully specified in such stems.

In nominal stems that are sequences of four light syllables /LLLL/, the hypothesis proposed predicts the third syllable to bear secondary stress- /ĹLL̀L/. In such stems, vowel /i/ in the syllable receiving secondary stress is predicted to resist harmony. The examples in 5 show that this is indeed the case. Since the final syllable is unstressed, vowel in this syllable alternates in 5 (a-c). Again, in examples 5 (d)-(e), stem-final vowel undergoes syncope for independent reasons. The fact that stems 5 (a) and (b) are borrowings from Sanskrit is not relevant since the vowel in the third syllable resists harmony in native stems (c-e). There are no non-compound nouns that are sequences of more than four light syllables with /i/ in all non-initial syllables. The stress pattern in LLLL stems can be accounted for using the same set of rhythmic constraints as earlier. The derivation is shown in tableau 5.

Input: /LLLL/		*MORA CLASH	STRESS-L	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a.	cv́.cv.cv.cv				*!*	
b.	cv.cv́.cv.cv		*!		*	
c.	cv.cv.cv́.cv		*!		*	
d.	cv.cv.cv.cv́		*!	*	**	
e.	cv́.cv̀.cv.cv	*!			*	*
f.	cv́.cv.cv.cv̀			*!	*	
g. ☞	cv́.cv.cv̀.cv					
h.	cv.cv́.cv.cv̀		*!	*		
i.	cv.cv́.cv̀.cv	*!	*			*
j.	cv.cv.cv́.cv̀	*!	*	*	*	*

Table 5: Stress assignment in nouns with four light syllables

If the final vowel in a nominal stem is a long /i/, then it does not change to /u/ in plural forms (example 6). Furthermore, the long vowel blocks harmony from spreading to a short vowel on its left (examples c., d. and e.). Again, initial syllable in all these stems bears primary stress. If initial syllable is heavy (bimoraic), then primary stress goes on the initial mora. The stress hypothesis proposed here predicts that the initial mora of the final heavy syllable carries secondary stress. The stress patterns in these stems are (a.), (b.) /H́H̀/ and (c.), (d.), (e.) /ĹLH̀/.

(6) Non-alternation of long /i/

a.	po:ṭi:	pó:ṭi̗:-lu	po:ṭi:lu	'contests'
b.	kiḷḷi:	kíḷḷi̗:-lu	kiḷḷi:lu	'betel nuts'
c.	gumiki:	gúmiki̗:-lu	gumiki:lu	'punches'
d.	takili:	tákili̗:-lu	takili:lu	'spindles'
e.	buriḍi:	búriḍi̗:-lu	buriḍi:lu	'deceptions'

Input: /HH/		*MORA CLASH	STRESS-L	WSP	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a.	cv́x.cv:			*!		*	
b.	cvx.cv́:		*!	*	*	*	
c. ☞	cv́x.cv̀:				*		*
d.	cvx.cv:		*!	*		* * *	

Table 6: Stress assignment in bisyllabic stems with two heavy syllables

In order to account for the stress patterns in these stems, the following additional constraint is needed-

- WSP: Heavy (bimoraic) syllables must be stressed.

The derivations are shown in tableaux 6 and 7. WSP has to outrank NONFINALITY so that secondary stress can go on the final heavy syllable. However, if NONFINALITY is defined as no stress on final mora and stress on a heavy (bimoraic) syllable goes on first mora, then there is no ranking between WSP and NONFINALITY. The ranking on constraints is- *MORA CLASH >> STRESS-L, WSP >> NONFINALITY >> *MORA LAPSE >> *SYLL CLASH

Input: /LLH/		*MORA CLASH	STRESS-L	WSP	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a.	cv́.cv.cv:			*!		**	
b.	cv.cv́.cv:		*!	*		*	
c. ☞	cv́.cv.cv̀:				*		
d.	cv́.cv̀.cv:	*!				*	*
e.	cv.cv.cv́:		*!		*	*	
f.	cv.cv́.cv̀:	*!	*		*		*

Table 7: Stress assignment in trisyllabic stems with final heavy syllable

In HLL type stems, the vowel /i/ in the second light syllable following a heavy initial syllable resists vowel harmony. On the other hand, if a final light syllable in a trisyllabic stem follows a heavy syllable, as in HHL or LHL, then the final vowel does not carry secondary stress. The vowel /i/ in the final syllable of such stems is predicted to undergo vowel harmony. This is indeed the case in the plural forms in example 7.

(7) Alternations in trisyllabic stems when final syllable is preceded by a heavy syllable

a.	tiwa:ci	tiwá:ci-lu	tiwa:culu	'carpets'
b.	wiwe:ki	wiwé:ki-lu	wiwe:kulu	'wise persons'
c.	se:na:ni	sé:nà:ni-lu	se:na:nulu	'commanders-in-chief'
d.	ra:ka:si	rá:kà:si-lu	ra:ka:sulu	'female demons'

Input: /LHL/		*MORA CLASH	STRESS-L	WSP	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a.	cv́.cvx.cv			*		**	
b. ☞	cv.cv́x.cv		*			*	
c.	cv́.cvx.cv̀			*	*	*	
d.	cv́.cv̀x.cv	*!				*	*
e.	cv.cvx.cv́		*	*	*	**	
f.	cv.cv́x.cv̀		*		*		*

Table 8: Stress assignment in trisyllabic stems with heavy second syllable

In examples 7 (a) and (b), primary stress is on the heavy syllable and not on the initial light syllable- /LH́L/. This is the primary stress rule reported in previous work (Sitapati, 1936; Pingali, 1985)- stress the second syllable if it is heavy, otherwise the first[5]. In the OT analysis

[5]The same is true in Malayalam. Hayes (1995, pp.92) presents this as evidence of a ban on degenerate foot when parsing words using the moraic trochee.

sketched so far, this is predicted as a result of *MORA CLASH outranking STRESS-L and WSP being high-ranked. In examples 7 (c) and (d), on the other hand, primary stress goes on initial and secondary stress on the heavy second syllable- /HHL/. These stress patterns can be derived with the same constraint ranking, as shown in tableaux 8 and 9. Again, the final vowel in these stems that alternates in plural forms is unstressed.

Input: /HHL/	*MORA CLASH	STRESS-L	WSP	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a. cv́x.cvx.cv			*		**	
b. cvx.cv́x.cv		*	*		**	
c. cv́x.cvx.cv̀			*	*	*	
d. ☞ cv́x.cv̀x.cv					*	*
e. cvx.cvx.cv́		*	*	*	***	
f. cvx.cv́x.cv̀		*	*	*	*	*

Table 9: Stress assignment in trisyllabic stems with heavy first and second syllables

(8) Non-alternation in bisyllabic stems with final heavy syllable

a.	kaḍi:	kaḍí:-lu	kaḍi:lu	'stone slabs'
b.	laḍi:	laḍí:-lu	laḍi:lu	'(a kind of) fire crackers'
c.	jari:	jarí:-lu	jari:lu	'golden threads'
d.	usiḍi	usíḍ-lu	usiḍlu	'flying ants'
e.	nemili	nemíl-lu	nemiḷḷu	'peacocks'
f.	jamili	jamíl-lu	jamiḷḷu	'pairs/couples'

In bisyllabic stems with an initial light and final heavy syllable (LH), the vowel /i/ in the final syllable does not change to /u/ in plural forms (example 8). There are not many stems of this type in the language. As seen earlier, stem-final long /i/ resists harmony since it carries stress due to WSP (examples a., b. and c.). In these stems, Primary stress is on the final heavy- /LH́/. Also, in some trisyllabic LLL stems, the final vowel undergoes syncope to make them /LH/ (CVCVC). These are shown in examples 8 (d)-(f). In these stems too, primary stress is on the final heavy. The vowel /i/ in this syllable does not alternate since it bears stress. The stress pattern in stems of this type is also accounted for by the same constraint ranking. The derivation is shown in tableau 10.

Input: /LH/	*MORA CLASH	STRESS-L	WSP	NONFINALITY	*MORA LAPSE	*SYLL CLASH
a. cv́.cvx			*		*	
b. ☞ cv.cv́x		*				
c. cv́.cv̀x	*!					*
d. cv.cvx		*	*	*	**	

Table 10: Stress assignment in bisyllabic stems with initial light and final heavy

A summary of the vowel alternations triggered by the plural marker in nominal stems is shown in 9.

(9) Rhythmic word types and vowel alternations in nouns

stem	Stress pattern	Plural form
CV.C$\underline{i}$	ĹL	CV.C$\underline{u}$-lu
CV.Ci:	LH́	CV.Ci:-lu
CV.CiC	LH́	CV.CiC-lu
CVX.C$\underline{i}$	H́L	CVX.C$\underline{u}$-lu
CV.C$\underline{i}$.C$\underline{i}$	ĹLL	CV.C$\underline{u}$.C$\underline{u}$-lu
CVX.Ci.C$\underline{i}$	H́L̀L	CVX.Ci.C($\underline{u}$)-lu
CV.CVX.C$\underline{i}$	LH́L	CV.CVX.C$\underline{u}$-lu
CV.CV.Ci:	ĹLH̀	CV.CV.Ci:-lu
CVX.CVX.C$\underline{i}$	H́H̀L	CVX.CVX.C$\underline{u}$-lu
CV.Ci.Ci.C$\underline{i}$	ĹLL̀L	CV.Ci.Ci.C$\underline{u}$-lu

Thus, in all the different (non-compound) stem types found in the language, the /i/-/u/ alternation is found only in syllables which are stressless. Crucially, resistance to harmony is only a function of stress and not of position in the word. Primary stress in Telugu goes on the heavier of the first two syllables in a word. Secondary stress goes on every alternate mora starting from the primary stressed syllable unless it is final. In heavy syllables (CVC, CVV, CVVC), stress goes on the initial mora. There are no other nominal suffixes that can trigger vowel harmony. A stressed vowel not only never alternates, but also blocks harmony from spreading to a stressless /i/ to its left, as seen in LLLL stems. There are no other nominal suffixes that can trigger harmony.

The OT constraint hierarchy proposed to derive the different stress patterns shown in 9 is shown in the Hasse diagram in figure 1.

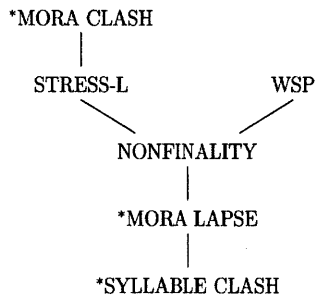


Figure 1: Constraint hierarchy to derive stress patterns in different rhythmic word types

With this clearcut generalization about the environments in which vowel harmony applies, I present an account of the /i/-/u/ alternation in nouns triggered by the vowel in the plural marker. Notice that harmony applies only to the vowel /i/ in unstressed syllables in nominal stems. Vowels other than /i/ in unstressed positions in nominal stems do not alternate in plural forms (example 10). The non-application of harmony to stem-final long vowels (/i:/ in example 6 and 8 (a-c)) can again be ascribed to stress (due to WSP). In addition, non-high vowels /a/ and /e/ in stem-final position do not alternate in plural forms. Non-alternation of /a/ suggests that harmony is with respect to backness. But, why is the mid-vowel /e/ opaque ? Previous analysis based on under-specification (Pingali, 1985) addressed this fact by stipulating that only high vowels in nominal stems are under-specified for the backness feature. The mid-vowel /e/ is fully specified and is therefore, unaffected by harmony. In the analysis that follows, I show that it is possible to account for the opacity of /e/ to backness harmony in terms of a ban on the occurrence of back mid-vowel in stem-final position. Another important fact to be noticed from the data in 10 is that opaque vowels /a/ and /e/ also block harmony from spreading to a unstressed /i/ to the left, such as in plural forms of [moṭima] 'pimple' and [guḍise] 'hut'. Recall that such blocking is also found with /i/ in syllables bearing secondary stress in LLLL stems (example 5).

(10) Non-alternation of non-high vowels

a.	tala	'head'	talalu	'head'
	konga	'crane'	kongalu	'cranes'
	tēḍā	'difference'	tēḍālu	'differences'
	cokkā	'shirt'	cokkālu	'shirts'
	pāḍe	'funeral bier'	pāḍelu	'funeral biers'
	binde	'(large) pot'	bindelu	'pots'
	gorre	'sheep'	gorrelu	'sheep (pl.)'
b.	piluka	'tuft of hair'	pilukalu	'tufts'
	maraka	'stain'	marakalu	'stains'
	moṭima	'pimple'	moṭimalu	'pimples'
	bīruwā	'wardrobe'	bīruwālu	'wardrobes'
	jābitā	'list'	jābitālu	'lists'
	guḍise	'hut'	guḍiselu	'huts'
	barise	'spear'	bariselu	'spears'

In a nominal stem consisting of three light syllables /ĹLL/, the vowel /i/ in syllables unstressed in the base changes to /u/ in the plural forms. This is triggered by the vowel /u/ in the plural suffix. This can be implemented in OT in a number of ways, through AGREE, ALIGN or SPREAD constraints. I will start with the constraint AGREE[α BK] that penalizes adjacent vowels that do not agree with respect to backness. Note that defined this way, this is a *local* constraint which only evaluates one pair of adjacent vowels at a time. The constraints required to derive the /i/-/u/ alternation in stem vowels triggered by the vowel in the plural suffix /lu/ are-

- BD-IDENT[STRESS]: Stress on a syllable in derivative must correspond to stress on that syllable in base and vice versa.
- AGREE[α BK]: Vowels in adjacent syllables should agree with respect to backness.
- BD-IDENTV-[STRESS]: A stressed vowel in base must match its correspondent in derivative in all features

- IDENTV-[SUFFIX]: Faithfulness to vowels in suffix
- IDENTV-[STEM]: Faithfulness to vowels in stem

The derivation of the plural form of a /ĹLL/ stem [kolimi] 'forge' using these constraints is shown in tableau 11. Following Pingali (1985), if I assume that suffix vowels are all stressed, then IDENTV-[SUFFIX] becomes redundant. But for now, I maintain this distinction between suffix vowels and stem vowels. The ranking among constraint is as follows: BD-IDENT[STRESS] >> BD-IDENTV-[STRESS], IDENTV-[SUFFIX] >> AGREE(α BK) >> IDENTV-[STEM]

Input: /kólimi + lu/	BD-IDENT[STR]	BD-IDENTV-[STR]	IDENTV-[SUFF]	AGR(α BK)	IDENTV-[STEM]
a. kólimilu				*!*	
b. kólimìlu	*!			**	
c. kólimili			*!		
d. kólimulu				*!*	*
e. ☞ kólumulu					**
f. kúlumulu		*!			***

Table 11: Vowel alternations in trisyllabic nouns with three light syllables

One issue that has been pointed out in the literature with using a local constraint to account for harmony is what has been called the *sour-grapes* effect (McCarthy, 2003). A constraint like AGREE(α BK) defined above favors candidates in which harmony applies totally, but gives up on candidates in which harmony is blocked. For example, in a stem where all stem vowels agree with respect to the feature that the local constraint evaluates, such as [teripi] 'curtain', AGREE[α BK] does not distinguish between disagreement between two stem vowels and disagreement between a stem vowel and a suffix vowel. This is illustrated in the derivation in table 12. In this example, AGREE assigns equal penalty to candidates (a), (b), (d) and (e) and makes the incorrect prediction that candidate (a) is the winner since it is most faithful to the input form instead of (e).

Input: /téripi + lu/	BD-IDENT[STR]	BD-IDENTV-[STR]	IDENTV-[SUFF]	AGR(α BK)	IDENTV-[STEM]
a. ☞ téripilu				*	
b. téripìlu	*!			*	
c. téripili			*!		
d. téripulu				*	*
e. térupulu				*	**
f. tórupulu		*!			***

Table 12: *Sour-grapes* effect with local AGREE

One way to avoid this *sour-grapes* effect is to instead use a non-local harmony constraint which evaluates all pairs of vowels with respect to feature F and penalizes according to the number of disagreeements. One version of such a constraint that implements the backness harmony in nouns is as follows-

- SPREAD-L(+BK): For the rightmost occurrence of [+BK] feature on a vowel, if a vowel to its left does not have this feature, a violation is incurred.

This version of SPREAD compares the rightmost [+BK] vowel to all vowels till the left edge of the word is reached. Another feature of SPREAD constraints in the literature is the specification

of directionality (Walker, 1998). Since in Telugu, the direction of spreading of the feature is from the suffix to the stem vowels, I define the constraint as SPREAD-L. This is obviously a stipulation but it is possible to derive directionality based on the co-occurence of back vowels in suffixed forms. If direction of spread is right-to-left, then [-BK][+BK] sequences are impossible but [+BK][-BK] sequences are possible. This can be implemented in OT using a sequence constraint- *[+BK][-BK]. I note the exact derivation of directionality as an open issue for now. In table 13 is shown the derivation of the plural form of the same stem with which local AGREE failed. In this example, candidate (a) and candidate (d) incur three and two violations of SPREAD respectively while the less faithful (e) incurs only one and therefore, is the winner. The ranking of constraints in this table is- BD-IDENT[STR] >> BD-IDENTV-[STRESS], IDENTV-[SUFFIX] >> SPREAD-L(+BK) >> IDENTV-[STEM].

Input: /téripi + lu/		BD-IDNT[STR]	BD-IDNTV-[STR]	IDNTV-[SUFF]	SPRD-L(+BK)	IDNTV-[STEM]
a.	téripilu				* * *	
b.	téripìlu	*!			* * *	
c.	téripili			*!		
d.	térupulu				**	*
e. ☞	térupulu				*	**
f.	tórupulu		*!			* * *

Table 13: Avoiding *sour-grapes* with non-local SPREAD

In trisyllabic nominal stems with a heavy initial syllable /HLL/, such as [yó:gìni] 'female ascetic', [tómmìdi] 'nine', the vowel /i/ in the second syllable following the initial heavy syllable does not alternate in plural forms- [yo:ginulu], [tommidulu]. This is because it bears secondary stress according to the hypothesis proposed earlier. In fact, this set of stems is the most crucial piece of evidence that shows the interaction between stress and vowel harmony. The plural forms of these stems can be derived using the same constraint ranking. This is shown in tableau 14.

Input: /yó:gìni + lu/		BD-IDNT[STR]	BD-IDNTV-[STR]	IDNTV-[SUFF]	SPRD-L(+BK)	IDNTV-[STEM]
a.	yó:gìnilu				**	
b.	yó:ginìlu	*!			**	
c.	yó:gìnili			*!		
d. ☞	yó:gìnulu				*	*
e.	yó:gùnulu		*!			**
f.	yú:gùnulu		*!*			**

Table 14: Vowel harmony in trisyllabic HLL stems

In stems of rhythmic type /LHL/, the vowel /i/ in final syllable alternates. Primary stress in these stems goes on the second heavy syllable- /LH́L/ and final syllable is unstressed. The derivation of the plural form of [mari:ci] 'ray of light' using the same constraints is shown in tableau 15. The same analysis accounts for /H́HL/ type stems, in which the vowel in the final light syllable alternates in plural forms, such as in [dēwēri] 'queen' plural [dēwērulu][6]. This is shown in the derivation in tableau 16.

[6]Interestingly, unlike in HLL (and some LLL) stems, the stem-final vowel is not syncopated here although the onset in the final syllable is /ɪ/.

Input: /marí:ci + lu/		BD-IDNT[STR]	BD-IDNTV-[STR]	IDNTV-[SUFF]	SPRD-L(+BK)	IDNTV-[STEM]
a.	marí:cilu				* * *	
b.	marí:cìlu	*!			* * *	
c.	marí:cili			*!		
d. ☞	marí:culu				*	*
e.	marú:culu		*!			**
f.	murú:culu		*!			* * *

Table 15: Vowel harmony in trisyllabic LHL stems

Input: /dé:wè:ri + lu/		BD-IDNT[STR]	BD-IDNTV-[STR]	IDNTV-[SUFF]	SPRD-L(+BK)	IDNTV-[STEM]
a.	dé:wè:rilu				* * * * *	
b.	dé:wè:rìlu	*!			* * * * *	
c.	dé:wè:rili			*!		
d. ☞	dé:wè:rulu				* * * *	*
e.	dé:wò:rulu		*!		**	* * *
f.	dó:wò:rulu		*!*			* * * * *

Table 16: Vowel harmony in trisyllabic HHL stems

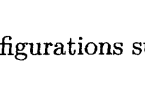
In stems of rhythmic type /LLH/, if the final vowel is long /i/, it does not alternate. In these stems, primary stress goes on the initial light syllable and secondary stress goes on the final heavy- /ĹLH̀/. The derivation of plural form of [gumiki:] 'punch' using the proposed constraints is shown in tableau 17.

Input: /gúmikì: + lu/		BD-IDNT[STR]	BD-IDNTV-[STR]	IDNTV-[SUFF]	SPRD-L(+BK)	IDNTV-[STEM]
a.	gúmikì:lu				* * *	
b.	gúmiku:lu	*!			*	**
c.	gúmikì:li			*!		
d.	gúmikù:lu		*!		*	**
e. ☞	gúmukì:lu				**	*
f.	gúmukù:lu		*!*			* * *

Table 17: Non-alternation in trisyllabic LLH stems

Note that the constraint ranking incorrectly predicts that candidate (e) is the winner instead of (a). Recall that /i/ in stressed syllable not only is opaque but also blocks spreading of VH to a stressless /i/ to its left. The harmony constaint SPREAD-L(+BK) as defined above does not capture this blocking property of stressed vowels. One way to address this problem is to constrain the harmony constraint to prevent it from skipping over potential targets that are opaque due to stress, following Walker (1998, pp.51)-

- SPREAD-L[+BK,PWD]: Let f be a variable ranging over occurrences of the feature [+BK] in a prosodic word P. For all vowels in P, if there is a feature f associated with a vowel v_i, assign a * to every vowel to the left of v_i which is not associated with the feature f.

This formulation of SPREAD treats harmony as autosegmental spreading rather than feature copying. In addition, a markedness constraint that bans gapping configurations such as 

,

which violate segmental adjacency in feature linking is required to rule out candidate (e) in tableau 17. Such a *GAP constraint would be undominated in the language. I do not show this constraint and the candidates it rules out in the derivation in tableau 18.

Input: /gúmikì: + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUF]	SPRD-L[+BK,PWD]	IDNTV[STEM]
a. ☞ gúmikì:lu				* * *	
b. gúmiku:lu	*!			*	**
c. gúmikì:li			*!		
d. gúmikù:lu		*!		*	**
e. gúmukù:lu		*!*			* * *

Table 18: Non-alternation in trisyllabic LLH stems

The autosegmental version of SPREAD and *GAP constraint are also required to derive harmony in plural forms of /LLLL/ type stems. In these stems, primary stress goes on initial syllable and secondary stress on the penultimate syllable- /ĹLL̀L/. Again, the vowel /i/ in the third syllable carrying secondary stress blocks harmony from spreading to an unstressed /i/ to its left in the second syllable. The derivation of the plural form of one such stem, [enimidi] 'eight' is shown in tableau 19. I show only the relevant candidates to illustrate the application of SPREAD-L[+BK,PWD].

Input: /énimídi + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. énimìdilu				* * **	
b. énimìdili			*!		
c. ☞ énimìdulu				* * *	*
d. énimùdulu		*!		**	**
e. énumùdulu		*!		*	* * *
f. énumudulu	*!	*		*	* * *
g. ónumùdulu		**!			* * **

Table 19: Vowel harmony in nouns with four light syllables

Since the harmony constraint SPREAD is defined with respect to the feature [+BK], it never affects any change in the vowel /a/ in unstressed syllables, thus accounting for its opacity. This is shown in the example in tableau 20.

Input: /míḍata + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. ☞ míḍatalu				*	
b. míḍatàlu	*!			*	
c. míḍatala			*!		
d. míḍatulu				*	*
e. míḍutulu				*	**
f. múḍutulu		*!			* * *

Table 20: Opacity of vowel /a/

Another case of non-application of harmony is in nominal stems which end in the mid-vowel /e/ such as, [cịtike] 'snap of fingers' and [ginne] 'container'. The non-application of harmony in these stems can be accounted for based on the distribution of mid-vowels in the language. The vowel /o/ does not occur in the stem-final position in this language (see table 37 in Appendix)[7]. Since spreading the backness of the suffix vowel to the stem vowels results in an illegitimate occurrence of a vowel, harmony does not apply here. This can be implemented in OT terms using a markedness constraint that bans /o/ in the stem-final position.

- *[+BK,-HI,-LO]#: No back mid-vowel in the stem-final position.

This is similar to what is referred to as condition C in the analysis of Turkish vowel harmony that all non-initial [-HI] vowels must be [-RD] (Bakovic, 2000). This constraint has to outrank the SPREAD constraint in order to derive the opacity of /e/. This is shown in the derivations in tableaux 21 and 22. The ranking of constraints in these tableaux is- BD-IDENT[STRESS] >> BD-IDENTV-[STRESS], IDENTV-[SUFFIX], *[+BK,-HI,-LO]# >> SPREAD-L(+BK,PWD) >> IDENTV-[STEM].

Input: /cịtike + lu/	BD-ID[STR]	BD-IDV[STR]	IDV[SUF]	*[+B,-H,-L]#	SPRD-L(+BK,P)	IDV[STEM]
a. ☞ cịtikelu					* * *	
b. cịtikèlu	*!				* * *	
c. cịtikele			*!			
d. cịtikolu				*!	**	*
e. cịtukolu				*!	*	**
f. cútukolu		*!		*		* * *

Table 21: Opacity of /e/ and blocking

Input: /gínne + lu/	BD-ID[STR]	BD-IDV[STR]	IDV[SUF]	*[+B,-H,-L]#	SPRD-L(+BK,P)	IDV[STEM]
a. ☞ gínnelu					**	
b. gínnèlu	*!				**	
c. gínneli			*!			
d. gínnolu				*!	*	*
e. gúnnolu		*!		*		**

Table 22: Opaque /e/

To summarize, the analysis proposed to derive stress-conditioned /i/-/u/ alternation in different types of nominal stems is shown in the Hasse diagram in figure 2.

The same ranking derives the alternation and opacity patterns in bisyllabic stems of types /ĹL/, /ḾL/, /ḾH̀/ and /ĹH/. The derivation of plural forms of example stems of these types are shown in tableaux 23, 24, 25 and 26.

[7]The mid-vowels /e/ and /o/ also do not occur in unstressed internal syllables (see table 38 in Appendix).

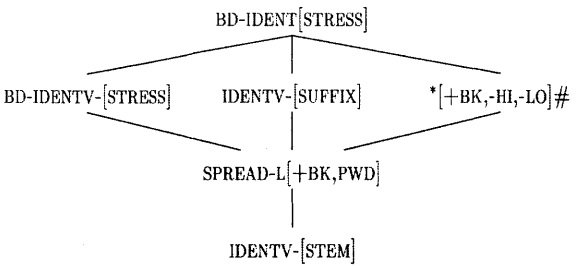


Figure 2: Constraint hierarchy to derive vowel harmony in nouns

Input: /cíti + lu/	BD-IDNT[STRESS]	BD-IDNTV[STR]	IDNTV[SUFF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. citilu				**	
b. citili			*		
c. ☞ citulu				*	*
d. cútulu		*			**
e. cutulu	*!	*			**

Table 23: Alternations in bisyllabic LL stems

Input: /pínni + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUFF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. pínnilu				**	
b. pínnìlu	*!			**	
c. pínnili			*!		
d. ☞ pínnulu				*	*
e. púnnulu		*!			**

Table 24: Alternations in bisyllabic HL stems

Input: /pó:ṭì: + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUFF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. ☞ pó:ṭì:lu				**	
b. pó:ṭu:lu	*!				**
c. pó:ṭì:li			*!		
d. pó:ṭù:lu		*!*			**

Table 25: Alternations in bisyllabic HH stems

Input: /nemíl + lu/	BD-IDNT[STR]	BD-IDNTV[STR]	IDNTV[SUFF]	SPRD-L(+BK,PWD)	IDNTV[STEM]
a. ☞ nemíl̩lu				**	
b. némul̩lu	*!			*	*
c. nemíl̩li			*!		
d. nemúl̩lu		*!		*	*
e. nomúl̩lu		*!			**

Table 26: Alternations in bisyllabic LH stems

3 Verbs

Just as in nouns, stem vowels alternate in verbal paradigms as well. This is shown in the examples in 11.

(11) Alternations in verbs

1.	kaḍugu			'wash'
a.	-/u/	imperative	kaḍugu	
b.	-/i/	perfective	kaḍigi	
			kaḍigindi	wash.past.3SF
			kaḍigæːḍu	wash.past.3SM
c.		imperfective	kaḍugutundi	wash.nonpast.3SF
			kaḍugutāḍu	wash.nonpast.3SM
d.	-/aka/	negative stem	kaḍagaka	
e.	-/aḍam/	gerund	kaḍagaḍam	
f.	-/incu/	causative	kaḍigincu	
g.	-/āli/	deontic modal	kaḍagāli	

2.	kadulu			'move'
a.	-/ika/	nominalizer	kadilika	'movement'

Unlike nouns where only the plural marker triggered alternations, vowel harmony in verbs is triggered by a variety of suffixes. The base form of the stem (citation form) is the same as the imperative form (1a in example 11). The vowel /u/ in non-initial syllables in the stem changes to /i/ in perfective forms (1b). This is triggered by the perfective suffix -/i/. The vowel /u/ in non-initial syllables does not alternate in imperfective forms (1c) since the vowel in the imperfective suffix -/tu/ is /u/. The vowel /u/ in non-initial syllables changes to /a/ in negative forms (1d). This is triggered by the negative suffix -/aka/. Similar /u/-/a/ alternation is triggered by the gerund suffix -/aḍam/ (1e) and the modal suffix -/āli/ (1g). The /u/ vowel in stems alternates with /i/ in causative forms (1f) triggered by the suffix -/incu/ and nominalized forms (2a) triggered by the suffix -/ika/. The trigger in all these alternations is a suffix vowel. The modal suffix is unlike other suffixes in that the trigger is a long vowel. The target is always a non-initial stem vowel. The choice of suffix is idiosyncratic to the verb stem. Not all suffixes can be affixed to all stems. Furthermore, verbal suffixes such as the causative, negative, modal, gerund and nominalizer markers that trigger harmony are disyllabic. It is the first vowel in the suffix that triggers harmony. Also, notice that both the stems in the example are trisyllabic LLL. Harmony in verbal stems is mostly found in LLL stems. In trisyllabic verbal stems that show alternations, the vowel in the second and third syllables is always /u/[8]. Another interesting pattern here is that tense suffixes like perfective -/i/ trigger backness harmony (/u/-/i/ alternation) while derivational suffixes can trigger both backness harmony (/u/-/i/ alternation in causative and nominalizer) as well as height harmony (/u/-/i/ alternation in gerund marker, modal marker and negative marker).

Since verbal morphology is quite complex compared to nouns, I first present some preliminaries required to analyze the vowel alternation patterns in example 11. The full paradigm of a 'harmonic' verb stem is shown in table 27. The morphological segmentation of these forms is not straight-forward. I assume the derivations in table 28. Agreement morphemes in Telugu, derived from the pronominal forms, begin with /ā/. The only exception is the third person

[8]See distribution of vowels in Appendix for more information.

Agr	Past	Non-Past	Progressive	Future progressive
1S	kaḍigæːnu	kaḍugutānu	kaḍugutunnānu	kaḍugutuṇṭānu
1P	kaḍigæːmu	kaḍugutāmu	kaḍugutunnāmu	kaḍugutuṇṭāmu
2S	kaḍigæːwu	kaḍugutāwu	kaḍugutunnāwu	kaḍugutuṇṭāwu
2P	kaḍigæːru	kaḍugutāru	kaḍugutunnāru	kaḍugutuṇṭāru
3Smasc	kaḍigæːḍu	kaḍugutāḍu	kaḍugutunnāḍu	kaḍugutuṇṭāḍu
3Snon-masc	kaḍigindi	kaḍugutundi	kaḍugutunnadi	kaḍugutuṇṭundi
3Phuman	kaḍigæːru	kaḍugutāru	kaḍugutunnāru	kaḍugutuṇṭāru
3Pnon-human	kaḍigæːyi	kaḍugutāyi	kaḍugutunnāyi	kaḍugutuṇṭāyi

Table 27: kaḍugu 'wash' paradigm

Form	Derivation
Past	stem+perfective+Agr
kaḍigæːnu	kaḍugu+i+ānu
kaḍigindi	kaḍugu+in+di
Non-Past	stem+imperfective+Agr
kaḍugutāmu	kaḍugu+tu+āmu
kaḍugutundi	kaḍugu+tun+di
Progressive	stem+imperfective+BE.perfective+Agr
kaḍugutunnāḍu	kaḍugu+tu+unna+āḍu
kaḍugutunnadi	kaḍugu+tu+unna+di
Future Progressive	stem+imperfective+BE.imperfective+Agr
kaḍugutuṇṭāru	kaḍugu+tu+uṇṭu+āru
kaḍugutuṇṭundi	kaḍugu+tu+uṇṭun+di

Table 28: Morphological derivation

non-masculine singular form -/di/ (derived from the pronominal form /adi/). The tense morphemes have the allomorphs /i/ and /in/ for the past and /tu/ and /tun/ for the non-past[9]. Krishnamurti and Gwynn (1985, pp.150-151) report /in/ as the historical past tense morpheme and point out dialects in which it has not changed to /i/ preceding a long vowel. In these dialects, for example, the first person singular past form of the example stem [kaḍugu] 'wash' is /kaḍiginānu/. The same is true of the non-past morpheme /tun/. There are dialects in which the third person singular non-past form is /kaḍugutudi/.

The example paradigm in table 27 shows that the second vowel in the past forms is an /i/ while in non-past forms, it is an /u/. The stem-final vowel shows up as /æː/ in all past forms except the third person singular non-masculine form. This is due to coalescence between a stem-final /i/ and initial /ā/ in the agreement suffix. Since Krishnamurti and Gwynn (1985, pp.150-151) did not identify this process as coalescence, they treat /æː/ as an allomorph of the past tense morpheme /in/ found only in past 1P, 2P and 3P masculine forms. Compare this to the non-past and progressive forms, where the non-past morpheme starts with a consonant, the third vowel in the stem is not deleted. This alternation is illustrated by listing the first person singular past and non-past forms for a few other verb stems in table 29. I also list the causative and gerund forms of these stems in the table.

In a trisyllabic LLL stem, if the onset in the final syllable is either /s/ or /c/, the vowel in the final syllable of the stem is obligatorily deleted in non-past and progressive forms as

[9]Actually, these morphemes denote aspect and not tense. Telugu, like other Dravidian languages, has no tense but only aspect. So, progressive forms represent the combination of Verb Stem + imperfective + BE + perfective. Future progressive forms are Verb stem + imperfective + BE + imperfective.

stem		1SM forms		causative	gerund
		Past	Non-Past		
nasugu	'mutter'	nasigæ:nu	nasugutānu	nasigincu	nasagaḍam
koruku	'bite'	korikæ:nu	korukutānu	korikincu	korakaḍam
tarumu	'chase'	tarimæ:nu	tarumutānu	tarimincu	taramaḍam
kalupu	'join/mix'	kalipæ:nu	kaluputānu	kalipincu	kalapaḍam
kadulu	'move'	kadilæ:nu	kadulutānu	kadilincu (kadulcu)	kadalaḍam
nemuru	'pet'	nemiræ:nu	nemurutānu	nemirincu (nemurcu)	nemaraḍam

Table 29: Vowel Harmony alternations

Agr	Past	Non-Past	Progressive	Future progressive
1S	karicæ:nu	karustānu	karustunnānu	karustunṭānu
1P	karicæ:mu	karustāmu	karustunnāmu	karustunṭāmu
2S	karicæ:wu	karustāwu	karustunnāwu	karustunṭāwu
2P	karicæ:ru	karustāru	karustunnāru	karustunṭāru
3Smasc	karicæ:ḍu	karustāḍu	karustunnāḍu	karustunṭāḍu
3Snon-masc	karicindi	karustundi	karustunnadi	karustunṭundi
3Phuman	karicæ:ru	karustāru	karustunnāru	karustunṭāru
3Pnon-human	karicæ:yi	karustāyi	karustunnāyi	karustunṭāyi

Table 30: karacu 'bite' paradigm

well. Notice from the example paradigm of such a verb in table 30 that the first person singular non-past form is /karustānu/ and not /karusutānu/. This has led to the assumption in previous work (Pingali, 1985) that the underlying representations of verbal stems showing vowel harmony is CVCVC- /karus/ or /karuc/ for the example verb. Also, recall that the base form of the verb is identical to the imperative form. Since the final vowel in all verb stems that show harmony is /u/, previous work such as Pingali (1985) treat the final /u/ as the imperative suffix and the verb to be underlyingly CVCVC. On the other hand, trisyllabic nominal stems which show vowel alternations are treated to be underlyingly CVCVCV. Furthermore, in nouns, alternations triggered by the plural marker only apply to the high front vowel /i/. Mid-vowel /e/ and the low vowel /a/ block harmony. Whereas in verbs, as mentioned earlier, harmony applies to back high vowel /u/ and is with respect to both backness and height. Thus, the harmony pattern in nouns and in verbs are treated as two separate phenomena by Pingali (1985).

In my analysis, I will explore the possibility of a unified account of both patterns. There are at least two independent arguments to claim that verb stems are also underlyingly CVCVCV-

- In past forms of harmony verbs (table 29 or 30), the vowel /æ:/ is found. I described the occurrence of this vowel in this context as the result of coalescence between the perfective morpheme /i/ and the vowel /ā/ in the following agreement morphemes. This process of /æ:/-formation is found with stem vowels elsewhere in the language: /guḍi/ 'temple' + /ā/ 'yes-no Q-marker' → /guḍæ:/ 'Is it a temple ?' (example 4(b) in Wilkinson (1974, pp.253)). In hiatus contexts between a final vowel of a suffixed word and a following /ā/, coalescence does not take place[10]: merisindi 'shine.3Pnon-masc'+ā → merisindā, *merisindæ:. Another crucial fact about the distribution of /æ:/ is that all verbs that show VH in alternations show /æ:/-formation in their paradigm. This coalescence is not found in the paradigm of non-harmony verbs, as can be noticed from the paradigm of the

[10]There seems to be dialectal variation on this point.

verb [tinu] 'eat' shown in table 31.

Agr	Past	Non-Past	Progressive	Future progressive
1S	tinnānu	tinṭānu	tinṭunnānu	tinṭunṭānu
1P	tinnāmu	tinṭāmu	tinṭunnāmu	tinṭunṭāmu
2S	tinnāwu	tinṭāwu	tinṭunnāwu	tinṭunṭāwu
2P	tinnāru	tinṭāru	tinṭunnāru	tinṭunṭāru
3Smasc	tinnāḍu	tinṭāḍu	tinṭunnāḍu	tinṭunṭāḍu
3Snon-masc	tinnadi	tinṭundi	tinṭunnadi	tinṭunṭundi
3Phuman	tinnāru	tinṭāru	tinṭunnāru	tinṭunṭāru
3Pnon-human	tinnāyi	tinṭāyi	tinṭunnāyi	tinṭunṭāyi

Table 31: tinu ('eat') paradigm

The distribution of /æ:/ in the past forms is an important cue about the underlying form of the verbal stems. One possible account of /æ:/ is that /i/ obligatorily leaves a trace only when it is a stem vowel. In a verb like /tinu/ 'eat', the underlying representation is CVC which is why there is no coalescence. On the other hand, the underlying form of a harmony verb stem is CVCVCV and in the first stage of suffixation, the stem vowels assimilate to the perfective morpheme /i/. In the next stage of derivation when the agreement suffix is affixed, a trace of the stem-final /i/ is preserved through coalescence.

- Notice in non-past forms of example verbs in table 29, there are two instances of /u/ following the initial vowel, such as in /nasugutānu/. If underlying representation of the verb stem is CVCVC, the second instance of /nasugutānu/ has to be accounted for. Pingali (1985) assumes that this is an epenthetic vowel that is inserted since the sequence /gt/ is not legitimate in the language. If on the other hand, the UR of the verb stem is CVCVCV, there is no need to posit an epenthetic vowel in this context.

Based on these arguments, I assume that verbs have the same underlying representation as nouns- CVCVCV. This allows the generalization about the interaction between stress and vowel harmony presented in section 2 to be relevant to verb stems as well. The vowel alternations found in different types of verbal stems are shown in 12. Again, the same pattern is found-stem-vowel (/u/) alternates in suffixed forms only when it is in unstressed syllables. Note that if verbs were underlyingly CVCVC (LH), the second syllable would be predicted to carry primary stress (/LH́/). A stress-based account of harmony proposed for nouns would make the incorrect prediction that the vowel in the second syllable blocks harmony. If verbs and nouns have the same word shape, then the constraint hierarchy in figure 1 (section 2) derives the stress patterns in 12 as well.

(12) Rhythmic word types and vowel alternations in verbs

stem	Stress pattern	Perfective	Imperfective	Causative	Gerund
CVX.C$\underline{u}$	HL	CVX.C$\underline{i}$	CVX.C$\underline{u}$-tu	CVX.C$\underline{i}$-ncu	CVX.C$\underline{a}$-ḍam
CV.C$\underline{u}$.C$\underline{u}$	LLL	CV.C$\underline{i}$.C$\underline{i}$	CV.C$\underline{u}$.C$\underline{u}$-tu	CV.C$\underline{i}$.C$\underline{i}$-ncu	CV.C$\underline{a}$.C$\underline{a}$-ḍam
CVX.Ci.C$\underline{u}$	HLL	CVX.Ci.C$\underline{i}$	CVX.Ci.C$\underline{u}$-tu	CVX.Ci.C$\underline{i}$-ncu	CVX.Ci.C$\underline{a}$-ḍam
CVX.CVX.C$\underline{u}$	HHL	CVX.CVX.C$\underline{i}$	CVX.CVX.C$\underline{u}$-tu	CVX.CVX.C$\underline{i}$-ncu	CVX.CVX.C$\underline{a}$-ḍam

Next, I briefly present a proposal to account for the vowel alternation patterns found in verbal stems. Again, there are a few significant differences between harmony in verbs and nouns. In nouns, the alternation is restricted to high vowels, /i/ in unstressed positions in stem

changes to /u/ in plural forms. On the other hand, in verbs, an /u/ in unstressed positions in the verbal stem can show up as either /i/ or /a/ in suffixed forms. So, unlike stress assignment, the constraint hierarchy proposed to account for nouns (figure 2 in section 2) cannot be used directly to account for the alternations in verbs. Also, note that in the set of trisyllabic /LLL/ verbs in Telugu which show harmony alternations, the distribution of vowels in non-initial syllables is much more restricted compared to that in nouns[11]. In the stem-final syllable, only /u/ occurs and in the second syllable only /i/, /u/, /a/ occur. If the vowel in the second syllable is other than /i u a/, then the stem is not /LLL/- it either involves a heavy initial syllable or both first and second syllables are heavy. In other words, a stem vowel other than /i u a/ in a verbal stem always occurs in a stressed position either by virtue of being either in a heavy syllable or in a non-final syllable following a heavy syllable. Unlike in nouns where unstressed mid-vowels blocked the spreading of backness, blocking of harmony in verbs is based entirely on stress.

As mentioned earlier, there is an interesting split in the kind of alternations triggered by verbal suffixes- inflectional suffixes (perfective and imperfective suffixes) trigger only /u/-/i/ alternation while derivational suffixes trigger both /u/-/i/ (causative and nominalizer suffixes) and /u/-/a/ (gerund, negative and modal suffixes). In nominal stems, the inflectional plural-marking suffix triggers /i/-/u/ alternation. Alternations triggered by inflectional suffixes in nouns and verbs can be unified using a revised version of the backness harmony constraint-

- SPREAD-L[αBK,PWD]: Let f be a variable ranging over occurrences of the feature [αBK] in a prosodic word P. For all vowels in P, if there is a feature f associated with a vowel v_i, assign a * to every vowel to the left of v_i which is not associated with the feature f.

This constraint spreads both [+BK] and [-BK] features from the suffix to the stem vowels. In addition, a different harmony constraint is needed to account for the /u/-/a/ alternation triggered by derivational suffixes-

- SPREAD-L[+LO,PWD]: Let f be a variable ranging over occurrences of the feature [+LO] in a prosodic word P. For all vowels in P, if there is a feature f associated with a vowel v_i, assign a * to every vowel to the left of v_i which is not associated with the feature f.

The ranking of all other constraints stays the same- BD-IDENT[STRESS] >> BD-IDENTV-[STRESS], IDENTV-[SUFFIX] >> SPREAD-L(αBK,PWD), SPREAD-L(+LO,PWD) >> IDENTV-[STEM]. This is shown in the Hasse diagram in figure 3. I do not spell out the full analysis with tableaux here and leave it for future work.

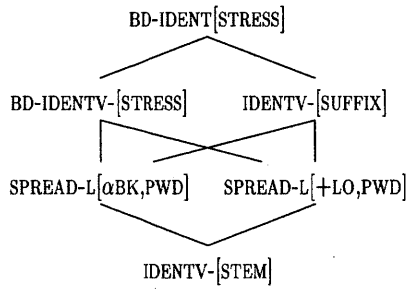


Figure 3: Constraint hierarchy to derive vowel harmony in verbs

[11] See table 42 in Appendix and related discussion.

4 Open Problems

In this section, I present two other patterns of vowel harmony in Telugu that are not accounted for by the analysis proposed in the previous sections. I also present a set of nominal stems that show a pattern of resistance to harmony not accounted for by the stress-based analysis in section 2.

4.1 Alternating post-positions

Nominal post-positions in Telugu have been reported to show an interesting pattern of harmony (Chekuri, 1976). This pattern has been described as progressive backness harmony triggered by the stem-final vowel, shown in example 13. As can be noticed from the examples, the vowel in the post-positions atlernates to agree with the stem-final vowel in the noun. The /u/ forms of these post-positions are assumed to be the underlying forms. This is because in case-marked pronominal forms, /i/ cannot occur- /nāku/ '1SG.Dat' (*/nāki/), /nīku/ '2SG.Dat' (*/nīki/), /māku/ '1P.Dat' (*/māki/), and /mīku/ '2P.Dat' (*/mīki/). If the stem-final vowel in a trisyllabic LLL stem is /i/, the post-position cannot have the /u/ form (i.(b,c), ii.(b,c), iii.(a,b) in 13). If stem-final vowel in a bisyllabic HL stem is /i/, again, the post-position can only have the /i/ form (i.d, ii.d, iii.c). If stem-final vowel in a bisyllabic LL stem is /i/, there is free variation (i.a and ii.a). In some stems, the final vowel is also in free variation but has to agree with the vowel in the post-position (i.e and ii.e). The final vowel in such stems is probably the enunciative vowel.

(13) Agreement in post-positions

i.	-/ku/	Dative	a.	gadi 'room'	gadi ki	gadi ku
			b.	maniʃi 'human'	maniʃi ki	*maniʃi ku
			c.	maridi 'brother-in-law'	maridi ki	*maridi ku
			d.	kāki 'crow'	kāki ki	*kāki ku
			e.	ūru 'village'	ūri ki, *ūru ki	ūru ku
ii.	-/nu/	Accusative	a.	gadi 'room'	gadi ni	gadi nu
			b.	maniʃi 'human'	maniʃi ni	*maniʃi nu
			c.	maridi 'brother-in-law'	maridi ni	*maridi nu
			d.	kāki 'crow'	kāki ni	*kāki nu
			e.	ūru 'village'	ūri ni, *ūru ni	ūru nu
iii.	-/wu/	2S marker	a.	maniʃi 'human'	maniʃi wi	*maniʃi wu
			b.	maridi 'brother-in-law'	maridi wi	*maridi wu
			c.	kāki 'crow'	kāki wi	*kāki wu

Previous analyses such as Pingali (1985) do not account for this pattern. I present a tentative proposal here about such alternating post-positions. Recall from section 2 that an alternate statement of the stress patterns in different nominal stems is in terms of metrical structure. Suppose that Telugu employs a *moraic trochee* to parse words into *feet*. There are two possibilities for a foot (Hayes, 1995, pp.69), listed in 14-

(14) **Moraic Trochee** $(\times\ .)$ $\underset{\smile\ \smile}{}$ $(\times)$ $\underset{-}{}$

where $\smile$ denotes a light syllable (CV), $-$ a heavy syllable and the grid mark $\times$ indicates the mora that gets the prominence in the foot. I assume that all non-light syllables in Telugu- VC, VV, CVC, CVCC, CVV, CVVC are heavy. Following Hayes (1995), I assume that metrical structure is derived in two steps- first, words are parsed into feet using moraic trochee. In the second step, prominence relations among feet are established using a metrical rule, as in 15-

(15) **End Rule (Left/Right)**

a. Create a new metrical constituent of maximal size on top of the foot structure.

b. Place the grid mark indicating head of the contituent in the leftmost/rightmost available position.

With this definition, assuming that words are parsed left-to-right, the metrical structures of a few example stem types are shown in table 32. I also assume that End Rule Left applies to calculate prominence at the word level.

			(×)	End Rule Left
			(× .)	Foot construction
LL	i	pani	⏑ ⏑	panulu 'works'
			(×)	
			(×)	
HL	ii	sākʃi	– ⏑	sākʃulu 'witnesses'
			(×)	
			(× .) .	
LLL	iii	kolimi	⏑⏑⏑	kolumulu 'forges'
			(×)	
			(× .) .	
LLL	iv	maniʃi	⏑⏑⏑	manuʃulu 'humans'
			(×)	
			(×)(× .)	
HLL	v	tommidi	– ⏑⏑	tommidulu '(sets of) nines'
			(×)	
			(×)(× .)	
HLŁ	vi	yōgini	– ⏑⏑	yōginulu 'female ascetics'
			(×)	
			(× .)(× .)	
LLLL	vii	parimiti 'limit'	⏑⏑ ⏑⏑	parimitulu 'limits'
			(×)	
			(× .)(× .)	
LLLL	vii	enimidi 'eight'	⏑⏑ ⏑⏑	enimidulu 'eights'

Table 32: Stress and Metrical structure

Notice that left-to-right word parsing using moraic trochee predicts all syllables that undergo harmony to be unstressed and all syllables that resist harmony to bear stress. All possible types of nominal stems are not shown in table 32 but it is clear that a foot-based analysis is an alternative way of accounting for the interaction between stress and harmony in this language. In trisyllabic LLL stems that show alternations in all non-initial syllables, such as, [kolimi] 'forge' (iii in table 32), moraic trochee predicts the second syllable to be footed but not prominent and the final syllable to be unfooted. One question that arises here is if this syllable forms a foot after the addition of the plural marker -/lu/ in [kolumulu]. The bimoraic trochee parsing algorithm would then predict primary stress on the initial syllable and secondary stress on the third syllable of the plural form /('⏑⏑)(ˌ⏑⏑)/. This structure would contradict the generalization that it is unstressed vowels that agree with a suffix vowel to the right. Since it is the stem vowel that changes to agree with the suffix vowel, the suffix does not form a foot with the final syllable in the LLL stem. This can also be taken to suggest that the suffix vowel in plural marker -/lu/ is stressed by itself.

Unlike the plural suffix, case-marking post-positions in example 13 seem to be able to form a trochaic foot with an unfooted stem syllable. This is one possible hypothesis to account for their alternation. Agreement between the vowel in post-positon and stem-final vowel is obligatory

when the post-position forms a foot with the stem vowel, as in [maniʃi] 'human' + /ku/ Dative is /maniʃiki/ 'human.Dat' and not /maniʃiku/ and similarly, /maniʃini/ 'human.Acc' but not /maniʃinu/. The trisyllabic stem [maniʃi] 'human' is parsed as /('⏑⏑) ⏑/ using the moraic trochee. The first two syllables form a trochaic foot and the third syllable is unfooted. Once the post-position is added, the stem final syllable can form a foot with the post-position, resulting in the structure /('⏑⏑)(,⏑⏑)/. This structure predicts secondary stress on the third syllable of the stem [maniʃi] by virtue of being the head of the second foot. The vowel in the unstressed post-position assimilates to the stressed head of the foot. The same is true of a bisyllabic stem with a heavy initial syllable such as [kāki] 'crow'- /kākiki/ 'crow.Dat', */kākiku/ and /kākini/ 'crow.Acc', */kākinu/ or a bisyllabic pronominal form such as [wāḍi] '3SM.oblique'- /wāḍiki/ '3SM.Dat', */wāḍiku/ and /wāḍini/ '3SM.Acc', */wāḍinu/. Here, the metrical structure of the stem, according to the moraic trochee is /('–) ⏑/. The initial heavy syllable forms a foot by itself and carries primary stress. The final light syllable is unfooted. It forms a foot with the post-position in /kākiki/ as /('–)(,⏑⏑)/. Again, parsing using moraic trochee predicts secondary stress on the stem-final vowel and the post-position to be unstressed in the same foot.

When the post-position cannot form a foot with a stem vowel, there is free variation. For example, in [gadi] 'room' /('⏑⏑)/, both syllables are footed and the initial syllable gets primary stress. With such stems, both /gadiki/ 'room.Dat' and /gadiku/ 'room.Dat' are possible[12]. Also, if the stem final vowel is any vowel other than /i/, there is free variation, for example, with [tala] 'head' and [ginne] 'container', both options are possible- /talaki/ or /talaku/, /ginneki/ or /ginneku/. In other words, alternation is only found with high stem-final vowels just as in suffix-triggered harmony in nouns. However, this pattern of harmony in post-positions differs from the patterns found in nominal and verbal stems in being left-to-right. So, the analysis of harmony proposed in sections 2 and 3 using SPREAD-L constraint cannot account for this pattern. But, if analysis of harmony were to reference feet, then perhaps there is a way to come up with a unified account of this pattern and the nominal and verbal patterns. I make note of this as an open issue.

4.2 Stem-internal harmony

In Telugu, there are many stems in which successive vowels are identical. This identity of non-initial stems vowels in monomorphemic lexical items (example 16) has been claimed to be due to vowel harmony (Babu, 1976).

(16) Agreement within stems

kalimi	'fortune'
cilipi	'silly'
teliwi	'intelligence'
urumu	'thunder'
moguḍu	'husband'
arudu	'rarity'
pidapa	'later/afterwards'
buḍaga	'bubble'
molaka	'plant'

In other words, this is equivalent to the claim that there is a static co-occurrence restriction at work in the lexicon. I tried to evaluate this using a sample of stems extracted from a

[12]Some speakers strictly prefer the harmonic forms even with these stems.

dictionary corpus[13]. Among trisyllabic LLL stems, stems with identical non-initial vowels (V_2 and V_3) are over-attested in the lexicon. The percentage of stems with identical V_2 and V_3 in the lexicon is 44.5%(620/1391) for nouns and %51(159/312) for verbs (Kolachina, 2012)[14]. Furthermore, many 'non-harmonic' (non-identical V_2 and V_3) stems have harmonic variants (example 17).

(17) Harmonic variants of stems

a.	bedaru	'fear'	beduru
	cedaru	'disturb'	ceduru
	kadalu	'move'	kadulu
	kasagu	'grind one's teeth'	kasugu
	paracu	'spread'	parucu
b.	kuriyu	'shower'	kuruwu
	oliyu	'peel'	oluwu
	taḍiyu	'drench'	taḍuwu
	bigiyu	'tighten'	biguwu
	kaliyu	'mingle'	kaluwu
c.	saraku	'commodity'	saruku
	sawati	'step-(mother)'	sawiti
	araṭi	'banana'	ariṭi
	buḍuta	'child'	buḍata
	munuka	'plunge'	munaka

In the LLL verbal stems in 17 a., the vowel /a/ in second syllable can change to /u/. This is unlike the patterns of harmony triggered by suffix in nominal and verbal stems where the vowel /a/ is always opaque. In the stems in 17 b., /i/ in second syllable can alternate with /u/. Note that most monomorphemic LLL verb stems in the language have the shape /CVCuCu/. The distribution of glides also seems to be dependent on vocalic context since the intervening glide is also affected by the spreading of backness. In the nominal stems in 17 c., the alternations are more complex. The vowel /a/ alternates with /u/, as in [saraku] ~ [saruku] as well as with /i/, in [sawati] ~ [sawiti]. Also, the vowel /u/ alternates with /a/ as in [buḍuta] ~ [buḍata]. This alternation is also found in suffix-triggered harmony in verbs. Another complication is that this optional stem harmony is not available in nominal stems of type /CV.Ci.Ca/, such as [moṭima] 'pimple' or [rawika] 'blouse'. These stems do not have a harmonic variant /CV.Ca.Ca/.

The optional pattern of harmony found in stems is similar to the suffix-triggered patterns of harmony accounted for in sections 2 and 3 in that the vowel that alternates is in an unstressed syllable- CV́.CV̲.CV. Unlike previous patterns, the trigger in this case is not a suffix vowel but a stem vowel.. In the examples discussed above, the trigger is always the final vowel. But, if this alternation is due to harmony, then in longer words, a vowel bearing secondary stress is predicted to cause alternation of an unstressed vowel to its left. I could find at least one such example in the dictionary. The /ĹLL̀L/ stem [animiti] 'inference' is a variant of Sanskrit [anumiti]. This is revealing because the vowel /u/ in unstressed second syllable changes to agree with the vowel /i/ on its right, which according to my analysis, carries secondary stress. It is perhaps possible to extend the analysis in sections 2 and 3 to this optional harmony pattern. But, I will not attempt this here and note this as an open problem for future work.

[13]A Telugu-English dictionary (Gwynn and Sastry, 1991), available in electronic format at `http://dsal.uchicago.edu/dictionaries/gwynn/`

[14]See relevant section in Appendix for more information.

4.3 Exceptional nouns

There is one set of nouns in which non-application of vowel harmony is not accounted for by the analysis proposed in section 2. These stems are shown in example 18.

(18) Lengthening final vowel to block harmony

i	guṇḍi	'button'	guṇḍīlu	'buttons'
ii	kurci	'chair'	kurcīlu	'chair'
iii	benci	'bench'	bencīlu	'bench'
iv	kiṭiki	'window'	kiṭikīlu	'windows'
v	giriwi	'mortgage'	giriwīlu	'mortgages'
vi	dōpiḍi 'robbery'	dōpiḍīlu 'robberies'		
vii	mārpiḍi 'alteration'	mārpiḍīlu 'alterations'		

Table 33: Exceptional bisyllabic nouns

The final syllable in bisyllabic stems example 18 (i)-(iii) is unstressed, yet the vowel in this syllable does not alternate in plural forms *[guṇḍulu], *[kurculu] or *[benculu]. Instead the final vowel is lengthened and protected from undergoing harmony. The same pattern in found in trisyllabic stems like (iv)-(v) where all three stem vowels are /i/. Previous work (Krishnamurti and Gwynn, 1985, pp.51), (Pingali, 1985, pp.105) claim that the final vowel in these stems is underlyingly long since these are borrowings (iii clearly from English). However, it is not true that stem-final /i/ in all borrowings is treated by speakers as long. For example, stem-final /i/ in the following borrowings from Sanskrit does change to /u/- [sākʃi] 'witness' plural [sākʃulu], [wiri] 'flower' plural [wirulu], [maniʃi] 'human' plural [manuʃulu]. Another speculation regarding the final /i/ in examples (ii)-(iii) is that speakers perceive them as long due to the preceding consonantal environment /c/. But, in a trisyllabic stem such as [tiwāci] 'carpet', the final vowel does alternate in the plural form [tiwāculu].

As for the trisyllabic stems (iv) and (v), one possible hypothesis is that the vowels in the stem, being identical form a plateau and there is faithfulness to this plateau in the plural form as claimed in previous work (Steriade, 2016). Plateau preservation would require all three vowels to undergo harmony in such stems. But, since the initial vowel bears primary stress /ĹLL/, it resists harmony. Lengthening the final vowel ensures that final vowel also carries stress (WSP outranks NONFINALITY in section 2) and hence, becomes opaque to harmony. As a result, the [+HI,-BK] plateau in the input is preserved. Comparing these stems to a trisyllabic harmony stem such as [kolimi] 'forge', plural [kolumulu] 'forges', this final vowel lengthening seems to apply only when the first vowel in the plateau is stressed. Interestingly, for some speakers, /ĹHL/ type stems can also have lengthening of final vowel (example 18 (vi)-(vii)). The other option for plural formation in these stems is- syncope of the final vowel and retroflex cluster formation as in [dōpiḍlu] 'robberies' and [mārpiḍlu] 'alterations'. As mentioned earlier, the syncope of the final vowel seems related to the final syllable being unstressed and the onset in the final syllable. But, it also perhaps depends whether the vowel spreads harmony to another stem vowel to its left. Since in stems (vi)-(vii), the vowel in the second syllable bears secondary stress and resists harmony, the final vowel can be syncopated. Compare this to the impossibility of syncope of final vowel in the plural form of [kolimi] 'forge', plural [kolumulu] 'forges', *[kolumlu]. In this stem, the feature [+BK] spreads to the vowel in the unstressed second syllable via the final vowel.

Most stems with such plateaus in the dictionary corpus are not countable and do not have plural forms, for example, [misimi] 'brilliance', [wiḍidi] 'accommodation', [niḍiwi] 'length', [timiri] 'numbness', [cikili] 'polishing', [wiriwi] 'abundance'.

5 Secondary stress: Experiment

In this section, I report a phonetic experiment to address the question- is secondary stress inferred based on the alternation pattern phonetically realized ? In other words, do the phonetic properties of a vowel change as a result of its occurrence in a position where it is predicted to carry secondary stress by the analysis ? The analysis of harmony in Telugu proposed in this thesis is predicated on the existence of secondary stress. As such, it would be useful to see if occurrence of a vowel in a secondary stress position has an effect on its phonetic realization[15]. I do this by comparing vowels across two contexts- the second syllable of a trisyllabic stem with a heavy initial syllable /HLL/ versus the second syllable of a trisyllabic stem with three light syllables /LLL/. In the first context, the vowel is predicted to carry secondary stress by the account of stress proposed in this thesis (/ḢL̀L/). In the second context, the vowel is predicted to be unstressed /ĹLL/. The hypothesis of this production experiment is as follows-

- The occurrence of a vowel in a secondary stress positon has an effect on its phonetic realization.

The basic structure of the experiment is to record native speakers utter verb stems and measure certain acoustic properties of vowels in the production data. The experiment has two sets of target items. One set of target items consists of /LLL/ stems with a vowel V_i in the second syllable. The second set of target items consists of /HLL/ stems with the same vowel V_i in the second syllable. Target items are all verbal stems selected from a dictionary corpus. It turned out that comparable target items are available only for the vowels /a/ and /i/. There are no /HLL/ stems with /u/ in the second syllable. The full set of target items used in the experiment are shown in table 34. One issue with the /HLL/ target items is that they are all instances of plausible compound verbs in which the initial heavy syllable is the first constituent of the compound and the rest is the second constituent[16]. So, it is unclear if stress on the second syllable in the trisyllabic stem is solely due to rhythmic structure or due to being the initial syllable of the second constituent of the compound. In hindsight, it would have been better to choose nominal stems from the experiment since in nominal stems, there is no such strong correlation between word shape and morphological compounding. Another issue about the target items is that all /LLL/ stems in the corpus with vowel /i/ in the second syllable end in /iyu/. These items complicate the measurement of phonetic properties of /i/ since it is followed by the front glide.

vowel	/LLL/ items	/HLL/ items
a	/karacu/, /kaḍacu/, /kalacu/ /maracu/, /maḍacu/, /malacu/	/kādanu/, /kharcawu/, /kōppaḍu/ /tōḍpaḍu/, /kimmanu/
i	/kiniyu/, /bigiyu/	/cippilu/, /siggilu/

Table 34: Target items in the experiment

Each of these target words is produced by the participants in a carrier phrase shown below. This carrier phrase was chosen because it allows the target word to be uttered in a neutral (non-focus) context.

- /telugulō <target> anna māṭaku reṇḍu art^{h}ālu./
  (In Telugu, the word <target> has two meanings.)

The experimental items were presented to the participants in psuedo-randomized order. The carrier phrase was not presented in the stimuli. The participants were given the carrier phrase

[15] In a number of languages, secondary stress has been shown to have no phonetic correlates though.

[16] More on distribution of vowels in non-initial syllables in Appendix.

at the beginning of the experiment and were asked to produce each target word in this context. There were 3 participants in the experiment- 2 male and 1 female. The recordings were all made in the phonetics lab at the department of Linguistics, MIT.

Measurements

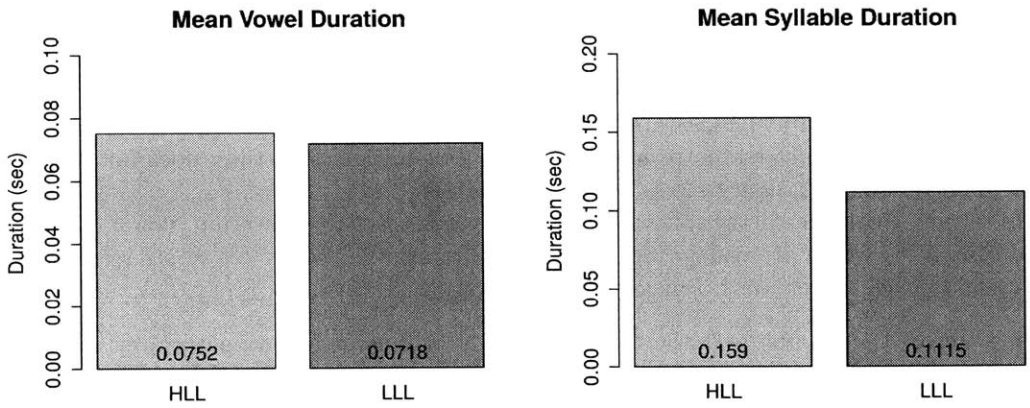
There is little clarity on what the exact acoustic correlates of primary stress in Telugu are. A preliminary study of /LLL/, /LLLL/ and /LLLL/ stems by Balusu (2001) reports syllable duration, vowel duration, median F_0 and F_0 range per vowel to be the most reliable cues of primary stress in this language. It is also reported that mean intensity, which is widely accepted as a cue to primary stress in many languages, is actually a bad cue in Telugu. But, this could be due to their comparison of mean intensity across non-identical vowels. Another issue with the target items of Balusu (2001) is that some of them are derived words, such as, [aramarika] 'reticence' (from [aramara]), [peḍasarapu] 'stubborn' (from [peḍasaram]). It is not clear how suffixes affects the overall stress pattern in the word. In addition, the study does not address the issue of correlates on primary stress on heavy syllables.

In this study, I considered the following basic properties- syllable duration, vowel duration and mean intensity which are widely reported in the literature as correlates of stress. For the medial vowel in each target word, I measured the following-

1. Duration of the syllable - if there is a geminate or cluster following the first vowel, I measure the second consonant in the cluster as onset of the second syllable.
2. Duration of the vowel
3. Mean intensity in the duration of the vowel

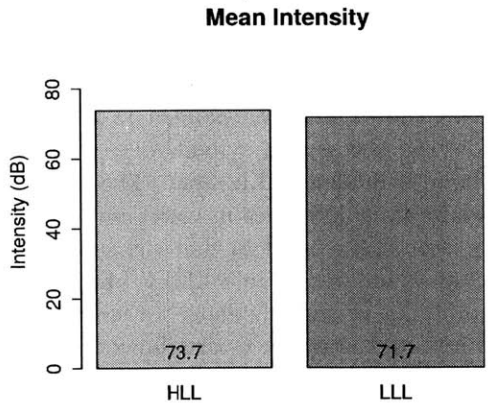
Results

The mean values of the three variables- vowel duration, syllable duration and mean intensity of the vowel in the second syllable are shown in the barplots in 4. The plots show that mean values of all three variables for the vowel in the second syllable of a HLL stem are higher compared to those of the vowel in the second syllable of LLL stem. The difference is highest in syllable duration (0.048 secs) (b), followed by the difference in vowel duration (0.034 secs) (a) and mean intensity (2 dB) (c). My analysis of stress predicts that the second syllable carries secondary stress in a HLL (/HL̀L/) stem, but is unstressed in a LLL (/LL̀L/) stem. If these differences in figure 4 turn out to be significant, they provide evidence for secondary stress inferred based on vowel alternations. The distribution of the variables are shown in the boxplots in figure 5. The bottom of the box represents the 25^{th} percentile, the middle line is the 50^{th} percentile (median) and the top represents the 75^{th} percentile. The whiskers show the range of values. Any values outside the range are shown as outliers. The boxplots show that the values of duration of vowel in unstressed position (/LL̲L/) are much more spread out compared to values in stressed position (/HL̲L/). There is little overlap between the range of values of syllable duration of a vowel in a stressed and an unstressed position. But, the range of values is comparable in the case of mean intensity. For all three variables, the median values show the same trend as the mean values in figure 4. The distribution can be further broken down by vowel. This is shown in figure 6. The differences due to stress are much clear in the case of the vowel /a/. One odd result about the distribution of values of duration of the vowel /i/ is that it is shorter in a stressed position (/HL̲L/) compared to an unstressed position (/LL̲L/). As mentioned earlier, the LLL target items with /i/ in the second syllable all end in /iyu/. The front glide following the vowel makes the measurement of duration difficult. But, with syllable duration and mean intensity, the same trend is found as with /a/- values are higher when the vowel is in a stressed positon compared to an unstressed position.



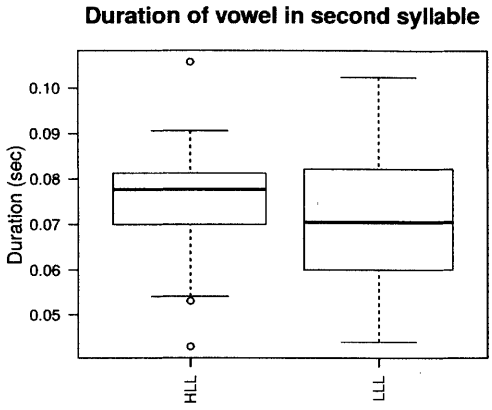
(a) Vowel duration

(b) Syllable duration

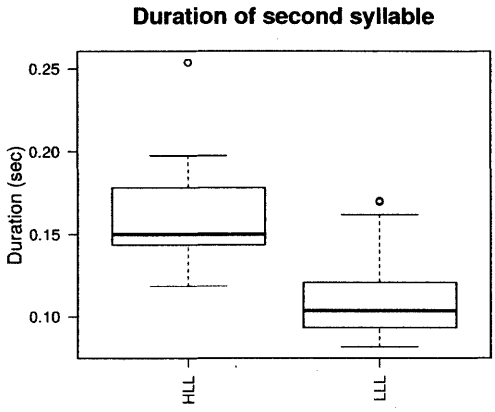


(c) Mean intensity

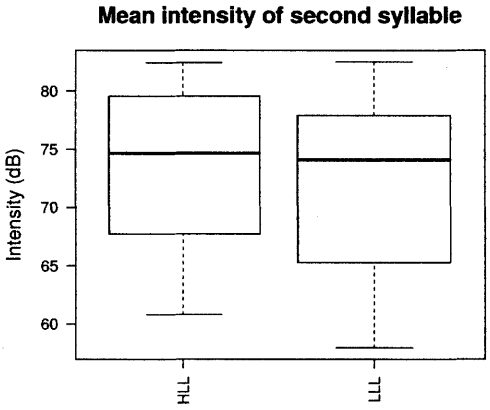
Figure 4: Comparison of phonetic properties vowels in stressed (/H$\underline{\text{L}}$L/) versus unstressed (/L$\underline{\text{L}}$L/) position



(a) Vowel duration

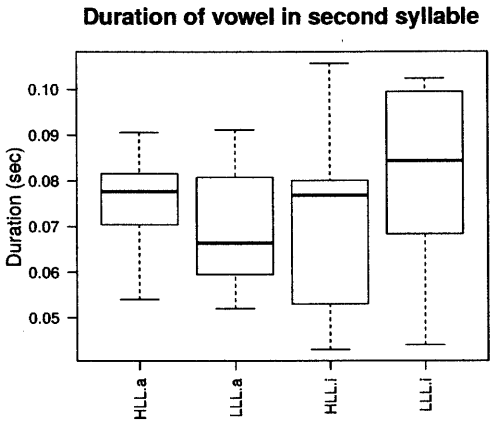


(b) Syllable duration

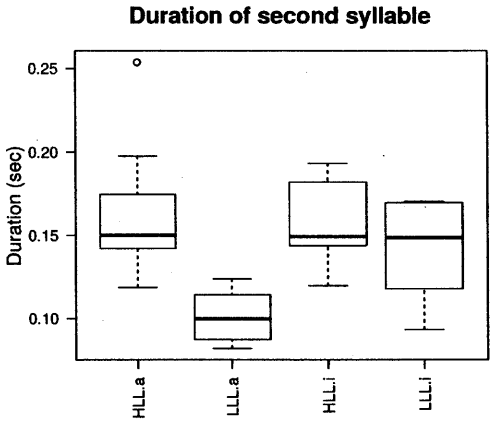


(c) Mean intensity

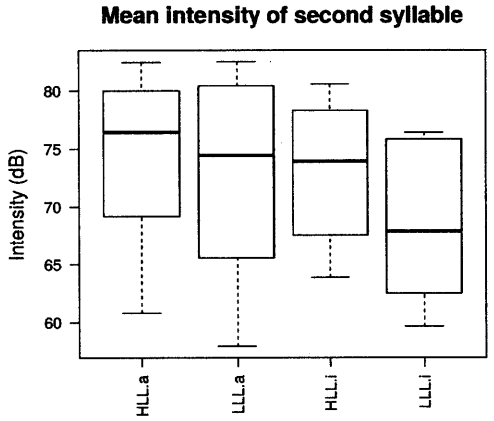
Figure 5: Comparison of distribution of variables



(a) Vowel duration



(b) Syllable duration



(c) Mean Intensity

Figure 6: Distribution by vowel

In order to check the significance of the differences between observed values, statistical analysis was performed by fitting linear mixed effect models to the data. I choose linear mixed effect models since they allow to control for random effects such as inter-speaker variation. I control for the effect of speaker-specific variation due to differences in vocal tract lengths or speech rates on the acoustic properties by including a random intercept corresponding to subject. The fixed effects in the statistical model are position (stressed /HLL/ versus unstressed /LLL/), the vowel and the interaction between them. I fit three models corresponding to the three response variables- vowel duration, syllable duration and intensity. The models were fitted using the *lmer* function from the *lme4 R* package (Bates et al., 2011).

In the model corresponding to vowel duration, the intercept has a value of 0.076 seconds for the base value of the vowel /a/ in a secondary stress position (/HLL/). The slope corresponding to the coefficient of stress is non-zero (−0.007) but this value is not significant since the p-value (0.29) is greater than 0.05. There is also no significant difference in the duration of /a/ versus /i/ in a secondary stress position. The coefficient of the interaction between position and harmony is -0.024 but the p-value is 0.08. So, the effect of interaction is also insignificant.

In the model corresponding to syllable duration, the intercept has a value of 0.16 seconds for the base value of the vowel /a/ in a secondary stress position. The value of the coefficient corresponding to position is -0.058 and this value is significant since $p = 0.02$. In other words, the duration of a syllable in a stressless position (LLL) is significantly lower than in a secondary stress position (HLL). The coefficient corresponding to the vowel has a value of -0.003 but is not signifcant since $p = 0.8$. In other words, there is no effect of vowel on length of the second syllable of trisyllabic stems. The value of the coefficient corresponding to the interaction between stress and vowel (0.04) is also significant ($p = 0.009$) in this model.

In the model corresponding to mean intensity of vowel, the intercept has a value of 73.95 for the base value of the vowel /a/ in a secondary stress position (/HLL/). In this model, the coefficient of the effects for secondary stress is non-zero (−1.137) but it is not significant ($p = 0.2$). Again, as before, the coefficient corresponding to vowel is not significant. However, there is a significant interaction effect between secondary stress and vowel. In other words, the difference between mean intensity of a vowel in a stress position and an unstressed position varies significantly between /a/ and /i/.

The conclusions of the experiment can be summarized as follows-

- The occurrence of a vowel in a secondary stress position has a significant effect on the duration of the syllable but not on the vowel duration or mean intensity.
- The difference in the duration of an open syllable in stressed versus unstressed position differs significantly if the vowel in the syllable is /i/ as opposed to /a/.
- The difference in mean intensity of a vowel in stressed versus unstressed position differs significantly across vowels.
- There is no significant effect of secondary stress on duration of vowel and mean intensity.
- It is plausible that the high values of duration of /i/ in a unstressed position (LLL) preceding a front glide /y/ obscure the effects of secondary stress on vowel duration and intensity. Experiment must be repeated with different target items with nouns where there is no such restriction in the lexicon.
- The onset consonant in the second syllable in the two sets of target items are not identical. This obscures the effect of secondary stress on syllable duration. Experiment must be repeated controlling for this, if necessary with nonce words.

6 Conclusions and Future work

This thesis reports a study of different patterns of vowel harmony in Telugu. The main factual generalizations discovered in this study are as follows-

1. Telugu has secondary stress on alternate moras starting from primary stress unless it is final. An alternate statement of this generalization is that stress in Telugu is assigned based on left-to-right word parsing using a bimoraic trochee.

2. Only unstressed vowels in nominal and verbal stems and a few nominal post-positions undergo harmony.

3. There is resistance to harmony in all contexts in which the vowel is in a stressed syllable.

4. The trigger for alternation is always an adjacent stressed vowel.

   - Stem vowels alternate to agree with a stressed vowel in a suffix to the right.
   - Vowels in post-positions alternate if they form a foot with the final vowel of the stem. They agree with the stem-final vowel since it is the head of the foot they are contained in.

5. The direction of harmony depends on the relative position of the stressed trigger vowel and the stressless vowel that undergoes harmony. It is left-to-right when a suffix vowel is the trigger and a stressless stem vowel undergoes harmony. It is right-to-left when a stressed stem vowel is the trigger and a stressless vowel in the post-position undergoes harmony.

6. The quality of alternation is a function of the type of morphemes. In purely inflectional suffixes, such as the plural marker in nouns, tense morphemes in verbs, and case-marking post-positions, there is only /i/-/u/ alternation. But, with derivational suffixes such as the causativizing and nominalizing suffixes, there are /u/-/a/ and /u/-/i/ alternations.

7. Secondary stress in Telugu is phonetically real in the sense that the duration of a syllable in a secondary stress position (/H$\underline{\text{L}}$L/) is significantly higher than in a unstressed position (/L$\underline{\text{L}}$L/).

I show that the different kinds of stress and harmony patterns in nominal and verbal stems can be derived using a common analysis. There are a number of unresolved issues in the analysis of the alternations. The exact implementation of the harmony constraint in OT that can account for all the patterns of alternation is not yet clear. One specific issue is whether the analysis of harmony needs to be foot-based, as the data on alternating post-positions suggest. The optional availability of harmonic variants in trisyllabic stems consisting of three light syllables is another open problem. Similarly, the effect of vowel alternations on neighboring glides is not accounted for by the analysis in this thesis. The derivation of directionality of the harmony constraint is also an open problem. This thesis raises all these questions which if addressed in future work, will give further insight into the properties of the typologically rare stress-based harmony.

Appendix: Telugu phonology

In this appendix, I give a brief sketch of the phonology of Telugu. It contains many details that are relevant background to the discussion in this thesis. I present a detailed corpus-based study of the application of vowel harmony.

Vowels

Telugu, like most Dravidian languages, inherited a vowel system comprised of five vowels with contrastive length- /i ī e ē a ā o ō u ū/ from Proto-Dravidian (Krishnamurti, 2003, pp.52). In addition, it has the front low /æ:/ and the diphthongs /ai au/.

i ī		u ū
e ē		o ō
	æ:	
	a ā	
ai		au

Table 35: Telugu vowel system

I extracted the distributions of these vowels in the lexicon using a dictionary corpus of Telugu[17]. In the word-initial position, all long and short vowels are found, as shown by the examples in table 36.

/i/	iruku	'narrowness'
/ī/	īḍucu	'drag'
/e/	eduru	'front'
/ē/	ēnugu	'elephant'
/a/	arise	'rice cake'
/ā/	āwiri	'steam'
/o/	ottiḍi	'pressure'
/ō/	ōpika	'stamina'
/u/	uniki	'existence'
/ū/	ūpiri	'breath'

Table 36: Vowels in word-initial position

All words in Telugu end in vowels. In the word-final position in polysyllabic mono-morphemic words, the vowels /i ī e a ā u/ are found, as shown in table 37. The round mid-vowels /o ō/ do not occur in the word-final position in mono-morphemic native words[18]. Monosyllabic function words like the disjunctive marker (-ō) and the locative case-marking post-position (lō) contain the vowel /ō/ and hence, words to which these morphemes are attached can have this vowel in the final syllable. Similarly, the vowel /ē/ is also not found in the final syllable in non-derived polysyllabic words, but is found in monosyllabic function words like the focus-marking morpheme (-ē). The long high back vowel /ū/ is also not found in the final syllable in non-derived polysyllabic words. In Telugu, final vowel lengthening is a marker of conjunction and additive focus (similar in meaning to English 'also'). As such, the long /ū/ shows up in the final position in words ending in /u/ when they are marked by this conjunctive affix, for example, [kālū kaḍupū] 'leg ([kālu]) and stomach ([kaḍupu])'. This kind of lengthening due to conjunction or emphasis also applies to /i e a/ in the word-final position.

[17] A Telugu-English dictionary (Gwynn and Sastry, 1991), available in electronic format at `http://dsal.uchicago.edu/dictionaries/gwynn/`

[18] There is one word with final /ō/ in the dictionary- [bāḍak^{h}ō] 'cheat', possibly a borrowing from Perso-Arabic.

/i/	ariṭi	'banana'
/ī/	buriḍī	'trickery'
/e/	guḍise	'hut'
/ē/	n/a	
/a/	tondara	'haste'
/ā/	saradā	'pleasure'
/o/	n/a	
/ō/	n/a	
/u/	kaḍupu	'stomach'
/ū/	n/a	

Table 37: Vowels in word-final position

In word-internal syllables, all five short vowels occur as shown by the examples in table 38. Most words in which mid-vowels /e o/ are found in an internal syllable seem to be morphologically complex. They are derived from morphemes in which the mid-vowel is in the initial position in the second constituent. For example, the word [temmera] 'zephyr' is derived from the morphemes [temma] 'moist' and [era] ('wind' from Proto-Dravidian (PDr))[19]. Similarly, the word [dākkonu] is derived from the morphemes [dāgu] 'to be concealed' and [konu] verbal reflexive. Thus, in mono-morphemic words, only /i u a/ occur in word-internal syllables. All five long vowels /ī ē ā ō ū/ occur in word-internal syllables. However, the distribution of long vowels in word-internal syllables is similar to that of mid-vowels /e o/ in that most words with a long vowel in a word-internal syllable are compounds which are not necessarily transparent, e.g., [pannīru] 'cold water/rose water' is [pan] ('dew' from PDr *pani) + [nīru] 'water', [selayēru] 'hill stream' is [sela] ('hole/crack'? from PDr) + [ēru] 'stream', [kāpāḍu] 'save' is [kāpu] 'guard' + [āḍu] 'play', [wāpōwu] 'lament' is [wā] (interjective indicating disapproval) + [pōwu] 'go' and [cēyūta] 'helping hand' is [cē] 'hand' + [ūta] 'support'[20]. Long vowels also occur in word-internal syllables in words of Sanskrit origin such as [ajēya] 'undefeatable', [prak^{h}yāta] 'famous', [asūya] 'jealousy' and Perso-Arabic borrowings such as [kaṭōra] 'steel bowl', [wakīlu] 'lawyer' and [galīju] 'dirty, impure'.

/i/	angili	'palate'
/ī/	pannīru	'rose water'
/e/	temmera	'zephyr'
/ē/	selayēru	'hill stream'
/a/	kaḍali	'sea'
/ā/	kāpāḍu	'save'
/o/	dākkonu	'hide'
/ō/	wāpōwu	'lament'
/u/	tarucu	'stir'
/ū/	cēyūta	'helping hand'

Table 38: Vowels in word-internal positions

Long vowels occur in consecutive syllables mostly in words of Sanskrit origin and borrowings from Perso-Arabic, e.g., [ākāsamu] 'sky' (from Skt. [ākāʃa]), [pārāṇi] 'red dye used in bridal make-up' (Skt.), [darōgā] 'superintendent' (Persian), [tamāʃā] 'joke' (Persian). In native words, consecutive long vowels are found in a few bisyllabic stems, such as [kājā] 'a kind of sweet', [pōṭī] 'contest', [ārā] 'clue/trace', [pēcī] 'contention'. In words with more than two syllables, consecutive long vowels indicate that the word is a compound derived from other morphemes.

[19]The /a + e/ hiatus context at the morpheme boundary is resolved by eliding the first vowel.

[20]The /ē + ū/ hiatus context at the morpheme boundary is resolved by inserting glide /y/.

Some examples of this type are shown in table 38- [kāpāḍu] 'save', [wāpōwu] 'lament' and [cēyūta] 'helping hand'. With consecutive long vowels, there do not seem to be any restrictions based on vowel quality. In other words, a long vowel can be followed by any of the five long vowels.

The diphthongs /ai au/ both occur in the initial syllable as shown in table 39. In the word-final position, only /ai/ is found, mostly in native words. Both diphthongs occur word-internally, and /ai/ is much more frequent compared to /au/. As in the case of long vowels, words with diphthongs in internal syllables are morphologically complex although the structure might be non-transparent. In other words, the only position in which both diphthongs occur in non-derived words is the initial syllable. In general, diphthongs in initial and word-internal syllables are found mostly in words of Sanskrit origin or Perso-Arabic borrowings. In some varieties of the language and for some speakers, a dipthong in a non-final syllable, is substituted by a long mid-vowel, e.g, [ēkamatyamu] 'unity' instead of [aikamatyamu], [adwētamu] 'non-dualism' instead of [adwaitamu], [ōcityamu] 'appropriateness' instead of [aucityamu] and [bōdd^{h}amu] 'Buddhism' instead of [baudd^{h}amu].

	word-initial	word-final	word-internal
/ai/	kaiwalyamu 'enlightenment'	rūpai 'rupee'	samaikyata 'unity'
	tailamu 'oil'	tomb^{h}ai 'ninety'	adwaitamu 'non-dualism'
	k^{h}aidi 'prisoner'	irawai 'twenty'	wagairā 'etcetera'
/au/	aucityamu 'appropriateness'	n/a	sārwabhaumyamu 'emperorship'
	baudd^{h}amu 'Buddhism'		akʃauhiṇi 'large army'
	pauruḍu 'citizen'		asaukaryamu 'inconvenience'

Table 39: Diphthongs in different positions

As for the distribution of /æ:/, it is found in initial syllables of lexical items, for example, [mæ:ka] 'goat', [ḍæ:ga] 'falcon'. Krishnamurti and Gwynn (1985) claim that /ē/ in initial syllable of lexical items is realized as /æ:/ when followed by /a/. It is also found in the past tense forms of verbs, for example, 3SM past tense form of [pāḍu] 'sing' is pāḍæ:ḍu. The /æ:/ in this context is of central importance in identifying the underlying representation of verb stems. In section 3, I show that the presence or absence of /æ:/ in the past forms of a verbal stem is an important diagnostic to whether or not it shows vowel harmony alternations. Additionally, /æ:/ is found word-finally when the yes-no question marker -/ā/ is suffixed to words ending in front vowels, e.g., guḍi 'temple' + ā is guḍæ: 'Is it a temple?', ginne 'container' + ā is ginnæ: 'Is it a container?'. Wilkinson (1974) describes this distribution of /æ/ as fronting of back vowels when preceded by /i/ at morpheme boundaries. The correct characterization of this distribution, however, is the coalescence of front vowels with back unrounded[21] /ā/ in hiatus contexts at morpheme boundaries.

Consonants

The consonant inventory of Telugu is shown in table 40. Voicing in consonants is contrastive in Telugu. Aspirated stops are found only in words of Sanskrit origin. In addition, borrowings from Sanskrit into Old Telugu added the sibilants /ʃ ṣ/ to the inventory. The phoneme /f/ is a recent addition to the inventory due to English and Perso-Arabic loanwords (Krishnamurti, 2003, pp.55). All consonants except /ṇ ḷ/ occur word-initially.

Consonant clusters of the type /Cr/ where C is one of /p b b^{h} t d k g s ʃ/ can occur word-initially. Most words with this type of word-initial cluster are of Sanskrit origin. In the dictionary corpus, there are very few native words which have the clusters /pr br tr kr mr

[21] In hiatus contexts involving long round /ō/, there is V_1-elision rather than coalescence, guḍi 'temple' + ō 'disjunctive' is guḍō 'temple or ..'.

	Labial	Dental	Alveolar	Palatal	Retroflex	Velar
Stops	p p^h	t t^h		c c^h	ṭ $ṭ^h$	k k^h
	b b^h	d d^h		j j^h	ḍ $ḍ^h$	g g^h
Fricative	f		s	ʃ	ṣ	h
Nasal	m	n			ṇ	
Lateral			l		ḷ	
Flap			r			
Glide	w			y		

Table 40: Telugu consonants

wr/ word-initially, for example, [proddu] 'dawn', [bratuku] 'live', [truncu] 'nip off', [krungu] 'shrink', [mraggu] 'perish' and [wrēlu] 'finger'. All these words have variants in which the /r/ is dropped- [poddu] 'dawn', [batuku] 'live', [tuncu] 'nip off', [kungu] 'shrink', [maggu] 'perish' and [wēlu] 'finger'. When this cluster is word-internal, the following clusters are also possible- /ḍr ṭr/. There are few words of Sanskrit origin in which the cluster /str/ is found. The sibilant-coronal stop cluster is actually homo-organic since in word-internal positions, when the coronal is retroflex, the sibilant also has to be retroflex /ṣṭr/. The only consonants that can occur in the coda position in syllables are the nasals /m n ṇ/ and the laterals /r l/. Nasal codas are homo-organic to the onset of the following syllable drawn from the following set- /p b t d ṭ ḍ k g/. In addition, the nasal /n/ can be followed by /s w y/ in words of Sanskrit origin. Lexical items in which lateral consonants /r l/ occur as codas are transitive variants of verbal stems, e.g. [kudurcu] 'arrange (tr.)' from [kuduru] 'arrange (itr.)', [kālcu] 'burn (tr.)' from [kālu] 'burn (itr.)'. The cluster /rc/ is also found in a few borrowings, such as [mirci] 'chilli pepper', [kurci] 'chair', [carca] 'discussion'. The following consonants can be long, following a short vowel- /p b m t d n ṭ ḍ ṇ c j k g s l ḷ r w y/. After a long vowel, the following consonants can be long- /p b m t n ṭ ṇ c j k g s l ḷ w/. Geminates following long vowels are mostly found in words of Sanskrit origin. In native words, a geminate after a long vowel indicates a morpheme boundary. In plural forms of some nominal stems with more than two syllables, if the onset of the final syllable is /ṭ ḍ/, there is formation of the retroflex clusters /ṭḷ ḍḷ/ at the boundary between the stem and the plural suffix -/lu/, for example, [tampaṭi] 'fire used for roasting', plural [tampaṭḷu] and [muṭṭaḍi] 'siege', plural [muṭṭaḍḷu]. Similarly, if the onset of the final syllable of a nominal stem with more than two syllables is /r l/, there is a /ḷḷ/ cluster at the morpheme boundary, such as [pandiri] 'marquee', plural [pandiḷḷu] and [angili] 'palate', plural [angiḷḷu].

Minimal word requirement

In Telugu, the majority of content words are at least disyllabic. There are very few content words, such as /strī/ 'woman', /lē/ 'get up (short of imperative form)', /rā/ 'come (short of imperative form)' which are monosyllabic with a long vowel. Most function words are monosyllabic with a long vowel, for example, /ī/ 'this', /ā/ 'that', /ē/ 'which', /nā/ 1S.Genitive, /mā/ 1P.Genitive, /nī/ 2S.Genitive, /mī/ 2P.Genitive, etc. The only function words that consist of only one light syllable are the case-marking post-positions, such as /ku/ 'Dative', /nu/ 'Accusative', /to/ 'Associative'[22]. This minimal word requirement of at least two syllables has not been recognized hitherto probably because it is obscured by the morphology. The citation forms of verb stems are identical to their imperative forms and always end with /u/ as shown in examples (i-v) in table 41. Previous work such as Pingali (1985), treats the /u/ as the imperative morpheme and these stems to be monosyllabic. Based on the same reasoning, stems

[22]Recall from the examples in section 4 that these post-positions have allomorphs based on the final vowel of the stem.

like [kaḍugu] (vi in table 41) which show vowel harmony alternations are treated as disyllabic (CVCVC). But, nouns which show vowel harmony alternations such as (viii) and (ix) in table 41 are trisyllabic. The analysis of Pingali (1985) addresses this difference between verbs and nouns with respect to vowel harmony by stipulating different underlying representations (URs)- CVCVC for verbs and CVCVCV for nouns. In section 3, I discuss the morphological analysis of the verbal forms and present two different kinds of evidence that argue against this difference in URs of nouns and verbs. One of the salient features of the analysis proposed in this thesis is that it derives the harmony facts with a unified analysis that treats both nouns and verbs alike.

i	tinu	eat
ii	tʃampu	kill
iii	lāgu	pull
iv	duwwu	comb
v	saddu	arrange
vi	kaḍugu	wash
vii	marugu	boil (itr.)
viii	koliki	hook
ix	koriwi	firebrand

Table 41: Verbal stems in Telugu

Enunciative vowel

Another confound regarding the underlying representations of stems is the issue of enunciative vowel. As mentioned earlier, all words in Telugu must end in a vowel. When a borrowing from Sanskrit or English ends in a consonant, such as [prayāṇam] 'journey' (Skt.) or [bas] 'bus' (Eng.), a vowel /u/ is inserted word-finally- [prayāṇamu] and [bassu]. Note that other changes may accompany the addition of this final /u/ such as gemination of the sibilant in [bassu][23]. This /u/ is added word-finally for 'euphonic' purposes and presumably, is not part of the underlying representation of these stems. However, there are native stems in which /u/ does occur in the final position, such as [g^{h}āṭu] 'pungent' and [pappu] 'kernel'. Bright (1972) claims that the enunciative vowel is phonetically weaker in comparison to a vowel that is underlyingly present. In languages like Malayalam and Tulu, this difference is also revealed in hiatus contexts where an enunciative vowel is elided but a vowel that is underlyingly present is preserved. In Telugu, it is not clear if this diagnostic is relevant since at first glance, all short vowels in hiatus contexts seem to undergo V_1-elision. In section 3, I present /æ:/-formation as a test to diagnose whether a vowel is part of the underlying representation or not. Another interesting observation regarding the enunciative vowel is that its elision in hiatus contexts is more acceptable in words with more than two syllables such as [prayāṇamu] compared to words like [bassu], for example, /prayāṇamu elā jarigindi ?/ 'How was the journey?' could be uttered /prayāṇamelā jarigindi ?/ in fast speech, but /bassu ekkaḍa undi ?/ 'Where is the bus?' cannot be /*bassekkaḍa undi ?/ This indicates that insertion of the enunciative vowel in monosyllabic loanwords could also be to satisfy the minimal word requirement.

Distribution of non-initial vowels in trisyllabic stems

A recurrent claim in previous work (Wilkinson, 1974; Pingali, 1985; Kissock and Dworak, 2009) is the notion that vowel harmony alternations in Telugu are due to phonetic underspecification

[23]Crosslinguistically, the enunciative vowel is one of the vowels in the inventory of the language. In Tamil, Malayalam, Tulu and certain dialects of Kannada, the enunctive vowel is /i/ (Bright, 1972).

of non-initial vowels in stems. This is equivalent to the claim that non-initial vowels are all identical. If underspecification is partial, there is at least a static co-occurrence restriction at work in the lexicon. I tried to evaluate these claims using a sample of stems extracted from the dictionary. In order to check restrictions on co-occurence of vowels in non-initial positions, the stems in the sample should contain at least two non-initial vowels. I extracted trisyllabic nouns and verbs from the dictionary corpus and counted vowel occurrences in the second and third syllables. These frequencies are shown in tables 42 and 44.

	a	ā	e	ē	i	ī	o	ō	u	ū	total
a	0	0	0	0	0	0	0	0	146	0	146
ā	0	0	0	0	0	0	0	0	47	0	47
e	0	0	0	0	0	0	0	0	20	0	20
ē	0	0	0	0	0	0	0	0	22	0	22
i	0	0	0	0	0	0	0	0	363	0	363
ī	0	0	0	0	0	0	0	0	0	0	0
o	0	0	0	0	0	0	0	0	27	0	27
ō	0	0	0	0	0	0	0	0	7	0	7
u	0	0	0	0	0	0	0	0	223	0	223
ū	0	0	0	0	0	0	0	0	6	0	6

Table 42: Vowel co-occurrence frequencies in non-initial syllables in trisyllabic verb stems

In verbs, the final vowel is always /u/. Stems of type C*V_1C*aC*u (146) and C*V_1C*iC*u (363) are comparable in frequency to stems of type C*V_1C*uC*u (223). At first glance, these numbers suggest that there is no restriction on co-occurrence on non-initial vowels in stems. However, some stems of the type C*V_1C*aC*u and C*V_1C*iC*u have a C*V_1C*uC*u variant, such as [nalagu] ~ [nalugu] 'crush/powder (tr.)', [toḍagu] ~ [toḍugu] 'clothe/dress (tr.)', [taragu] ~ [tarugu] 'diminish (itr.)/cut (tr.)', [jaḍiyu] ~ [jaḍuwu] 'fear (itr.)/hinder (tr.)', [wiriyu] ~ [wiruwu] 'crack open (itr./tr.)', [puliyu] ~ [puluwu] 'ferment (itr.)'. One feature common to all these stems with variants is that they are sequences of light syllables. Stems of type C*V_1C*uC*u show harmonic alternations in their paradigms. A manual inspection of stems of this type reveals a curious similarity to the free variation found in C*V_1C*aC*u and C*V_1C*iC*u stems- C*V_1C*uC*u that show harmonic alternations in their paradigms are necessarily sequences of light syllables. Similarly, variant forms of C*V_1C*aC*u and C*V_1C*iC*u stems such as the ones listed above also show alternations in their paradigms. Trisyllabic verbal stems with /i/ or /a/ in second syllable with a heavy initial syllable neither have a harmonic variant nor do they show alternations in their paradigms, for example, [kimmanu] 'to say something in response' (*[kimmunu]), [lōbaḍu] 'succumb (itr.)' (*[lōbuḍu]), [aṇṭagu] 'defile (itr.)' (*[aṇṭugu]), [cūpincu] 'show' (*[cūpuncu]), [wāṭillu] 'befall' (*[wātullu]), [cējikku] 'to be caught' (*[cējukku]). Likewise, if a C*V_1C*uC*u stem has a heavy initial syllable, such as in [pastuṇḍu] 'fast', [tonguṇḍu] 'sleep' or [wākruccu] 'speak'(from Skt.), it does not show alternations in its paradigm. So, a verb must be a sequence of light syllables if it has to either have a harmonic variant or show alternations in its paradigm. It could be argued that these exceptional stems are morphologically derived- [kimmanu] is [kimmu] (meaning unknown) + [anu] 'say', [lōbaḍu] is [lō] (meaning unknown) + [paḍu] 'fall', [aṇṭagu] is [aṇṭu] 'impurity' + [agu] 'become' [cūpincu] 'show' is [cūpu] 'sight' + [incu] causative, [wāṭillu] 'befall' is [wāṭu] 'force' + [illu] (meaning unknown) and *[cējikku] 'to be caught' is [cē] 'hand' + *[cikku] 'tangle', but they are non-transparent compounds as some of the constituent morphs are no longer meaningful in the language. There are also a number of trisyllabic verbal stems in which the vowel in the second

syllable is either long (except /ī/) or a short mid-vowel /e o/. As mentioned earlier, stems with long vowels in an internal syllable are compounds derived from smaller morphemes. Some examples are shown in table 43. Again, all these stems involve a heavy initial and they neither have a harmonic variant nor do they show alternations in their paradigms. Until the relationship between morphological structure and metrical structure is clearly established, there are two kinds of generalizations here that speakers can arrive at- one that only those verb stems that are sequences of light syllables show harmony and the vowel following a heavy syllable is immune to harmony, and the other that verb stems that are exceptions to harmony involve some kind of (non-transparent) morphological structure.

medial vowel	stem	segmentation
āC*u	pōrāḍu 'fight (tr.)'	pōru 'quarrel' + āḍu 'play'
eC*u	kowwekku 'to become arrogant'	kowwu 'fat' + ekku 'climb'
ēC*u	tōsēyu 'push (tr.)'	tōsi 'shove' + ēyu 'throw'
īC*u	n/a	
oC*u	mēlkonu 'wake up'	mēlu 'wake (tr.)' + konu verbal reflexive
ōC*u	kōlpōwu 'lose'	kōlu 'seize?' + pōwu 'go'
ūC*u	cēkūru 'accrue'	cē 'hand' + kūru 'stuff/pack'

Table 43: Verb stems with morphological structure

In nouns, the co-occurrence of non-initial vowels is less restricted in that all vowels except /ē o ō ū/ occur in the final position. The percentage of nominal stems in which non-initial vowels are identical is 38.32 (1262/3293). This is much higher than the percentage of verbal stems with identical non-initial vowels (25.93). Among nominal stems of type $C^*V_1C^*aC^*\bar{a}$ in the lexicon, some are borrowings from Sanskrit/Indic, such as, [mudarā] 'remission', [āsarā] 'shelter', some are Perso-Arabic borrowings like [gābarā] 'fright', [dāk^{h}alā] 'proof' and some are native stems, such as [cekaḍā] 'cart', [biraḍa] 'cork', [gāwancā] 'piece of cloth'. None of these show alternations in their plural forms nor do they have any variant forms. Most stems of the type $C^*V_1C^*aC^*i$ contain a heavy initial syllable, e.g., [kūṭami] 'union/society', [tampaṭi] 'fire for roasting', [muṭṭaḍi] 'siege/assault'. These stems do not have a harmonic variant, *[kūṭimi], *[tampiṭi] and *[muṭṭiḍi]. The final /i/ in these stems changes to /u/ in plural forms such as in [kūṭamulu] 'unions' unless the onset in the final syllable is not one of /ḍ ṭ l r/ in which case it undergoes syncope and a retroflex cluster is formed, as in [muṭṭaḍlu] 'sieges' or [tampaṭlu] 'fires'. There are also quite a few (49) $C^*V_1C^*aC^*i$ stems which are sequences of light syllables, such as, [araṭi] 'banana', [sawati] 'step-(mother)', [korawi] 'firebrand', [wirati] 'break', [nemali] 'peacock', [maradi] 'brother-in-law', [yuwati] 'young woman', [sudati] 'beautiful woman'. Many of these stems have a harmonic variant listed in the dictionary corpus- [ariṭi] 'banana', [sawiti] 'step-(mother)', [koriwi] 'firebrand', [maridi] 'brother-in-law' and all of them show alternations in their plural forms. It is unclear if stems of Sanskrit origin like [yuwati] 'young woman', [sudati] 'beautiful woman', [sumati] 'good sense', [walati] 'clever woman' have a harmonic variant. Note that all these stems have a common ending. Among stems of type $C^*V_1C^*aC^*u$, there are items which have a heavy initial syllable such as [jālaru] 'mesh', [kōḍalu] 'daughter-in-law', [singaḍu] 'gypsy', and items which have a heavy second syllable such as [uṭanku] 'clever person', [edarpu] 'kind of loan' [24], [wipattu] 'calamity' and items in which both first and second syllables are heavy such as [antastu] 'position/stature', [tākaṭṭu] 'mortgage', [samsattu] 'meeting'. These do not have harmonic variants, in other words, the second vowel in these stems cannot change to

[24]There are many verbs ending in -/pu/ which is a nominalizing suffix in Telugu. So, these could all be derived stems although the morphological structure is non-transparent.

/u/. On the other hand, if a C*V$_1$C*aC*u stem is a sequence of light syllables, then it has a harmonic variant, such as [parapu] ~ [parupu] 'mattress', [ceraku] ~ [ceruku] 'sugarcane', [tagawu] ~ [taguwu] 'dispute'. There are exceptions to this free variation- stems ending in /lu/ such as [molalu] 'piles', [hoyalu] 'charm', [haḍalu] 'fright' do not have a harmonic variant. All these stems are probably plural forms of bisyllabic stems which are no longer meaningful in the language.

	a	ā	e	ē	i	ī	o	ō	u	ū	total
a	481	50	1	0	387	13	0	0	250	0	1183
ā	62	42	1	0	200	21	0	0	167	0	493
e	56	0	2	0	5	0	0	0	19	0	82
ē	14	9	0	0	7	3	0	0	32	0	65
i	234	12	28	0	190	34	0	0	57	0	555
ī	14	3	0	0	13	0	0	0	48	0	78
o	0	0	0	0	3	0	0	0	1	0	4
ō	14	6	1	0	25	5	0	0	15	0	66
u	94	14	0	0	54	1	0	0	547	0	711
ū	8	3	0	0	20	4	0	0	21	0	56

Table 44: Vowel co-occurrence frequencies in non-initial syllables in trisyllabic noun stems

Most nominal stems of type C*V$_1$C*āC*V$_3$, which contain /ā/ in the second syllable, are either borrowings from Sanskrit/Indic and Perso-Arabic, or compounds derived from smaller morphemes. A large fraction of stems of this type end in /i/ (200/493) and /u/ (167/493). None of these stems have harmonic variants in which V$_2$ and V$_3$ are identical, for example, [tupāki] 'gun' (*[tupiki]), [guḍāru] 'tent' (*[guḍuru]). Stems ending in /i/ show alternations in their plural forms regardless of whether the initial syllable is heavy or light, such as in [tupākulu] 'guns' and [cinnāri] 'kid', plural [cinnārulu] 'kids'. This shows that the vowel in a light syllable following a heavy syllable is not preserved if it is in the final position.

All nominal stems of type C*V$_1$C*eC*V$_3$ involve a heavy initial syllable, for example, [duwwena] 'comb', [kattera] 'scissors', [jalleḍa] 'sieve', [pukkeḍu] 'mouthful', [tāyettu] 'amulet', [panneṇḍu] 'twelve', [munjeyyi] 'forearm', [pērneyyi] 'solidified ghee', [necceli] 'close friend', [mōceyyi] 'elbow', [lōceyyi] 'palm'. None of these stems have a harmonic variant. Also, none of the C*V$_1$C*eC*i show alternations in their plural forms- [duwwenalu] 'combs', [katteralu] 'scissors', [jalleḍalu] 'sieves', [neccelḷu] 'close friends'[25]. As mentioned earlier, all these stems with /e/ in the second syllable are morphologically complex, for example, [duwwena] is derived from [duwwu] 'comb (v.)', [kattera] 'scissors' from [katti] 'knife', [munjeyyi] 'forearm' from [ceyyi] 'arm', [necceli] 'close friend' from [celi] 'friend'. Stems of type C*V$_1$C*ēC*V$_3$ also never have a harmonic variant. Stems with final /i/ show alternations in their plural forms, as in, [triwēni] 'confluence of three streams', plural [triwēnulu].

There are very few (4) stems of type C*V$_1$C*oC*V$_3$. All of them involve a heavy initial syllable and do not have any harmonic variants. If a stem has final /i/, it changes to /u/ in its plural form, as in, [kowwotti] 'candle' (compound of [kowwu] 'wax/fat' and [otti] 'wick'), plural [kowwottulu]. Most stems of type C*V$_1$C*ōC*V$_3$ are either borrowings, such as [namōdu] 'entry', [langōṭi] 'loin cloth' or morphologically complex, such as, [cēdōḍu] 'help' (from [cē] 'hand' and [tōḍu] 'support'). Again, when a stem of this type has a final /i/, it changes to /u/ in its

[25]The noun stems ending in /yyi/ have suppletive forms- [munjētulu] 'forearms', [mōcētulu] 'forearms', [lōcētulu] 'palms'.

plural forms- [kabōdi] 'blind person' plural [kabōdulu] 'blind persons', [udyōgi] 'employee' plural [udyōgulu] 'employees'.

Nominal stems of type $C^*V_1C^*iC^*V_3$ are numerous (555) in the dictionary corpus. Within this set, stems of type $C^*V_1C^*iC^*a$ are most frequent (234). If a stem of this type has a heavy initial syllable, such as in [ennika] 'election', [nālika] 'tongue', [kaṇḍriga] 'hamlet', no harmonic variant of the stem is possible- *[ennaka], *[nālaka], *[kaṇḍraga]. The non-initial vowels in these stems do not alternate in their plural forms- [ennikalu], [nālikalu], [kaṇḍrigalu]. When a $C^*V_1C^*iC^*a$ stem consists of three light syllables, such as in, [moṭima] 'pimple', [garika] 'type of grass' or [wanita] 'woman', it does not have a harmonic variant such as *[moṭama], *[garaka] or *[wanata]. This is unlike trisyllabic stem types such as $C^*V_1C^*aC^*i$ or $C^*V_1C^*aC^*u$, where a harmonic variant was possible if the stem consisted of light syllables. Stems of type $C^*V_1C^*iC^*a$, whether with a heavy initial syllable or not, have very few endings- /ima/, /ika/, /iga/, /isa/ and /ita/. All these endings are productive derivational morphemes in Sanskrit borrowings. It's plausible speakers treat lexical items with these endings are morphologically derived and hence, do not create a harmonic variant. None of the $C^*V_1C^*iC^*a$ stems show vowel alternations in their plural form- [moṭimalu] 'pimples', [garikalu] 'blades of grass', [wanitalu] 'women'. Stems of type $C^*V_1C^*iC^*ā$ are all borrowings from either Sanskrit or Perso-Arabic, such as [jābitā] 'list/inventory', [phāyidā] 'interest on capital', [sinimā] 'cinema'. These stems do not have harmonic variants nor do they show vowel alternations in their plural forms. Stems of type $C^*V_1C^*iC^*e$ have a $C^*V_1C^*iC^*a$ variant, for example, [ciṭike] ~ [ciṭika] 'snap of fingers', [toḍime] ~ [toḍima] 'stalk', [garise] ~ [garisa] 'basket'. None of these stems have a harmonic variant despite being sequences of light syllables. They do not show vowel alternations in their plural forms- [ciṭikelu], [toḍimelu], [gariselu]. Stems of type $C^*V_1C^*iC^*i$ show alternations in non-initial vowels if they consist only of light syllables, such as in, [taripi] 'calf (that has been weaned)' plural [tarupulu], [koliki] 'hook' plural [kolukulu]. If they have a heavy initial syllable, then only the vowel in the final syllable alternates, for example, [tommidi] 'nine' plural [tommidulu] 'nines', [lēk^{h}ini] 'female author' plural [lēk^{h}inulu]. Stems of type $C^*V_1C^*iC^*ī$ include borrowings, such as [tanikī] 'inspection', [durbinī] 'telescope', [rāyitī] 'concession' and also native stems, such as [kalitī] 'adulteration', [bāwilī] 'ear ornament', [takilī] 'spindle'. None of these stems show alternations in their plural forms- [tanikīlu] 'inspections', [durbinīlu] 'telescopes', [rāyitīlu] 'concessions', [kalitīlu] 'adulterations', [bāwilīlu] 'ear ornaments', [takilīlu] 'spindles'. Since V_2 and V_3 are both front high vowels, the question of harmonic variants does not arise. There are quite a few (57) stems of type $C^*V_1C^*iC^*u$ in the dictionary corpus. Most of these stems are morphologically complex and are derived. For example, stems with the ending -/impu/ are derived from bisyllabic stems, such as [gurtimpu] 'recognition' from [gurtu] 'memory', [taggimpu] 'reduction' from [taggu] 'decrease'. All these stems involve a heavy initial syllable. There are just 3 $C^*V_1C^*iC^*u$ stems that are sequences of light syllables- [moyilu] 'cloud', [rayitu] 'farmer' and [taliru] 'sprout'. The stem [moyilu] 'cloud' has the variant [mogulu]. The other two stems do not have harmonic variants, perhaps because [rayitu] is a borrowing (from Indic) and [taliru] is a derived word.

Nominal stems of type $C^*V_1C^*īC^*V_3$ are mostly either borrowings, such as, [jigīʃa] 'ambition', [kanjīrā] 'stringed instrument', [rasīdu] 'receipt' or derived words containing more than one morpheme. If the stem is a derived word, then it always involves a heavy initial syllable, for example, [tūnīga] 'dragon fly' (derived from [tūnu (meaning unknown) and īga] 'fly'), [kannīru] 'tears' (derived from [kannu] 'eye' and nīru] 'stream'). None of these stems have harmonic variants. Only when the stem-final vowel is /i/, it shows alternations in plural forms, such as in [wālmīki] 'name of a hill tribe', plural [wālmīkulu].

Nominal stems of type $C^*V_1C^*uC^*V_3$ are the most frequent (711) in the dictionary corpus. Among stems of type $C^*V_1C^*uC^*a$, there is a familiar pattern with regards to the availability of a harmonic variant- if the stem is a sequence of light syllables, then it has a harmonic $C^*V_1C^*aC^*a$ variant. For example, [miḍuta] ~ [miḍata] 'locust', [ciluka] ~ [cilaka] 'parrot',

[kuduwa] ~ [kudawa] 'mortgage'. If the stem has a heavy initial syllable, then the vowel in the second syllable cannot undergo harmony (opaque), such as in, [piccuka] 'sparrow' (*[piccaka]) and [pīnuga] 'corpse' (*[pīnaga]). These stems do not show alternations in their plural forms since the stem-final /a/ in nouns is opaque. Almost all stems of type C*V_1C*uC*ā involve a heavy initial syllable, such as, [bīruwā] 'almirah', [bāwu[ṭā] 'flag'. In these stems, the vowel in the second syllable following a heavy first syllable does not undergo change and therefore, no harmonic variant of the stem is possible. There is only one trisyllabic nominal stem of this type with a light initial syllable- [surumā] 'collyrium used in eye make-up', which is a borrowing. It is not clear if the harmonic variant [suramā] is possible. Stems of type C*V_1C*uC*i always involve a heavy initial syllable, such as [ingudi] 'kind of plant', [sannuti] 'praise', [samputi] 'volume of a book'. The vowel in the second syllable after the heavy initial syllable is immune to harmony. The final /i/ in these stems changes to /u/ in plural forms, for example, [ingudulu] 'plants'. There are a few C*V_1C*uC*i stems which are sequences of light syllables, which are borrowings from Sanskrit, such as, [suruci] 'good taste', [aʃuci] 'impurity'. These stems are derived nouns, for example, /su/ prefix meaning good and /ruci/ 'taste', /a/ prefix meaning negative and /ʃuci/ 'purity'. The vowel in the second syllable cannot change to agree with vowel in the third syllable probably because it carries stress in the base morpheme. These are abstract uncountable nouns and hence, it is not clear if stem-final /i/ changes to /u/ in plural forms. There is just one C*V_1C*uC*ī type stem, [samujjī] 'equal' which is a compound borrowed from Sanskrit. In this stem, the second syllable is also heavy and it does not have a harmonic variant. The stem type C*V_1C*uC*u is the most common (547) in the corpus. Within this set, more than half the number of stems (321) involve an heavy syllable. There are many (226) stems which are sequence of light syllables. These stems are not relevant for alternations since the non-initial vowels are all /u/. But, their high frequency in the language lends support to the claim about stem-internal harmony (Babu, 1976).

Stems of type C*V_1C*ūC*V_3 are again mostly either borrowings or contain more than one morpheme. For example, [asūya] 'jealousy', [talūkā] 'subdivision of district', [nājūku] 'sensitive' are all borrowings (from Indic or Perso-Arabic). These stems do not have harmonic variants. As seen with previous combinations, C*V_1C*ūC*V_3 stems which are derived always involve a heavy initial syllable, such as, [gōngūra] 'a kind of green vegetable' (derived from [gōngu] 'name of plant' and [kūra] 'vegetable'), [munnūru] 'three hundred' (derived from [mun] 'three' and nūru] 'hundred'). None of these stems show alternations in their plural forms.

Stress

Previous work on Telugu phonology contains differing claims about the stress system of the language. Pingali (1985) reports the following generalizations, taken from Sitapati (1936)-

- In a non-compound word, if the vowel in the second syllable is long and the vowel in the first is short, the second syllable receives the stress.
- In all other cases, the first syllable receives the stress.

In other words, primary stress is sensitive to both vowel length (stress long over short) and position (limited to first two syllables). This is illustrated in the examples shown in table 45. Note that examples ii. and iii. in table 45 are borrowings from Sanskrit or Perso-Arabic. The detailed corpus study presented earlier revealed that this pattern of a light first syllable and a long vowel in the second syllable is mostly found in borrowings. In native stems, if the vowel in the second syllable is long, the first syllable either has a long vowel or has a coda ((C)VC). Sitapati (1936) also reports that in compound words, secondary stress is seen on the prominent syllable of the second element of the compound. Recall from sections 2 and 3 that most of the nominal and verbal stems that show vowel harmony alternations in suffixed forms are trisyllabic

i.	'palaka	slate
ii.	pra'māṇamu	pledge
iii.	ga'lību	pillow-cover
iv.	'kāki	crow
v.	'sīsa	bottle

Table 45: Stress placement in Telugu (from Pingali (1985))

sequences of light syllables and the first vowel of these stems resists assimilation. According to the stress rule of Sitapati (1936), in such stems, primary stress goes on the initial syllable.

Krishnamurti (2003, pp.59-60) reports an experimental study on eliciting speaker judgements about stress. The main point of departure in this study is the finding that there is variation across speakers with regard to the placement of primary stress in a trisyllabic stem that consists of light syllables CVCVCV. In a stem like [palaka] 'slate', the number of subjects who judged the second syllable to be stressed was almost twice the number of those who judged the first to be stressed. It is not clear if the fact that all three vowels in the stem are identical has any effect of the judgements elicited. To avoid confusion, I refrain from recounting the details of this study here. Similarly, a preliminary study of acoustic correlates of stress in words comprised of light syllables found that vowel duration, syllable duration, fundamental frequency and its range are reliable markers of primary stress in Telugu (Balusu, 2001). Peak loudness and mean intensity were shown to be the poorest cues to primary stress.

At this point, further phonetic studies are required to clearly establish the facts about the vowel system and stress patterns in Telugu. In this thesis, I assume the stress rules of Sitapati (1936) reported by Pingali (1985). The above primary stress rules are identical to the facts reported for Malayalam by Mohanan (1986). Hayes (1995, pp.92-93) proposes a foot-based metrical analysis to account for the primary stress facts of Malayalam.

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