ATR Quality in the Luo Vowel System

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Abstract: ATR quality in Luo has received a fair amount of attention and study, with substantial research dating as far back as Jacobson's (1978) radiographic investigation of ATR vowels in four Western Nilotic languages. Despite the amount of research that has been done, there is no clear consensus on the acoustic and articulatory properties of Luo ATR quality, nor the harmony patterns seen within the language. The wide variance in articulation of ATR qualities among Luo speakers presents a challenge for researchers who are seeking consistent, measurable data. The equally challenging ATR harmony patterns in Luo reflect a combination of [+ATR] dominance, commonly found in Western Nilotic languages, and assimilation patterns that are triggered from the root, which some have suggested indicates a shift towards the ATR patterns of West African languages (Kutsch Lojenga 1986).

Thus, the purpose of this description of Luo is twofold. A preliminary discussion of the acoustic qualities of Luo ATR vowels will first be presented with discussion of relevant literature and the results of an acoustic analysis of Luo’s underlying nine-vowel system. Second, a description of some of the characteristic ATR harmony patterns in Luo will be given. The argument will be made that despite the profuse examples of ATR harmony patterns triggered by the root, there are other factors that suggest that Luo is characterized by strong [+ATR] dominance, namely, strong dominant [+ATR] suffixes, the failure of second person prefixes to harmonize to the root, [+ATR] leftward spreading across word boundaries, and the presence of an allophonic variant of /a/.

Introduction

Luo, alternatively known as Dholuo (ISO: [luo]), is a Western Nilotic language spoken in Western Kenya, numbering 4,410,000 speakers (Lewis 2009). Situated on the eastern side of the Lake Nyanza gulf, Luo lies the farthest south of all the Western Nilotic languages and is the second largest Nilo-Saharan language (Storch 2005). Owino (2003) notes two regional varieties of Luo: the Trans-Yala dialect and the Southern Nyanza dialect. As the latter is a more standardized, as well as more extensively researched variety, the language data and linguistic analysis of this article focus on the
Southern Nyanza dialect. Most closely related linguistically to Luo is the Ugandan language Adhola, which has been considered by some to also be a dialect of Luo (Storch 2005, Tucker 1994).

This study of the ATR quality in the Luo vowel system is divided in two parts. First, after introductory remarks in Section 1, an acoustic analysis will be presented in Section 2, noting relevant research and presenting the results of a vowel plot study performed. ATR processes will be the subject of part two in Sections 3 and 4, with a brief examination of theoretical considerations in Section 5. Grammatical ATR in Luo will first be described where changes in the ATR quality of the root distinguishes transitive/intransitive grammatical relations, followed by a discussion of the evidence of [+ATR] dominance in Luo. I will assert that Luo shows a robust system of [+ATR] dominance, contrary to the proposed shift to root-triggered ATR harmony systems that are common in West African languages, a shift that has been suggested by Kutsch Lojenga (1986) and Dimmendaal (2002) among others. This is shown by not only ATR spread occurring from the root to affixes, but also from suffixes to roots, in spreading across word boundaries, and in the allophonic variation of /a/.

1. The Luo vowel system

1.1 The vowel inventory of Luo

Luo has an underlying nine-vowel system with ATR contrast in the high and mid vowels, and cross-height ATR harmony, both characteristic of Western Nilotic languages. An allophonic low [+ATR] vowel does appear as a result of harmony processes as discussed more specifically in Section 4.5, and noted throughout this paper. Many researchers have suggested similar ten-vowel systems for Proto-Nilotic

1 For the language data included in this article, I am greatly indebted to Ruth Patta, a first language speaker of the Southern Nyanza dialect of Luo, who served as my language consultant throughout this project. As well, I would like to acknowledge Rod Casali for his invaluable consultation, critique, and guidance during the course of this study, as well as my classmates of LING 680 at the Canada Institute of Linguistics for their collaboration in collecting the SII Comparative African Wordlist for Luo. The research presented in this paper was performed under the direction of the LING 680 Advanced Field Methods course.

2 See Appendix A for a map of the language distribution of Western Nilotic languages.
(Hall et. al. 1975, Dimmendaal 1988, Storch 2005, among others) and Western Nilotic languages have not strayed very far at all from this system, still typically retaining nine or ten-vowel systems (Hall et. al. 1974).\(^3\) In (1) below the underlying vowel inventory of Luo, divided into its two ATR sets. The [+ATR] allophone of [a] is included in parentheses but does not appear to have phonemic status in the language.

(1) The underlying vowel inventory of Luo

\[
\begin{array}{ccc}
+ATR & -ATR \\
i & u & i & o \\
e & o & e & o \\
\end{array}
\]

Nilotic languages are largely characterized by monosyllabic roots (Bender 2000) and consequently, CVC minimal pairs are clearly found in Luo for each of the phonemic vowels. Examples of minimal pairs for contrasting ATR vowel sets are clearly seen in (2) and examples of CVC words with [a] are shown in (3).\(^4\)

(2) Minimal pairs for ATR contrast

\[
\begin{array}{lll}
+ATR & \text{[-ATR]} \\
\text{a.} & \text{piṭ} & \text{‘huge pile’} & \text{piṭ} & \text{‘harvest, produce’} \\
& \text{bilo} & \text{‘amulet, charm’} & \text{bilo} & \text{‘taste’} \\
& \text{piɲ} & \text{‘country’} & \text{piɲ} & \text{‘down’} \\
\text{b.} & \text{lur} & \text{‘walk carefully’} & \text{lur} & \text{‘pluck’} \\
& \text{buk} & \text{‘book} & \text{buk} & \text{‘provoke’} \\
& \text{putṭ} & \text{‘cripple’} & \text{puɖ} & \text{‘pluck’}\(^5\)
\end{array}
\]

\(^3\) There are of course exceptions to this as in the Dinka-Nuer languages which have very complex manifestations of the Proto-Nilotic vowel system (see Anderson 1987, 1992–1994, Yigezu 1995).

\(^4\) These minimal pairs may also differ in tone. However, I have eliminated the tone markings in this chart to highlight the ATR contrast. In pairs where the tone is different, these examples demonstrate near-minimal pairs which is adequate for the purposes here of comparing ATR quality.

\(^5\) Because of the limited number of clear minimal pairs with [u]/[ʊ], a near-minimal pair was chosen here.
c. le ‘animal’ le ‘axe’
leɾ ‘vein’ leɾ ‘clean’
bet ‘sit’ bet ‘cut’

d. tok ‘back’ tɔk ‘serve’
 tô ‘dew’ tɔ ‘death’
lotʃ ‘peg’ lotʃ ‘kingdom’

(3) bat ‘arm’
dak ‘dwell’
lar ‘threshing floor’

Occurrences of the allophonic [/ʌ/] will be discussed further in Section 2 as there are no minimal pairs for [a] and [/ʌ/]. This allophone is conditioned by harmony processes.

1.2 Further characteristics of the Luo vowel system

As is characteristic of Nilotic languages, phonemic tone is present in Luo, although there is disagreement as to whether there are two or three underlying tones. I will be assuming three underlying tones: low, high, and downstepped high, and have minimally marked the underlying tones on the examples, mainly to show the tense/aspect of verbs. I am relying heavily on Tucker’s (1994) interpretation of tone in Luo and have not meant these tone markings to be authoritative by any means, but they are nevertheless present to aid the reader.

Vowel length is also phonemic in Luo, with grammatical and lexical implications. However, this process is not well-documented and is a subject for a study all its own. Given the minimal and conflicting descriptions of vowel length in the current research on Luo, as well as the fact that length is underspecified in the Luo orthography, I have chosen to not designate vowel length in the data represented in this paper and the analysis remains apparently unaffected by this omission. Typically accompanied with length, stress is present and mainly falls on the root vowel segment (Tucker 1994).

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6 In the examples following in this paper, the acute accent represents high tone [´], the grave accent represents low tone [´], and the macron diacritic, typically used for mid tone, represents downstepped high tone [´].
Luo is not atypical of Western Nilotic languages in its phonemic inventory of a nine-vowel ATR system. Including the tenth allophonic [ʌ], Luo has a symmetrical vowel set with ATR pairs at five heights. Nor is Luo atypical in its phonemic inventory of consonants; the Luo consonant system includes five places of articulation, which although unusual in the world’s languages is not at all uncommon in Western Nilotic (see Hall et. al. 1975 on Proto-Nilotic). See Holst (2007), Storch (2005), and Tucker (1994) for further discussion on consonant systems in Luo and in Western Nilotic.

2. An acoustic analysis of Luo vowels

2.1 Articulatory properties of ATR quality noted in research

A question in African linguistics that has been at the forefront of linguistic research for several decades, is that of the articulatory and acoustic properties of ATR feature distinctions. What is meant here by the term ‘ATR feature distinction’ is simply the differences speakers make between [+ATR] and [-ATR] sets of vowels. This section contains a few highlights of articulatory studies on Luo and related languages, and a discussion of how the complex articulatory factors of ATR relate to acoustic measurements. Luo especially has been highlighted due to its unique speaker variability in regards to ATR articulation, shown by Jacobson’s radiographic studies of three Western Nilotic languages: Shilluk, Dinka, and Luo (1978, 1980). Jacobson performed x-rays of speakers’ vocal tracts and oral cavities as they produced the vowels found in their own sound inventory, in order to determine the articulatory mechanisms used in ATR vowels.

Jacobson concluded first, that four different mechanisms were being used to create ATR distinctions: tongue height, tongue root advancement or retraction, dilation or constriction of the pharyngeal cavity, and laryngeal displacement. Second, he

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7 The possible palatal plosives have been represented here as alveolar-palatal affricates which is not wholly uncommon in descriptions of Western Nilotic languages. See Holst (2007) for a discussion on these consonant sounds in Western Nilotic.

8 See Tiede (1996) for an MRI study demonstrating these mechanisms. Lindau-Webb (1987) also investigated tongue mechanisms in Akan and Luo and has asserted ATR languages have two underlying tongue mechanisms (termed “front raising” and “back raising”) contrary to the three underlying mechanisms typically associated with ATR languages (height, backness, and advanced tongue root).
concluded that not only do speakers vary from language to language in which mechanisms are used to produce ATR qualities, they may also vary among speakers of the same language. English uses primarily tongue height to distinguish its equivalent tense/lax values. In contrast, Shilluk in Jacobson's study uses the mechanisms of tongue advancement and laryngeal displacement. Dinka hardly utilizes these four mechanisms at all but alters voice quality of its vowels by modifying the sound source, i.e. vocal fold vibration. Luo speakers, in further contrast, can be shown to use any of the four mechanisms to produce ATR feature distinctions, and articulation of ATR varies widely between speakers. Figure 1 demonstrates these differences in the x-ray tracings of three different Luo speakers producing back vowels. Tracings marked with hollow shapes delineate [+ATR] vowels while tracings marked with solid shapes delineate [-ATR] vowels:

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9 see Tiede (1996) for a comparison of English with ATR languages
What may be seen in the above radiographic tracings is the wide variance among these three Luo speakers in the articulation of ATR features. Speaker 1 demonstrates the use of the height mechanism, particularly in distinguishing the [+ATR] and [-ATR] mid vowels. Speaker 2 makes wide use of tongue root advancement and retraction as well as pharyngeal expansion or constriction to distinguish the different ATR values.
Most noticeable in Speaker 3 is the lowering of the larynx for [+ATR] vowels and the raising of the larynx for [-ATR] vowels. This unexpected variance within the same language presents a challenge for researchers looking for consistent ATR articulatory measurements within languages.

According to an MRI study performed by Tiede (1996) comparing vowels in English and Akan, pharyngeal expansion is the primary distinguishing characteristic of the ATR feature among typical ATR languages. As this pharyngeal expansion may be created through multiple mechanisms, as Jacobson noted (1980), it should not be altogether surprising to see these mechanisms utilized differently even among speakers of the same language. These varying articulatory mechanisms should ideally be reflected in acoustic measurements in very similar ways, as changes in the formant values reflect the changes in the size of the pharyngeal cavity. An expansion of the pharyngeal cavity should result in a lower resonant frequency, whether laryngeal displacement or tongue root advancement was utilized. This is not always the case, however, as can be seen in overlapping formant values discussed below.

A challenge not uncommon in ATR languages, is the overlap of vowel formant measurements, particularly in the [-ATR] high vowels ([ɪ]/[ʊ]) and the [+ATR] mid vowels ([e]/[o]) in which the latter may have lower formant measurements than the former high vowels. Creider and Hall (1998) have claimed [ɪ] and [ʊ] are especially vulnerable to neutralization to [e] and [o] for articulatory reasons; that is, when the tongue is raised, it is naturally pulled forward, thus [-ATR] and [+high] features come in conflict. In languages where neutralization of [-ATR] high vowels has not occurred and the lines between formant values are blurred, speaker intuition and harmony processes can often bring to light the distinction, although this does not help researchers who are strictly looking for measurable articulatory or acoustic data. Slightly less common but present in Luo, is the overlap of the [+ATR] and [-ATR] high vowels, which can prove more challenging as speaker intuition not uncommonly fails to distinguish between the two high vowel sets. Both cases of vowel formant overlap

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10 See Starwalt (2008) and Casali (2003, 2008) for an in-depth discussion of this phenomenon in seven- and nine-vowel systems.

11 Noonan (1992) discovered this same difficulty in determining the high vowels in his acoustic study of Lango, a closely related language to Luo.
can be seen in Jacobson’s plot of Luo vowels in Figure 2, where the high vowels and the [+ATR] mid vowels overlap with F₁ values:

![Figure 2: Jacobson’s plot of Luo vowels (1978)](image)

The articulatory question of “what is ATR?” has certainly not been unequivocally answered in the current literature, nor is there an established foolproof acoustic measure of the ATR feature as seen in the above vowel plot where the back high vowels are especially indistinguishable, according to formant values. While F₁ is notably the primary acoustic measure of ATR, this discussion proves there are cases where F₁ fails to clearly delineate two vowels differing in ATR quality. In cases such as the high vowels in Luo, still further articulatory factors other than Jacobson’s (1980) four ATR mechanisms may be affecting vowel quality, which are not reflected in the formant values.

In a phonetic study of ATR features in Maa using electroglottography, Guion et. al. (2004) introduce the factor of glottal constriction which is typically connected with breathy/creaky voice quality. [+ATR] has generally been acknowledged to be more “breathy” or “hollow” in impressionistic terms while [-ATR] is considered more “bright” or “brassy”. While the “breathiness” of [+ATR] vowels may be merely a result of the expansion of the pharynx, it may also be combined with the same articulatory properties of true breathy features, produced by the more open glottis.

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12 Note that Jacobson here is using an older system of IPA symbols here where [ɩ] = [i] and [ɷ] = [ʊ].
Guion et. al. (2004) suggest speakers may adapt variations of both breathiness and expanded pharynx to create robust vowel quality distinctions as the two enhance the [+ATR] feature. They further assert that advancement of the tongue root may be physically connected to open glottis. The relevance of this is seen in vowels of two different sets that have nearly identical F₁ measurements but are audibly (and phonologically) different; the difference may be one of breathiness/non-breathiness more than space in the pharyngeal cavity. Since true breathy voice is produced at the glottis, it is typically not reflected in formant values and would therefore not effect F₁.

The established Luo orthography is based on the Swahili five-vowel orthography and does not specify tone or ATR quality, making it difficult for Luo speakers to hear the distinctions not reflected in their writing system. With speaker perception strongly influenced against hearing ATR contrast and a failure of formant values to evidence the ATR quality of a vowel, determining ATR value in the high vowels presents a challenge. In Starwalt’s (2008) acoustic analysis of eleven ATR languages, a variety of acoustic measurements were used to determine ATR quality. While the primary acoustic correlate of ATR is the first formant measurement, a secondary acoustic correlate may be necessary when first formant measurements overlap; correlates such as F₁ bandwidth, spectral tilt (rate of decline in amplitude of increasing harmonics), or center of gravity were used in the study. ¹³ Starwalt demonstrates that the effectiveness of this secondary acoustic correlate of ATR is language specific; which of these acoustic measurements is helpful is dependent on the language under study. These differences in which measurement tools accurately distinguish ATR categories is a reflection of the variances in ATR feature articulation.

Given these challenges in determining ATR quality, a preliminary step in this study of ATR in Luo was to determine whether the same extent of overlap in first formant measurements as Jacobson (1978) found in his vowel plot would be seen currently in recorded speech of a Luo speaker; and secondly, whether additional acoustic measurements such as Starwalt used would be necessary to determine the harmony processes at work in the language. The starting point for answering these questions was an investigation of the ranges of first formant values for each vowel, then a vowel plot

¹³ “the measure of the mean of the frequencies of the sound’s spectrum” (Starwalt 2008: 94)
similar to Jacobson’s (Figure 2. above) was constructed based on current formant values.

2.2 A vowel plot of $F_1$ and $F_2$ values of Luo vowels: The methodology

Five CVC environments were chosen as contexts to record each vowel for an acoustic analysis of Luo vowels. Only real Luo words were selected and voiceless obstruents were favored for consonant choice, while approximants, nasals, and palatals were avoided as they showed the most influence on vowel quality. One exception to these guidelines was the context [l_r] which was a highly productive context and had minimal to no effects on the medial vowel. Where no existing Luo word occurred with a specific vowel in a context, comparable words with similar manners and places of articulation were chosen. See appendix B for a list of contexts and recorded words used in the vowel plot.

The nine underlying vowels of Luo were used in the vowel plot as well as the [+ATR] allophone of [a]. Ideally, the word choice for the allophonic vowel [ʌ] would also follow the same guidelines as the underlying vowels. However, as the occurrence of this vowel was quite limited and only surfaced due to harmony processes, it was not possible to record CVC forms. Instead, existing recordings of CVC nouns with the second person singular and plural possessive suffixes, /-i/ and /-u/, were used. As this was an addition to this study at a later date, contexts were not identical to the contexts used for the other vowels, although these could be found if the study were to be repeated.

Three tokens of each word (only two tokens for [ʌ]), for a total of 149 vowels, were recorded with an Audio Technica AT899 condenser microphone (headset mounted) and a USBPre digital recorder (manufactured by Sound Devices) at a 48 KHz sampling rate with 16 bit resolution. $F_1$, $F_2$, and $F_3$ bandwidth measurements were taken using the spectrum display in the Speech Analyzer computer program (www.sil.org). Only one pitch period was measured in the center of the vowel, during steady state formants, and away from consonant transitions to obtain the most accurate readings. An example of a measurement taken in Speech Analyzer using the spectrum display is given in (4) with the Luo word [del] ‘body,’. The waveform and spectrogram are also shown. The spectrum display below provides formant and bandwidth values for the period in the
waveform between the two cursor lines; the spectrogram demonstrates the central, steady formant state of this portion of the vowel, which is ideal for taking acoustic measurements.

(4) Waveform, spectrogram, and spectrum display for taking $F_1$ measurements in Speech Analyzer

The single pitch period between the cursors on the waveform display above exemplifies a steady formant state position in the middle of the vowel, away from consonant transitions. Formant and $F_1$ bandwidth values are given in the lowest display, the spectrum. Consistent measurements for each vowel token were taken and as CVC root words are typically lengthened for stress, accurate measurements were effectively obtained.

2.3 A vowel plot of $F_1$ and $F_2$ values of Luo vowels: Results

The $F_1$ and $F_2$ formant values were then plotted on a graph using the logarithmic Bark scale to correlate with speaker perception of relative height and backness of sounds.\textsuperscript{14} The $F_1$ value is plotted on the vertical axis and the $F_2$ value is plotted on the horizontal axis in the following chart in Figure 3, and all 149 data points are represented. I have departed here from graphing the value of $F_2 - F_1$ on the horizontal axis as in Jacobson’s vowel plot in Figure 2 because the graph of the standard $F_2$ value seems to be more

\textsuperscript{14} The computer program FPlot, designed specifically to create vowel plots based on $F_1$ and $F_2$ values, was used to create the graphs in Figures 3–5.
representative of how speakers perceive these vowels in relation to each other. This is especially the case in regards to the low central vowel [a] (compare Figure 2 where [a] occurs in line with the back vowels, whereas in Figure 3, [a] is more central in the plot).

Figure 3: All data points for each vowel recorded for a female Luo speaker

Many similarities may be seen between this vowel plot and Jacobson’s 1978 vowel plot in Figure 2 above. The front and back high vowels occur very close to each other and the [+ATR] back mid vowel has some overlap with the [-ATR] high back vowel. Unlike Jacobson’s plot however, the [+ATR] front mid vowel is quite distinct from the [-ATR] high front vowel. Further, while the higher vowels occur very close together, a line could still be drawn to divide the vowel sets as presented in Figure 4 below. In this
enlarged and modified plot, the vowels with $F_1$ values that overlap with other vowel sets are circled and this overlap is far less extreme than what was seen in Jacobson’s plot.

**Figure 4:** A plot of $F_1$ values of [+ATR]/[-ATR] high vowels with [+ATR] mid vowels

![Figure 4](image)

Based on what can be seen in Figure 4, $F_1$ values are very telling and fairly consistent in determining the ATR quality of Luo vowels with this particular speaker, even among the high vowels. The range of $F_1$ values for this speaker is shown in (5).

(5) Minimum and maximum $F_1$ values in Hertz for recorded vowels

<table>
<thead>
<tr>
<th>Front Vowels</th>
<th>Minimum $F_1$ Value</th>
<th>Maximum $F_1$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[i]</td>
<td>229</td>
<td>290</td>
</tr>
<tr>
<td>[i]</td>
<td>279</td>
<td>350</td>
</tr>
<tr>
<td>[e]</td>
<td>397</td>
<td>434</td>
</tr>
<tr>
<td>[ɛ]</td>
<td>518</td>
<td>606</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Back &amp; Central Vowels</th>
<th>Minimum $F_1$ Value</th>
<th>Maximum $F_1$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[u]</td>
<td>224</td>
<td>269</td>
</tr>
<tr>
<td>[o]</td>
<td>270</td>
<td>358</td>
</tr>
<tr>
<td>[o]</td>
<td>328</td>
<td>409</td>
</tr>
<tr>
<td>[ə]</td>
<td>513</td>
<td>625</td>
</tr>
<tr>
<td>[ʌ]</td>
<td>652</td>
<td>790</td>
</tr>
<tr>
<td>[a]</td>
<td>792</td>
<td>941</td>
</tr>
</tbody>
</table>

In the $F_1$ value ranges above, it is evident there is true overlap in only the front high vowels and the [-ATR] high and [+ATR] mid back vowels. As shown in the numerical values of $F_1$, there is actually no overlap between the high back vowels as it appears in...
the vowel plot, however, the two sets are notably close in formant values. To reiterate, there is more distinction between the ATR sets than Jacobson discovered in Luo several decades ago. Based on the fifteen data points per vowel, average $F_1$ values can also be determined as in the plot in Figure 5:

Figure 5: Average data points for each vowel recorded for a female Luo speaker

![Formant values graph](image)

The above plot demonstrates average ATR values for a female speaker of Luo and is representative of a typical ten-vowel ATR language. Numerical average formant values are given below in (6).

(6) Average formant values in Hertz for a female Luo speaker

<table>
<thead>
<tr>
<th>Front Vowels</th>
<th>$F_1$ Value</th>
<th>$F_2$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[i]</td>
<td>256</td>
<td>2526</td>
</tr>
<tr>
<td>[i]</td>
<td>309</td>
<td>2577</td>
</tr>
<tr>
<td>[e]</td>
<td>415</td>
<td>2270</td>
</tr>
<tr>
<td>[ɛ]</td>
<td>559</td>
<td>2199</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Back &amp; Central Vowels</th>
<th>$F_1$ Value</th>
<th>$F_2$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[u]</td>
<td>241</td>
<td>716</td>
</tr>
<tr>
<td>[o]</td>
<td>316</td>
<td>763</td>
</tr>
<tr>
<td>[o]</td>
<td>363</td>
<td>830</td>
</tr>
<tr>
<td>[ɔ]</td>
<td>585</td>
<td>992</td>
</tr>
<tr>
<td>[ʌ]</td>
<td>737</td>
<td>1627</td>
</tr>
<tr>
<td>[a]</td>
<td>870</td>
<td>1660</td>
</tr>
</tbody>
</table>

The formant values provided here were highly useful in the analysis of the harmony patterns, aiding in confirming the ATR values of difficult vowels. These values are quite typical for a female speaker of an ATR language and surprisingly, they are quite
distinguishable even in the high vowels. In looking at the values for [ʌ], this confirms suspicions that this allophone is very distinct from its [-ATR] counterpart. One last acoustic measurement taken alongside formant measurements in this study is F₁ bandwidth, which we discuss next.

2.4 The acoustic measure of bandwidth in Luo

As previously noted, bandwidth may be a secondary correlate of ATR in some languages, where a narrower F₁ bandwidth is found in [+ATR] vowels and a wider F₁ bandwidth is found in [-ATR] vowels, as in Akan (Hess 1992) and Ikposo (Starwalt 2008). In comparison, F₁ bandwidth in Luo is somewhat less helpful and there are certainly not clear-cut divisions in bandwidth values distinguishing ATR values. The ranges of F₁ bandwidth values for each Luo vowel can be seen in the following chart. These bandwidth values were taken at the same time and place as the formant measurements in the spectrum display in Speech Analyzer.

(7) F₁ bandwidth ranges for Luo vowels in Hertz

<table>
<thead>
<tr>
<th>[+ATR] Vowels</th>
<th>Minimum F₁ Bandwidth</th>
<th>Maximum F₁ Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>[i]</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>[u]</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>[e]</td>
<td>19</td>
<td>58</td>
</tr>
<tr>
<td>[o]</td>
<td>20</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[-ATR] Vowels</th>
<th>Minimum F₁ Bandwidth</th>
<th>Maximum F₁ Bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ɪ]</td>
<td>30</td>
<td>59</td>
</tr>
<tr>
<td>[ʊ]</td>
<td>24</td>
<td>75</td>
</tr>
<tr>
<td>[ɛ]</td>
<td>37</td>
<td>65</td>
</tr>
<tr>
<td>[ɔ]</td>
<td>32</td>
<td>114</td>
</tr>
<tr>
<td>[ʌ]</td>
<td>33</td>
<td>201</td>
</tr>
<tr>
<td>[a]</td>
<td>44</td>
<td>140</td>
</tr>
</tbody>
</table>

The bandwidth ranges for Luo show a wider range of values for [-ATR] vowels than for [+ATR] vowels, as well as generally higher F₁ bandwidth values for [-ATR] vowels than for [+ATR] vowels. However, within these ranges some [+ATR] vowels have a higher bandwidth value than expected and some [-ATR] vowels have a lower bandwidth value than expected. While F₁ bandwidth values on the low end of the spectrum may be assumed to be [+ATR] and values on the high side may be assumed to be [-ATR], this does not aid in determining the large number of vowels which have F₁ bandwidth values somewhere in the middle (30–50) range. A more in-depth study of
F₁ bandwidth values and their relationship to ATR quality is needed in order to determine precisely what these values are reflecting and how they could be useful.¹⁵

In conclusion of this acoustic analysis of Luo, the complicated articulatory mechanisms of ATR are evident in the variety of studies performed on ATR articulation. Further, acoustic measurements of ATR can vary in effectiveness by language and even by speaker. While F₁ is the primary relevant acoustic measurement of ATR values, it can fail to distinguish these values in especially the high vowels. While this has been noted in research on Luo, the F₁ values proved to be effective indicators of ATR values for this particular speaker, with the exception of a few anomalous measurements out of the 149 recorded vowels.

3. Grammatical ATR in Luo

3.1 Grammatical ATR in Western Nilotic languages

Grammatical ATR is a unique process in which changes in grammatical categories are marked by changes in ATR qualities, and the change occurs apart from harmony processes. The ATR feature uniquely conveys grammatical information in a similar manner as grammatical floating tone (see Roberts 1994 for a typological discussion of this type of phenomenon). While unique in the world's languages, this process is very typical in Western Nilotic languages (Hall et. al 1975). The vast majority of Nilotic languages are [+ATR] dominant, meaning that in harmony processes the [+ATR] feature will spread to [-ATR] vowels but the [-ATR] feature will not spread to [+ATR] vowels;¹⁶ thus, these grammatical vowel quality alternations will be evidenced only in [-ATR] roots. The fact that underlyingly [+ATR] roots will not alternate in ATR quality but will show other phonological changes to reflect the grammatical category, demonstrates first, the dominance of [+ATR] in that it does not ‘lose’ its ATR feature

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¹⁵ Bandwidth measurements are typically taken alongside formant measurements, however I observed great variance in bandwidth values depending on how many pitch periods were selected in Speech Analyzer. A further direction of study would be to compare bandwidth measurements using different numbers of pitch periods and using different types of acoustic analysis software.

¹⁶ See Hall et. al. 1975. Also, Casali (2003) asserts five-height ATR systems (typically the nine- or ten-vowel systems which are prototypical of Nilotic languages) are virtually always [+ATR] dominant.
in reverse grammatical processes; and second, that [-ATR] forms are the unmarked grammatical categories where this alternation occurs.

To demonstrate grammatical ATR changes, multiple examples of these processes occurring in Western Nilotic languages are presented here. In (8a–b) for example, the unmarked form in Nandi (Hall et. al. 1975) and Anywa (Reh 1996) is the singular [-ATR] noun form. The plural, in contrast, varies in ATR quality to reflect the change in number and the whole word alternates to the more marked [+ATR] vowels. Dinka (Hall et. al. 1975, Anderson 1987), which has a complex vowel system with contrastive ATR quality as well as breathy/creaky distinctions, similarly uses voice quality to mark the plural form with the [+breathy] feature in (8c).

b. Anywa: ‘river’ Sing. [nàam] Pl. [ǹ̥m]
c. Dinka: ‘pipe’ Sing. [dak] Pl. [d̥ak]

Here the change in vowel quality is not due to processes of vowel harmony but is indicative of the number of the noun, and this grammatical information is conveyed solely by vowel quality.18 Underlyingly [+ATR] forms are not represented here but show a variety of alternations, most typically consonantal and tonal changes. Even more widespread in Western Nilotic languages is the use of ATR features to delineate valency changes. The terms used by researchers to describe the differences in the varying categories of grammatical relations does not show consensus, most likely because the object/patient of the clause is not necessarily eliminated but is made optional in the marked construction. Consider the examples in (9) from Päri (Andersen 2006) where the unmarked form of the verb /gɛ̌ɛr/ ‘build’ (9a) surfaces in a transitive construction and the object is marked either explicitly or as a 3S suffix on the verb. In (9b), however, the root form of the verb changes to the [+ATR] [gêed] (accompanied

\______________

17 I have departed here from Hall’s representation of the IPA characters and have adapted their phonetic transcriptions to remain consistent with the equivalent IPA characters used in this paper.
18 It should be noted that number distinctions in Western Nilotic languages are extremely complex and these changes represented here are not all-encompassing for the noun systems of Nandi, Anywa, and Dinka. ATR alternation is merely one way in which these languages may denote number in nouns.
also by a final consonant change), the generic verbal suffix [-o] is used, and the object is optional and accompanied with a preposition.

(9) a. (ɔ̀ttɔ́) á-gɛɛɛɛ́-ɛ
    house PT-build-3S¹⁹
    ‘He has built it (the house)’

b. gɛɛɛɛ-ó (kí ɔttɔ́)
    build.ANTP-VS PREP house
    ‘He is building (a house).’

In (9b), object demotion has occurred, even as the object is stated in the clause construction. Because the object is sometimes present and other times absent, a variety of terms has been used to describe very similar types of these constructions in Western Nilotic languages: ‘qualitative’ (Tucker 1994), ‘intransitive’ (Okoth Okombo 1982, Noonan 1992, among others), ‘patient-deleted’ (Reh 1996), ‘antipassive’ (Andersen 2006), and more have been used in relevant literature to describe the marked clause where object demotion has occurred. For the sake of consistency with previous discussions by researchers on this phenomena, verbal constructions as in (9b) will here be considered with the more frequently occurring term ‘intransitive,’ with the acknowledgment that these constructions may take a demoted object and do not function as intransitives in English. As will be shown for Luo, even the object in the transitive forms is optional and the usage of the alternate forms is based on semantic emphasis or specification more than syntax.

Many other examples may be given of Western Nilotic languages which use ATR to distinguish transitive/intransitive clauses. In (10), Anywa (Reh 1996) demonstrates a nearly identical process as seen in Päri where the [-ATR] verb becomes [+ATR] in the intransitive clause in (10b). Jumjum and Mabaan (Andersen 1999, 2006), which have two harmonizing vowel sets loosely based on ATR, alternate the vowels from each set in a similar manner (see Mabaan in (10d) where the [+ATR] variant occurs when the object is not specified).

¹⁹ Morphological glosses used in (9) and (10): PT (past tense), ANTP (antipassive), VS (verbal suffix), INT (intransitive), PREP (preposition).
Western Nilotic languages using this type of vowel alternation are not limited to those presented here. Grammatical ATR, especially when used for number and transitivity differences, is clearly not uncommon in this language family and Luo is no exception. This may clearly be seen in an investigation of Luo transitive and intransitive statements.

3.2 Grammatical ATR at work in Luo

Number distinctions in Western Nilotic languages reflect a wide variety of changes within each language, utilizing multiple suffixes, broad consonant alternations, tone, length, and voicing variance, as well as voice quality changes; therefore, it is too extensive a topic to be included here. Instead, I will focus primarily on transitive/intransitive changes in Luo which specifically reflect ATR alternation. In (11), a series of inherently [-ATR] verbs are shown in imperative, transitive, and intransitive forms. The imperative and transitive forms are unmarked and remain [-ATR] while the intransitive forms are the more marked forms and surface as [+ATR]. This is consistent with what was seen above in (9) and (10) with other Western Nilotic languages.
(11) [-ATR] Verbs

<table>
<thead>
<tr>
<th></th>
<th>Imperative</th>
<th>Transitive</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ‘cut in strips (fabric)’</td>
<td>lir</td>
<td>lir law</td>
<td>lir²⁰</td>
</tr>
<tr>
<td>b. ‘plant (sorghum)’</td>
<td>piḍ</td>
<td>piḍ bèl</td>
<td>piṭ</td>
</tr>
<tr>
<td>c. ‘move (sorghum)’</td>
<td>sud</td>
<td>sud bèl</td>
<td>sud</td>
</tr>
<tr>
<td>d. ‘strip by plucking (sorghum)’</td>
<td>lur</td>
<td>lur bèl</td>
<td>lur</td>
</tr>
<tr>
<td>e. ‘spread (sorghum)’</td>
<td>peḍ</td>
<td>peḍ bèl</td>
<td>peṭ</td>
</tr>
<tr>
<td>f. ‘peel (sorghum)’</td>
<td>pok</td>
<td>pok bèl</td>
<td>pok</td>
</tr>
<tr>
<td>g. ‘serve (sorghum)’</td>
<td>tok</td>
<td>tok bèl</td>
<td>tok</td>
</tr>
</tbody>
</table>

(11b) and (11e) undergo voicing changes to the final consonant but ATR quality is the primary correlate distinguishing the two grammatical classes. (Tone in this case is not relevant in these simple examples here and has been omitted in (11-13).) The above [-ATR] transitive and intransitive verbs may also occur in the simple infinitive form with the /-ɔ/ verbal suffix, represented in (12). Here harmony applies to the verbal suffix in the intransitive forms and the whole word surfaces as [+ATR].

(12) [-ATR] Verbs

<table>
<thead>
<tr>
<th></th>
<th>Transitive</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ‘cut in strips (fabric)’</td>
<td>lir-ɔ law</td>
<td>lir-ɔ</td>
</tr>
<tr>
<td>b. ‘plant (sorghum)’</td>
<td>piḍ-ɔ bèl</td>
<td>piṭ-ɔ</td>
</tr>
<tr>
<td>c. ‘move (sorghum)’</td>
<td>sud-ɔ bèl</td>
<td>sud-ɔ</td>
</tr>
</tbody>
</table>

Inherently [+ATR] verbs on the other hand do not undergo changes in vowel quality, i.e. the reverse does not happen where the [+ATR] verb becomes [-ATR] in the imperative and transitive forms. Rather, contextual factors or occasional consonantal changes are the primary indicators of this change in grammatical category. This is evident below where the forms in (13c) demonstrate devoicing of the final consonant, and alternatively, the verbs in (13a, b) are not distinguishable for these grammatical classes.

(13) [+ATR] Verbs

<table>
<thead>
<tr>
<th></th>
<th>Imperative</th>
<th>Transitive</th>
<th>Intransitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. ‘cultivate (sorghum)’</td>
<td>pur</td>
<td>pur bèl</td>
<td>pur</td>
</tr>
</tbody>
</table>

²⁰ Morpheme-by-morpheme glosses are self-explanatory for most of the examples throughout this paper and will only be provided in more complex multi-word constructions. Except where noted, the English free gloss follows the order of morphological components and Luo word order is SVO as in English.
b. ‘put (sorghum)’ ket ket bɛl ket

c. ‘pluck (sorghum)’ puɖ puɖ bɛl puʈ

As noted in Section 3.1, the distinction between ‘transitive’ and ‘intransitive’ classes is not one of syntax in the strict sense that the former occurs with an object and the latter does not. Rather, when the speaker is referring to an action that has a specific object, he/she may use the transitive form whether or not the object is actually stated in the sentence. In the context of walking with a friend past a farm and seeing the work that is being done, one could say [ɔ-ɔtʊŋɔ] ‘he is planting.’ Here the transitive form may be used because it is clear that a specific thing is being planted and both speakers are aware of the specific object. Conversely, if someone asks a speaker where their brother was, they could respond with [o-piŋ-o] ‘he is planting,’ in reference to the work he is doing, not the object he is planting. In this case the intransitive form is used because the speaker does not want to specify what he is planting but emphasize the occupation or act of planting. This demonstrates the form used is based on semantics (what the speaker wants to emphasize) rather than syntax (the order of constituents).

The intransitive may also occur with an oblique or indirect object in Luo, as I discovered quite by accident. In a recording of an inherently [-ATR] verb [tɔk] ‘serve (food)’ with pronominal suffixes, all forms surfaced as [+ATR], shown in (14). Despite the fact that the person being served was specified, the food being served was not specified, and this decrease in valency was reflected in a [+ATR] intransitive form of the verb.

(14) a. ɗ-ʈók-nɛ ‘He has served him’
b. ɗ-ʈók-nɪ ‘He has served you’
c. ɗ-ʈók-ɔnʊ ‘He has served you (PL)’
d. gi-tók-nɛ ‘They have served him’
e. gi-tók-nɪ ‘They have served you’

These examples of grammatical ATR in Luo demonstrate the way in which ATR functions as a suprasegmental feature, applying to words to change their grammatical function. They also demonstrate [+ATR] dominance, as only the inherently [-ATR] roots change to [+ATR] in intransitive forms, while [+ATR] roots show no ATR alternation. Lastly, these examples have shown how the transitive and imperative forms cause the underlying forms of the roots to surface and are thus the unmarked
grammatical forms. This is a very unique process that applies broadly across Western Nilotic languages where ATR changes are applied based on grammatical motivations rather than from the harmony processes which will be investigated next.

4. Harmony Processes at work in Luo

4.1 Indications of ATR dominance

As noted in Section 3, nine- and ten- vowel systems typically display [+ATR] dominance over the [-ATR] dominance characteristic of seven-vowel systems with mid vowel contrast (Casali 2003). Casali classifies ATR dominance into six basic manifestations: (i) ATR spreading from a dominant affix to a root, (ii) ATR spreading between lexical compounds, (iii) ATR spreading across word boundaries, (iv) spreading from a root to its affixes (considered weak assimilation), (v) allophonic variants conditioned by harmony, and (vi) ATR preservation in coalescence. Of the five Western Nilotic languages Casali (2003) studied in his comparison of 100+ Niger-Congo and Nilo-Saharan languages, three displayed (i), spreading from a dominant affix to a root (Acholi, Alur, and Lango), one displayed (iv) weak assimilation (Anywa), and one displayed (i), (iv), and (v) (Mayak).

Notably at least four, if not all six, of these processes are exemplified in Luo, suggesting [+ATR] dominance is not only robust, but more so than what has been seen in related languages and in descriptions of Luo. Neither (vi) coalescence nor (ii) harmony in lexical compounds were focused on in this study. However, these processes have been observed in a few examples and would be expected to occur given the other harmony patterns seen in the language. Four of these six processes will now be treated in turn to evidence this strong [+ATR] dominance in Luo.

4.2 Affix harmonization with the root

ATR spreading from the root to an affix is prevalent in Luo and well-documented in the literature. This is possibly the reason why Luo is often described as portraying a kind of
ATR harmony where the ATR feature of the word is determined solely by the root.\textsuperscript{21} Multiple affixes harmonize to the ATR value of the root and without investigating the less obvious harmony patterns in the language, there seems to be no way of knowing the underlying forms of the affixes, the dominant ATR feature, or even if there is a dominant ATR feature in the language. It should be noted here that the possibility of a language where neither ATR feature is dominant is strongly disputed in Casali (2008), and despite the prevalence of ATR spread triggered by the root in Luo, the sections following will clearly show [+ATR] dominance. As the reader will observe in the following data, ATR spread is also seen from [+ATR] suffixes to [-ATR] roots, rather than in the reverse direction. Assymetry of the ATR feature is exhibited in the harmony patterns of Luo and only the [+ATR] feature appears to spread.

Within the data, certain suffixes and certain roots were seen to always surface as [+ATR], never as [-ATR]. However, other affixes and roots were seen to surface as [-ATR] in some contexts, and surface as [+ATR] in other contexts. From these differing behaviors of morphemes when placed in identical contexts, it was tentatively assumed that the [-ATR] feature was unmarked and morphemes that surfaced as [-ATR] were displaying their underlying ATR value. Morphemes which failed to surface as [-ATR] in all environments were assumed to be underlingly [+ATR]. This was the starting framework for determining the underlying forms of morphemes in Luo and is used in the following descriptions of harmony patterns. While this is a simplified explanation of the complex process of determining underlying forms in Luo and more could be said on the subject, this will suffice for providing the reader with an understanding of the underlying forms assumed in the data.

This presentation of harmony processes at work in Luo begins with an examination of the more prevalent harmony pattern of ATR spread from [+ATR] roots in infinitival suffixes, third-person prefixes on the verb, plural marking, and demonstratives. In the following examples, the infinitival suffix /-ɔ/ appears in its underlying form with

\textsuperscript{21} The term "root-control" has been used by many to describe the process of ATR spread from the root to affixes. However, this term often has theoretical assumptions linked and can vary in its scope of use. I have, therefore, decided to avoid using the term altogether rather than confuse the reader with a definition of what exactly is meant by "root-control" in this paper.
[-ATR] roots in (15) and then undergoes ATR harmony with the verb root in (16), surfacing as [+ATR].

(15)  a. bfl-ɔ́ ‘to taste’
     b. sók-ɔ́ ‘to braid’
     c. gɛ̃r-ɔ́ ‘to build’
     d. hɔl-ɔ́ ‘to borrow’

(16)  a. pît-ɔ́ ‘to plant’
     b. pük-ɔ́ ‘to spill’
     c. téd-ɔ́ ‘to cook’
     d. gól-ɔ́ ‘to remove’

To demonstrate that [a] behaves as [-ATR], it is shown here in (17) where it occurs with the [-ATR] affix.

(17)  a. hám-ɔ́ ‘to yawn’
     b. pák-ɔ́ ‘to congratulate’
     c. pád-ɔ́ ‘to slap’
     d. kád-ɔ́ ‘to overtake’

Harmonization with the root is also seen in prefixes as in (18) where the third person prefixes surface as their underlying [-ATR] forms with [-ATR] verbs, but undergo ATR spreading in (19) with [+ATR] verbs.

(18)  a. ɔ̀-d̪ɪ́ ‘He\textsuperscript{22} is going’
     b. gí-ñ̂ ‘They are going’
     c. ɔ̀-gídɔ́ ‘He is tickling’
     d. gí-gídɔ́ ‘They are tickling’

(19)  a. ɔ́-bírɔ̀ ‘He is coming’
     b. gí-bírɔ̀ ‘They are coming’
     c. ɔ́-kétɔ̀ ‘He is putting’
     d. gí-kétɔ̀ ‘They are putting’

Again, the verbal prefixes harmonize with the [-ATR] feature of [a] root vowels in verbs as in (20).

\textsuperscript{22} Luo third person encompasses both genders and may be either animate or inanimate: ‘he,’ ‘she,’ or ‘it.’
(20)  a. ɔ́-ká  ‘He is overtaking’
b. gí-ká  ‘They are overtaking’

While number markings are extensive and complex in Luo, as in most Western Nilotic languages, harmony processes may be seen in the plural suffix /-ɛ/. Examples (21–22) demonstrate a class of plurals which is marked by this suffix and minimal consonantal changes are evoked (consonant change seen only in 21b–d). In the first set of examples in (21), the underlying forms of all segments surface while in (22), the suffix has undergone ATR spreading from the inherently [+ATR] root.

(21) Gloss  Sg.  Pl.
   a. ‘mountain’ gót  gód-è
   b. ‘chair’ kóm  kómb-è
   c. ‘monitor lizard’ nětʃ  něj-è
   d. ‘music’ ŭóm  ŭóbmb-è

(22) Gloss  Sg.  Pl.
   a. ‘shoulder’ gók  gók-è
   b. ‘bag’ òfúkò  òfúk-è
   c. ‘mother’ mérò  mér-è
   d. ‘twin’ rút  rúd-è

Demonstrative suffixes may also undergo ATR spreading (contrary to data in Tucker (1994) who classifies demonstratives as ‘neutral’ suffixes that are unaffected by the stem vowel). In (23), the [-ATR] demonstrative suffix /-nì/ occurs with a [-ATR] word while in (24), ATR spread is seen in the suffix with an inherently [+ATR] verb.

(23) a. bìlò-nì  ‘This charm’
b. lót-nì  ‘This cane’
c. lé-nì  ‘This axe’
d. gód-nì  ‘This mountain’

23 Storch (2005) suggests many of these plural suffixes are various -C + /ɛ/ suffixes in which the consonant has assimilated to the root-final consonant, resulting in the multitude of root-final consonant changes seen in the plural forms. A clear description of what is occurring in the number system in Luo has yet to be presented and a presentation of this suffix as /-ɛ/ will suffice here.
In these examples, ATR harmonization with the root can be evidently seen in the infinitival, plural, and demonstrative suffixes as well as in verbal prefixes. There are many other affixes which show this kind of assimilation process to the ATR feature of the root. In moving on to the following discussion, the dominance of [+ATR] can be observed, indicating there is more than simple root ATR harmony occurring and that the [-ATR] forms of the harmonizing affixes illustrated above are underlying.

4.3 Dominant [+ATR] spreading from suffixes

The clearest evidence for dominant [+ATR] suffixes is seen in the second person singular and plural suffixes which can modify nouns or verbs. A treatment of how this suffix incurs ATR spreading on nouns in possessive paradigms will be given first. In the following examples (25–26), four possessive paradigms demonstrate first, [+ATR] spread from the root to [-ATR] possessive suffixes (i.e. first and third person forms), and second, ATR spread in the opposite direction from second person suffixes to a [-ATR] root. Inherently [+ATR] nouns are shown in the left column and inherently [-ATR] nouns are shown in the right column, while forms that have undergone spreading from the second person suffix are underlined.

(24) a. tink-ni ‘This chin’
   b. kund-ni ‘This cattle pen’
   c. lek-ni ‘This dream’
   d. po-f-ni ‘This grapefruit’

(25) [ATR]                        [-ATR]
    dênd-à  ‘my body’           bênd-à  ‘my sorghum’
    dênd-i  ‘your body’        bênd-i  ‘your sorghum’
    dênd-è  ‘his body’         bênd-è  ‘his sorghum’
    dênd-wà ‘our body’         bênd-wà ‘our sorghum’
    dênd-ù  ‘your (PL) body’   bênd-ù  ‘your (PL) sorghum’
    dênd-gì ‘their body’       bênd-gì ‘their sorghum’
The first person suffixes (/-/a/, /-wa/) occurring with [+ATR] roots above in (25–26) have not been marked with the allophonic [ʌ] because they cannot be shown with certainty to have undergone assimilation to the root. As this vowel is word final, acoustic measurements as well as auditory perception have not currently provided enough substantial evidence to confirm the quality of this vowel and I have left these first person suffixes as their underlying form. While the expectation would be that these suffixes would assimilate to the verb and would become [ʌ], further acoustic analysis of first person suffixes is needed to confirm this change with certainty. It is far easier to ascertain the acoustic properties of a root vowel /a/, and this same process of ATR spread from the suffix can be seen in the second person possessives on nouns with /a/. This is convincing evidence of the [+ATR] allophonic variant of [a]. Both the phonetic and phonemic forms of root nouns with [a] are provided in (27) and (28). Again, the relevant second person forms have been underlined.

(26)  
<table>
<thead>
<tr>
<th>[+ATR]</th>
<th>[-ATR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>bùr-à</td>
<td>‘my den’</td>
</tr>
<tr>
<td>bùr-i</td>
<td>‘your den’</td>
</tr>
<tr>
<td>bùr-è</td>
<td>‘his den’</td>
</tr>
<tr>
<td>bùr-wà</td>
<td>‘our den’</td>
</tr>
<tr>
<td>bùr-ù</td>
<td>‘your (PL) den’</td>
</tr>
<tr>
<td>bùr-gi</td>
<td>‘their den’</td>
</tr>
</tbody>
</table>

(27)  
<table>
<thead>
<tr>
<th>sad-a/</th>
<th>[sád-à]</th>
<th>‘my shirt’</th>
</tr>
</thead>
<tbody>
<tr>
<td>sad-i/</td>
<td>[sád-i]</td>
<td>‘my shirt’</td>
</tr>
<tr>
<td>sad-ɛ/</td>
<td>[sàd-ɛ]</td>
<td>‘his shirt’</td>
</tr>
<tr>
<td>sad-wa/</td>
<td>[sád-wà]</td>
<td>‘our shirt’</td>
</tr>
<tr>
<td>sad-u/</td>
<td>[sád-ù]</td>
<td>‘your (PL) shirt’</td>
</tr>
<tr>
<td>sad-gi/</td>
<td>[sád-gì]</td>
<td>‘their shirt’</td>
</tr>
</tbody>
</table>

(28)  
<table>
<thead>
<tr>
<th>lak-a/</th>
<th>[làk-à]</th>
<th>‘my tooth’</th>
</tr>
</thead>
<tbody>
<tr>
<td>lak-i/</td>
<td>[làk-i]</td>
<td>‘your tooth’</td>
</tr>
<tr>
<td>lak-ɛ/</td>
<td>[làk-ɛ]</td>
<td>‘his tooth’</td>
</tr>
<tr>
<td>lak-wa/</td>
<td>[làk-wà]</td>
<td>‘our tooth’</td>
</tr>
</tbody>
</table>

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This same process can be seen in pronominal suffixes on verbs, as the second person verbal suffixes also demonstrate dominance by spreading their [+ATR] features to the root. [+ATR] verbs are shown in the left column in (29) for a comparison of the differences seen between inherently [-ATR] and [+ATR] verbs. Prefixes in these examples mark person, tense, and aspect, while the suffix is the pronominal object. In (29a) for example, the [-ATR] verb occurs with [-ATR] affixes. However in (29b), both the prefix and the root undergo ATR spreading from the second person suffix. This strong dominant suffix causes ATR changes throughout the entire word. The same is seen in the plural second person suffix in (29c).

(29) [+ATR] [-ATR]
   a. ò-tér-è ‘He has accompanied him’  àsúd-è ‘He has moved him’
   b. ò-tér-i ‘He has accompanied you’  ò-súd-i ‘He has moved you’
   c. ò-tér-óu ‘He has accompanied you (PL)’  ò-súd-óu ‘He has moved you(PL)’
   d. gi-tér-è ‘They have accompanied him’  gi-súd-è ‘They have moved him’
   e. gi-tér-i ‘They have accompanied you’  gi-súd-i ‘They have moved you’

An example of a verb with [a] as the root vowel exemplifies the same patterns once again, with allophonic [ʌ] surfacing in second person forms. It is clear from the changes in acoustic measurements of [ʌ], as well as auditory differences, that /a/ is not merely transparent to harmony processes, but that it participates in harmony as well and will produce an allophonic variation. This is clearly seen in the phonetic forms in (30b, c, e).

(30) a. /ɔ-pák-ê/ [ɔ-pak-ɛ] ‘He has congratulated him’
   b. /ɔ-pák-i/ [ɔ-pak-ɛ] ‘He has congratulated you’
   c. /ɔ-pák-óu/ [ɔ-pak-ou] ‘He has congratulated you (PL)’
   d. /gi-pák-ê/ [gi-pak-ɛ] ‘They have congratulated him’
   e. /gi-pák-i/ [gi-pak-i] ‘They have congratulated you’

24 There are many tense/aspect verbal forms in Luo for past tense: all past examples were elicited in recent completed past tense for reasons relating to tone. This specific time orientation is not relevant for the topic of this presentation and has not been reflected in the gloss.
The second person reciprocal forms as well demonstrate ATR spreading in a similar manner. In (31a, d), no spreading has occurred, while in (31b, c, e, f) the entire word has become [+ATR] due to the dominant suffix.

(31)  
a. ɔ̀-sū̀d-rè ‘He has moved himself’  
b. i-sū̀d-rì ‘You have moved yourself’  
c. ù-sū̀d-rù ‘You (PL) have moved yourselves’  
d. gi-kóp-rè ‘They have imitated themselves’  
e. i-kóp-rì ‘You have imitated yourself’  
f. ù-kóp-rù ‘You (PL) have imitated yourselves’

In the previous examples, ATR spreading occurs from the suffix to the root and the prefix, but in (31) it is even more clear that this spread extends through the entire word to multiple prefixes. When the imperative negative prefix /kìk/ is added to an inherently [-ATR] form with a following second person suffix, it will also harmonize with the dominant [+ATR] suffix, where in other contexts, it will remain [-ATR]. Total [+ATR] harmony is shown in (31b–d).

(31)  
<table>
<thead>
<tr>
<th></th>
<th>[+ATR]</th>
<th>[-ATR]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kìk-gí-tér-è ‘Let them not accompany him’</td>
<td>kìk-gí-sū̀d-è ‘Let them not move him’</td>
<td></td>
</tr>
<tr>
<td>b. kìk-gí-tèr-i ‘Let them not accompany you’</td>
<td>kìk-gí-sú̀d-ì ‘Let them not move you’</td>
<td></td>
</tr>
<tr>
<td>c. kìk-ó-tér-ì ‘Let him not accompany you’</td>
<td>kìk-ó-sú̀d-ì ‘Let him not move you’</td>
<td></td>
</tr>
<tr>
<td>d. kìk-ó-tèr-òu ‘Let him not accompany you (PL)’</td>
<td>kìk-ó-sú̀d-òu ‘Let him not move you (PL)’</td>
<td></td>
</tr>
</tbody>
</table>

This process of [+ATR] dominant second person suffixes effecting vowel harmony in the whole word is comprehensive in Luo nouns and verbs. The phenomenon of the root assimilating to the [+ATR] feature of the suffix is highly consistent with few, if any, anomalies in the data.

4.4 Leftward [+ATR] spreading across word boundaries

As Hyman (2002) suggests, there is a phonetic expectation that ATR spread will be anticipatory (based on articulatory and perceptual factors), that is, it spreads regressively from right-to-left. While some languages do in fact demonstrate rightward
spreading, this usually occurs when spreading is bidirectional and leftward spreading is typically more extensive. 25

In Luo, examples of ATR spreading across word boundaries that demonstrate this process is unidirectional and only spreads from left to right. The [+ATR] feature may spread across one word boundary only and the rightward word must be inherently [+ATR] in order for the spread to occur. In observing noun phrases, ATR spread is clearly applied from a [+ATR] adjective to a [-ATR] noun in (34) and from a [+ATR] possessor to a [-ATR] possessed item in the genitive constructions in (35). 26

(34)a. /kɔɾ/ + /mabor/ → [ kor mabor ]
room long ‘The long room’
b. /gɔt/ + /modik/ → [ got mogik ]
mountain last ‘The last mountain’
c. /le/ + /modikre/ → [ le modikre ]
axe dull ‘The dull axe’

(35)a. /lu̯t̪/ + /dede/ → [ lut̪ dede ]
cane grasshopper ‘The grasshopper’s cane’
b. /dɔb̪k/ + /rudo/ → [ dog rudo ]
speech ostrich ‘The ostrich’s speech’
c. /ɔb̪ɔk/ + /pof/ → [ obɔk pof ]
leaf grapefruit ‘The grapefruit’s leaf’

In the examples above, a [-ATR] noun precedes a [+ATR] word and ATR spreading is evidenced. In a reverse construction, however, where a [+ATR] word precedes a [-ATR] noun, no spreading is manifested. In the examples in (36), rightward spreading does not occur to the [-ATR] words in the constructions.

(36) a. /kul/ + /maler/ → [ kul maler ]
cattle pen clean ‘The clean cattle pen’
b. /pof/ + /mɔtɔp/ → [ pof mɔtɔp ]

26 Tone here is not marked in these simple noun phrases in (34–37) to highlight the vowel quality changes.
In normal speech, it is clear that ATR spreading can only extend across one word boundary. In the examples in (37), the conjunctive /kɔd/ undergoes alternation depending on the order of the construction. The segments that have undergone spreading in (37) have been underlined and all other forms surface as their underlying forms. In (37a), when the [+ATR] /dede/ ‘grasshopper’ appears first, the underlying form of the conjunction surfaces and no harmony processes are seen. However, when /dede/ occurs last in the sequence, ATR spreads across one word boundary and the conjunction becomes [+ATR]. The leftmost [-ATR] word /gɔt/ ‘mountain’ is unaffected by this spread, demonstrating the limitation of the spread to one word boundary. (37b–d) demonstrate this same process.

(37)  a. dede kɔd gɔt ‘The grasshopper and the mountain’
gɔt kɔd dede ‘The mountain and the grasshopper’

b. pof kɔd bɛl ‘The grapefruit and the sorghum’
bɛl kɔd pof ‘The sorghum and the grapefruit’

c. hoho kɔd ɾɔmbɔ ‘The valley and the ram’
ɾɔmbɔ kɔd hoho ‘The ram and the valley’

d. kulo kɔd gɔt ‘The river and the mountain’
gɔt kɔd kulo ‘The mountain and the river’

This is quite clear categorical ATR spreading across a word boundary, which occurs consistently in these kinds of constructions and offers clear evidence of [+ATR] dominance and unidirectional leftward spreading.

The same kinds of patterns are seen in verbal constructions as in (38) where a [+ATR] verb root causes spreading to the previous subject, but not to the following object. In (38a) and (39a), no spreading is seen with [-ATR] verb roots. In (38b, c) and (39b), spreading occurs from the root to the preceding subject.
Swenson: ATR Quality in Luo

(38) a. ɔr ã-lúlò bel ‘The father-in-law plucked sorghum’
    b. ɔr ò-tèdò bel ‘The father-in-law cooked sorghum’
    c. ɔr ò-pógò bel ‘The father-in-law scattered sorghum’

(39) a. ɔtʃ ã-hèrò rombo ‘The fish loved the ram’
    b. ɔtʃ ò-téò rombo ‘The father-in-law cooked sorghum’

A [+ATR] object may also cause spreading to occur to a [-ATR] verb root as in (40b, d). However when this same [+ATR] noun occurs in the subject position, the [-ATR] verb root remains unaffected as in (40a, c).

(40) a. dede ã-tólò ɔr ‘The grasshopper roasted the father-in-law’
    b. ɔr ò-tólò dede ‘The father-in-law roasted the grasshopper’
    c. kulo ã-hèrò ɔtʃ ‘The river loved the fish’
    d. ɔtʃ ò-hèrò kulo ‘The fish loved the river’

In the case of a root that is inherently [-ATR] but surfaces as [+ATR] due to a dominant second person suffix (as seen in Section 4.3), this root will not trigger the same kinds of harmony processes as an inherently [+ATR] root. While an inherently [+ATR] verb root will trigger ATR spreading to occur to the preceding subject as in (38) and (39), a [-ATR] root which becomes [+ATR] due to a dominant suffix will not cause the preceding subject to become [+ATR]. In (41b, d), the preceding subject remains [-ATR] even though it is followed by a verb which surfaces as [+ATR].

(41) a. ɔr ã-tológica ‘The father-in-law roasted it’
    b. ɔr ò-tológica ‘The father-in-law roasted you’
    c. ɔtʃ ã-hèr-è ‘The fish loved him’
    d. ɔtʃ ò-hèr-è ‘The fish loved you’

The importance of the underlying ATR value is demonstrated further with the behavior of the negative particle /ɔk/ in (42). In (42a) the underlying forms are realized and the negative particle /ɔk/ remains [-ATR]. In (42b), the second person suffix causes ATR spreading to occur to the verb and its prefix. However, because the verb is not inherently [-ATR], spreading does not affect the ATR value of the negative particle. Contrast (42b) with (42c), in which an inherently [+ATR] verb does cause spreading to the preceding negative particle because of its underlying ATR value.
(42) a. ɔ̀k ɡì-sùd-è ‘They have not moved him’
b. ɔ̀k ɡì-sùd-i ‘They have not moved you’
c. ɔ̀k ɡì-tèr-è ‘They have not accompanied him’

Interestingly, the negative particle /ɔk/ behaves quite differently from the imperative negative prefix /kík-/ in example (43). As was seen in (42b), the particle in (43b) does not undergo spreading from the inherently [-ATR] verb that has surfaced as [+ATR]. In contrast, the imperative negative prefix in (43a) is affected by the word internal spreading from the second person suffix, and surfaces as [+ATR].

(43) a. kík-ó-súd-i ‘Let him not move you’
b. ɔ̀k ð-súd-i ‘He has not moved you’

The examples in (43) are evidence that the declarative negative /ɔk/ is its own particle while the imperative negative constitutes a prefix. The [-ATR] prefix undergoes spreading as a result of the dominant [+ATR] suffix, while the negative particle in (43b) does not undergo spreading because of the word boundary and the [-ATR] underlying feature of the verb root.

These examples show clearly the unidirectional nature of ATR spreading across word boundaries in Luo, following the typologically expected right-to-left direction of spreading. This is a clear indication of strong [+ATR] dominance at work in Luo and it could be assumed this same process would occur in lexical compounds from right-to-left, a fifth manifestation of [+ATR] dominance (Casali 2003) as noted in Section 4.1. Lastly, the allophonic variation of /a/ will be discussed as the fourth manifestation of [+ATR] dominance presented in this paper.

4.5 Behavior of [a]; the case of [bawo]

The low central vowel phoneme /a/ has been clearly shown to have an allophonic variant, although literature on Luo vowel systems has given this phoneme widely differing treatments. On one end of the spectrum, there are researchers who have not observed a [+ATR] allophone and consider [a] to be a neutral vowel with neither feature attributed to it (Okoth Okombo 1982, Owino 2003, Dimmendaal 2002). Secondly, there are researchers who have observed the presence of an allophonic
[ + ATR] version of /a/ (Storch 2005). Lastly, Tucker (1994) goes as far as to claim [ʌ] (or [ə]) as an admittedly rare, but distinct phoneme.

Dimmendaal (2002) offers examples (reproduced in (44) without tone markings) of [a] reverting to [ɛ] in [+ATR] scenarios, such as the switch from transitive to intransitive. This contrast was not found however in my own data of the intransitive forms of verbs with [a] in the root, shown in (45). Compare (44a) and (45a) where instead of [ɛ] in the intransitive, the root vowel appears as [ʌ] in [kʌtʃo].

(44)

<table>
<thead>
<tr>
<th>Transitive</th>
<th>Intransitive</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kajɔ</td>
<td>ketʃo</td>
<td>‘bite’</td>
</tr>
<tr>
<td>b. tʃamo</td>
<td>tʃemo</td>
<td>‘eat’</td>
</tr>
</tbody>
</table>

(45)

| a. kàjɔ̀   | kàtʃɔ́       | ‘bite’|
| b. kàdɔ̀   | kàtɔ́       | ‘overtake’|
| c. hàdɔ̀   | hàtɔ́       | ‘harden’|

Conversely, Tucker provides a brief list of minimal pairs for this set of low central vowels, but again, in my own data, the differences between most of these words were in the tone rather than vowel quality. I have reproduced a minimal pair from Tucker in (46a) and noted my own findings regarding this pair in (46b).

(46)

| a. kwʌɾo  | ‘redness’    | kwʌɾɔ²⁷  | ‘grandfather’ |
| b. kwáɾɔ́ | ‘redness’    | kwáɾɔ́   | ‘grandfather’ |

Despite the difference between Tucker’s data and my own, there was one word pair that uniquely adds to this discussion of a [+ATR] version of /a/: [bʌɔ] ‘board’ and [bɔɔ] ‘to patch.’ What is surprising in the behavior of [bʌɔ] ‘board’ is that when the [o] is dropped with the addition of possessive suffixes, the [+ATR] allophone persists and causes [-ATR] possessive suffixes to assimilate to the [+ATR] feature of the allophone, as seen in (48). In (47) as comparison, the [-ATR] verb [baɔ] behaves as expected, with a change to the root vowel in (47b) with the dominant [+ATR] second person suffix. The allophonic [ʌ] is expected as well to appear in (48b) for the same reason; the dominant second person suffix would spread to or maintain the [+ATR] quality of the root. However, in (48a) and (48c), the allophone [ʌ] in the root not only

²⁷ I have adapted Tucker’s characters to the standard IPA symbols for the sake of consistency for the reader throughout this paper.
persists, but spreads its [+ATR] feature to the inherently [-ATR] first and third person possessive suffixes. What is striking about (48a, c) is how inherently [-ATR] suffixes undergo spreading from [ʌ] in the root, behavior which would be expected of a [+ATR] phoneme, not an allophone.

(47)  a.  [ bɔw-à ]  ‘Patch me’
      b.  [ bɔw-úri ]  ‘Patch yourself’
      c.  [ bɔw-ɛ ]  ‘Patch it’

(48)  a.  [ bɔp-à ]  ‘My plank’
      b.  [ bɔp-ì ]  ‘Your plank’
      c.  [ bɔp-ɛ ]  ‘His plank’

Discrepancies within descriptions of Luo, as well as the case of [bɔo] above would seem to suggest a historical [ʌ] phoneme which still evidences remnance in the language but has lost its phonemic status in the language. Creider et. al. (1998) provide an apt understanding of this process occurring in Luo, acknowledging the disappearing [+ATR] version of /a/ especially among younger speakers. They note the particular vulnerability of the [+ATR] low central vowel to neutralization for articulatory reasons. Further, they assert the natural path Luo seems to be taking is resorting to the [e] vowel as a [+ATR] variant of [a] (cf. Dimmendaal 2002).

While Creider et. al. and Dimmendaal may be correct in that Luo has gradually lost its phonemic [+ATR] variant of /a/, the allophonic [ʌ] is still quite distinctive in this particular speaker. This was shown both in acoustic measurements (see Section 2 above) and impressionistic voice quality (being breathier than its [-ATR] counterpart). Based on the likely historical phonemic [ʌ] as well as the strong [+ATR] dominance seen in Luo, the presence of this allophone is not unexpected.

5. Second person prefixes: A case of disharmony and theoretical implications

5.1 Disharmony in second person prefixes

A question that remains untreated in Section 4 above is that of the second person verbal prefixes. Vowel harmony throughout the whole word has been clearly shown in Luo in [+ATR] spread from: (i) root to suffix, (ii) root to prefix, and (iii) suffix to root.
However, the possible existence of neutral [+ATR] prefixes in Luo suggests disharmony may occur. In cases where a second person prefix occurs on a [-ATR] verb, it was expected from a typological perspective (see Hyman 2002) for the [-ATR] prefix to also occur, but this expectation was not always met.

Acoustic difficulties were notable in measuring the formant values, as well as hearing the ATR distinctions clearly in the second person prefixes. Speaker intuition also failed to determine the underlying forms as my language consultant was unsure of the ATR values of the segments, often confusing ATR quality with tone or length. As prefixes are unstressed in Luo, typically short in duration, and generally high-toned, the formant measurements were often unsatisfactory. Interference of the fundamental frequency ($F_0$) with the first formant called the formant values of these prefixes into question. Setting these difficulties aside, there were clear instances where the prefix with [-ATR] roots surfaced as [-ATR] as in the examples in (32) and surfaced as [+ATR] as in the examples in (33). Note that both [+ATR] and [-ATR] prefixes surfaced with these [-ATR] roots, whether a high-toned prefix for present tense was used or the low-toned prefix for the recent past tense was used.

(32)  a. ɪ́-lí́r-ɛ̀ ‘You are cutting it’
    b. ʊ́-d̪ɪ̀ ‘You (PL) are going’
    c. ɪ̀-kát̪ɔ̀ ‘You have overtaken’

(33)  a. ɪ̀-só́d-ɛ̀ ‘You have moved it’
    b. ɪ-ð̪i ‘You are going’
    c. ɪ-pò́kɔ̀ ‘You are peeling’
    d. ʊ̀-só́d-ɛ̀ ‘You (PL) have moved it’
    e. ʊ̀-tɔ́kɔ̀ bèl ‘You (PL) have served sorghum’
    f. ʊ́-ká́tɔ̀ ‘You (PL) are overtaking’

Despite these variances which appear unpatterned throughout the data, the majority of second person prefixes occur as [+ATR] with [-ATR] roots as in (33). The occurrences of [-ATR] second person prefixes with [-ATR] roots seem to be anomalies. Recording the prefixes in tenses that utilized lower-toned prefixes of the recent past tense further confirmed suspicions that the most common form of the prefix was [+ATR]. Based on frequency and persistence of the [+ATR] prefix, I have therefore
assumed the underlying forms of the second person prefixes to be /i-/ for the singular and /u-/ for the plural.

5.2 Theoretical implications: Historical change afoot?

Where a [-ATR] second person prefix occurs, the question remains as to whether this is simply phonetically motivated due to the [-ATR] articulation of the rest of the word, or whether this prefix is losing its inherent [+ATR] value. Dimmendaal (2002) observes an ongoing shift in Nilo-Saharan languages towards ATR harmony patterns triggered solely by the root and towards neutral affixes becoming "weak," although he notes this shift is less so in Western Nilotic. Interestingly, it is the same second person prefixes that have been called into question by Kutsch Lojenga (1986) in the closely related language, Alur; her interpretation of what is occurring with the second person prefixes in Alur is precisely the type of historical shift Dimmendaal has described.

In Lojenga’s article on the ATR system of Alur (1986), she asserts that West African ATR languages typically display root triggered harmony patterns, while East African languages (including Western Nilotic) demonstrate ATR dominance systems not based primarily on the root. Alur, she suggests, is moving towards a type of system where all affixes are becoming [-ATR] and the root determines the ATR quality of the whole word. This she determined by noting that the children seemed to be using [-ATR] affixes with all [-ATR] roots, and the adults would alternate between using the [-ATR] forms and the [+ATR] forms of affixes in the same contexts. The context especially noted was that of the second person prefixes which were surfacing as [-ATR] among children, but both [-ATR] and [+ATR] second person forms were seen among adults; a situation very similar to what is seen in Luo second person prefixes. It remains to be seen whether the instances of variation where they surface as [-ATR] are merely phonetically motivated or whether this variation is evidence that Luo and Alur are undergoing the same kind of language shift towards historically [+ATR] prefixes becoming [-ATR]. A second question raised by Lojenga on this issue, is a more overarching one. She claims that systems in which harmony is triggered solely by the root eliminate lexical ambiguity in roots and that this is a natural progression of development. This raises the theoretical questions of, first, whether development of ATR harmony in languages does in fact progress towards root triggered harmony
patterns, and second, in considering Luo, whether the same type of progression will be seen.

It is important to note a typological consideration in explanation of this apparent disharmony occurring in Luo, namely that ATR spread from a prefix to root is very rare cross-linguistically (Hyman (2002) asserts this does occur in Kinande). Motivations for a restriction on prefix-control in languages are clear as Hyman (2002) suggests the most optimal environments for ATR spread are first, from prominent segments (roots) to weaker segments (affixes), and second, as an anticipatory process (from right-to-left) due to articulatory and perceptual factors. Prefixes satisfy neither of these criteria and are thus rarely seen as triggers of ATR harmony.

A second important typological consideration regarding Western Nilotic languages is the pervasiveness of neutral cognate subject prefixes (i.e. subject prefixes which keep their inherent [+ATR] or [-ATR] features and do not trigger or undergo ATR spreading) (Dimmendaal 2002). In general, the pronominal pattern of Nilo-Saharan languages for 1st/2nd/3rd person is characterized by the vowels A/I/E respectively, or O in the case of many third-person prefixes (Bender 2000). This pattern may appear in independent pronouns or in affixes marked on the root. The ATR quality of the affixes and their resulting harmony patterns vary per language, but there is a tendency of the underlying forms of the first and third person forms to be [-ATR] and the second person forms to be underlyingly [+ATR]. Dimmendaal (2002) notes that the second person prefix /i-/ in Lango, a language closely related to Luo, is opaque and not only does it not alternate to harmonize with the root, it blocks spreading to other segments (see also Noonan 1992). The presence of a [+ATR] neutral prefix for the second person is not undocumented in closely related languages and it is thus safe to assume this is what occurs in Luo.

Casali (2012) has noted the presence of ‘exceptional affixes’ which are neutral and neither undergo spreading nor trigger spreading, and asserts these are quite common in ATR languages. This seems to be the case with the second person prefixes in Luo which are inherently [+ATR] but never trigger spreading. Lojenga’s application of second person prefixes in Alur to typology and patterns of historical change in ATR languages is a noteworthy consideration. Whether the second person prefixes in Luo are losing their inherent [+ATR] feature and becoming [-ATR] cannot be answered from the data presented here and is a subject for further research. However, Lojenga’s claim that Alur
may be moving in the direction of harmony patterns characterized primarily by ATR assimilation to the root seems far removed from Luo. Rather, Luo shows strong harmony patterns of [+ATR] dominance in multiple environments as seen in the manifestations of ATR dominance represented in the data above.

6. Conclusion

In conclusion, the Luo vowel system shows many aspects of [+ATR] dominance in the presence of [+ATR] spread from roots to affixes, dominant [+ATR] suffixes triggering harmony in the root, leftward spreading across word boundaries, and in the presence of a [+ATR] allophonic version of /a/. The suprasegmental nature of the ATR feature may also be seen in the phenomenon of grammatical ATR, a process common in Western Nilotic languages. The neutral [+ATR] second person prefixes and the occasional [-ATR] free variance of these prefixes with [-ATR] roots raises questions as to whether these prefixes are losing their inherent [+ATR] feature, either as the result of historical change in process or phonetic motivations. Some have suggested Luo resembles or is moving towards patterns seen in ATR languages which are dominated by harmony patterns triggered by the root. However, other harmony patterns at work in the language are robust and have yet to show this type of shift is at work.

The acoustic properties of ATR in Luo are also challenging in terms of articulatory properties and in regard to the wide variance of ATR articulatory mechanisms utilized by speakers. However, much can be gained with instrumental acoustic analysis. The first formant measurements are the primary correlate and are highly useful in determining ATR distinctions, even among the high vowels. Given this framework of ATR acoustic measurements and of harmony processes at work in Luo, we can better understand the phonological changes seen in the ATR quality of the Luo vowel system.
Appendix A: Language distribution for Western Nilotic languages

Illustration by Monika Feinen, The Cologne Institute, reproduced with permission from Storch (2005:19).
## Appendix B: Contexts of recorded vowels

<table>
<thead>
<tr>
<th></th>
<th>P_k</th>
<th>P_ᵄ</th>
<th>L_r</th>
<th>K_t</th>
<th>P_k</th>
</tr>
</thead>
<tbody>
<tr>
<td>i]</td>
<td>tik ‘smell’</td>
<td>pit ‘large pile’</td>
<td>dir ‘push’</td>
<td>kit ‘stone of..’</td>
<td>tik ‘chin’</td>
</tr>
<tr>
<td>i]</td>
<td>sik ‘stay forever’</td>
<td>pit ‘produce’</td>
<td>lir ‘strip’</td>
<td>gid ‘tickle’</td>
<td>pik ‘push through’</td>
</tr>
<tr>
<td>u]</td>
<td>tuk ‘move’</td>
<td>put ‘cripple’</td>
<td>lur ‘walk carefully’</td>
<td>kut ‘deep hole’</td>
<td>puk ‘pour’</td>
</tr>
<tr>
<td>o]</td>
<td>suk ‘braid’</td>
<td>büt ‘relax’</td>
<td>lur ‘pluck’</td>
<td>got ‘somberness’</td>
<td>bük ‘provoke’</td>
</tr>
<tr>
<td>e]</td>
<td>dek ‘be late’</td>
<td>peł ‘spread’ (Tr.)</td>
<td>ler ‘vein’</td>
<td>ket ‘put’</td>
<td>lek ‘dream’</td>
</tr>
<tr>
<td>ε]</td>
<td>tek ‘hard’</td>
<td>peł ‘spread’ (Int.)</td>
<td>ler ‘light’</td>
<td>ket ‘stick of...’</td>
<td>peł ‘weight’</td>
</tr>
<tr>
<td>o]</td>
<td>tok ‘back’</td>
<td>büt ‘taste, texture’</td>
<td>lor ‘close’</td>
<td>kot ‘coat’</td>
<td>pok ‘inheritance’</td>
</tr>
<tr>
<td>ɔ]</td>
<td>tok ‘serve’</td>
<td>poł ‘smooth’</td>
<td>lor ‘descend’</td>
<td>got ‘mountain’</td>
<td>pok ‘peel’</td>
</tr>
<tr>
<td>a]</td>
<td>dak ‘stay’</td>
<td>bat ‘side’</td>
<td>lar ‘threshing floor’</td>
<td>kat ‘braid’</td>
<td>pak ‘cheer’</td>
</tr>
</tbody>
</table>

Words used for the allophone [ʌ]:

<table>
<thead>
<tr>
<th>Phonemic Form</th>
<th>Phonetic Form</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>lak-i</td>
<td>łak-i</td>
<td>'your tooth'</td>
</tr>
<tr>
<td>lak-u</td>
<td>łak-u</td>
<td>'your (PL) tooth'</td>
</tr>
<tr>
<td>sad-i</td>
<td>säd-i</td>
<td>'your shirt'</td>
</tr>
<tr>
<td>sad-u</td>
<td>säd-u</td>
<td>'your (PL) shirt'</td>
</tr>
<tr>
<td>mbak-i</td>
<td>mbäk-i</td>
<td>'your story'</td>
</tr>
<tr>
<td>mbak-u</td>
<td>mbäk-u</td>
<td>'your (PL) story'</td>
</tr>
<tr>
<td>bap-i</td>
<td>bap-i</td>
<td>'your plank'</td>
</tr>
</tbody>
</table>
References


