Vowel Harmony in QFLFP

Eileen Blum[1]

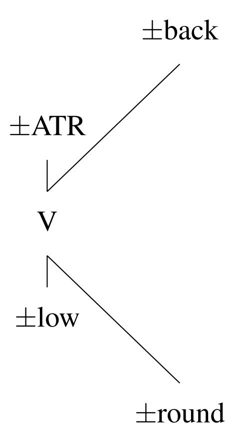
1 Introduction

Last time we talked about vowel harmony transformations with neutral vowels. We saw how QFLFP can be used to describe spreading and blocking over strings. Dine, then introduced two-tiered autosegmental representations of tone and showed that we can also use QFLFP to describe autosegmental spreading (Chandlee & Jardine, 2019; Goldsmith, 1976). Today, I will combine these two approaches to show that QFLFP can be used to describe spreading and blocking of vowel features over multi-tiered autosegmental representations.

1.1 Multi-tiered ARs of vowel harmony

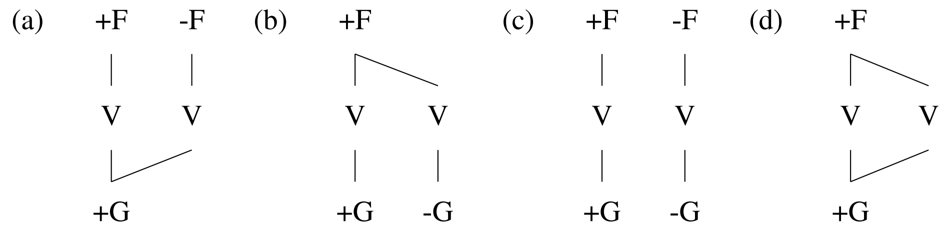
Unlike for tone, we will represent vowel harmony patterns using autosegmental representations (ARs) with more than two tiers. Ignoring consonants, we can assume there is one tier, which consists of vowels and each feature (i.e. ATR, back, low, round, etc.) is represented on a separate tier with both its + and - minus values. Assuming a bottlebrush feature configuraton, each feature tier is connected to the vowel tier via association, as shown in (1).

(1) Bottlebrush configuration with a multi-tiered AR



A single vowel is thus necessarily associated to multiple feature tiers. Assuming both the Obligatory Contour Principle (OCP) and the No Crossing Constraint (NCC), multi-tiered ARs of vowel harmony can utilize multiple association, but only in one direction; a single vowel cannot be associated to both the + and - value of a feature. The possible surface configurations of association that include both + and - values on a tier are shown in (2).

(2) Possible vowel harmony ARs



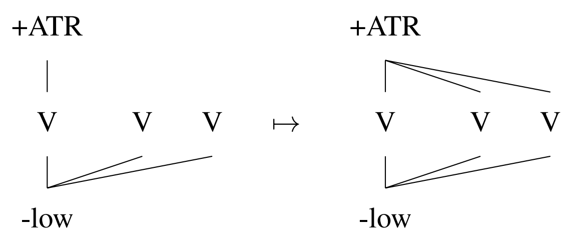
In (2a) two vowels are associated to a single +G feature and in (2b) two vowels are associated to a single +F feature. However, if we assume both the OCP and the NCC then on any feature tier if both the + and - values of a feature are present they must be associated to different vowels, as in (2a-c). Lastly, (2d) shows full spreading where both vowels are associated to a single feature on each tier.

2 Association Relation

2.1 Unbounded spreading

Following Dine's logical characterization of ARs, we could define each element on each tier and a binary association relation that holds between them. For example, a vowel harmony pattern like the one in Akan can be described as an ATR feature spreading from the left until it is blocked by a +low vowel (Clements, 1976). A word with no +low vowels will show unbounded feature spreading, as in (3).

(3) Unbounded Feature Spreading



Unbounded feature spreading is straightforwardly captured with QFLFP because all surface features are found underlyingly and the associations can be said to spread iteratively. We thus define a unary relation for vowels and each feature (separate ones for + and - values).

(4) $\langle \mathrm{D}; \mathrm{p}, \mathrm{s}, \mathscr{A}, \mathrm{P}_V, \mathrm{P}_{+ATR}, \mathrm{P}_{-ATR}, \mathrm{P}_{+low}, \mathrm{P}_{-low} \rangle$

$$\mathrm{P}'_V(x) \stackrel{\text{def}}{=} \mathrm{P}_V(x)$$

$$\mathrm{P}'_{+ATR}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+ATR}(x) \qquad \mathrm{P}'_{-ATR}(x) \stackrel{\text{def}}{=} \mathrm{P}_{-ATR}(x)$$

$$\mathrm{P}'_{+low}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+low}(x) \qquad \mathrm{P}'_{-low}(x) \stackrel{\text{def}}{=} \mathrm{P}_{-low}(x)$$

We can also define two association relations, between the vowel tier and each feature tier.

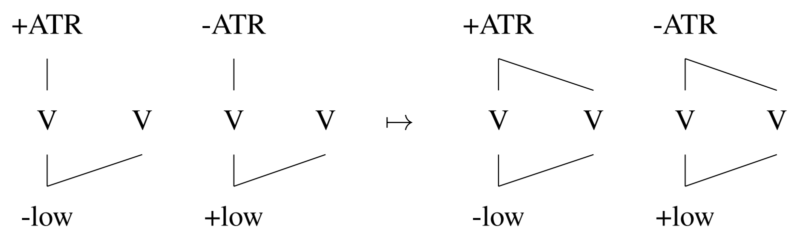
$$\mathscr{A}'_{ATR}(x,y) \stackrel{\text{def}}{=} \mathscr{A}_{ATR}(x,y) \vee [lfpR(x', p(y'))](x,y)$$

$$\mathscr{A}'_{low}(x,y) \stackrel{\text{def}}{=} \mathscr{A}_{low}(x,y) \vee [lfpR(x', p(y'))](x,y)$$

2.2 Blocking

However, Akan ATR harmony is blocked by a +low vowel so we need to add a restriction to these association definitions. If we stipulate that +low vowels are underlyingly specified for ATR, we will see something like (5).

(5) Blocking



Again, each feature and all the vowels only appear in the output structure if they are present in the input structure. The idea that we want to capture is that a feature spreads from one vowel onto successive *unassociated* vowels and stops when it reaches another vowel that is *underlyingly associated*. Is it possible to incorporate blocking into the definitions of the binary association relation?

(6) $\langle \mathrm{D}; \mathrm{p}, \mathrm{s}, \mathscr{A}, \mathrm{P}_V, \mathrm{P}_{+ATR}, \mathrm{P}_{-ATR}, \mathrm{P}_{+low}, \mathrm{P}_{-low} \rangle$

$$\mathrm{P}'_V(x) \stackrel{\text{def}}{=} \mathrm{P}_V(x)$$

$$\mathrm{P}'_{+ATR}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+ATR}(x) \qquad \mathrm{P}'_{-ATR}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+ATR}(x)$$

$$\mathrm{P}'_{+low}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+low}(x) \qquad \mathrm{P}'_{-low}(x) \stackrel{\text{def}}{=} \mathrm{P}_{+low}(x)$$

$$\mathscr{A}'_{ATR}(x,y) \stackrel{\text{def}}{=} \mathscr{A}_{ATR}(x,y) \vee [lfpR(x', p(y')) \wedge \ldots]$$

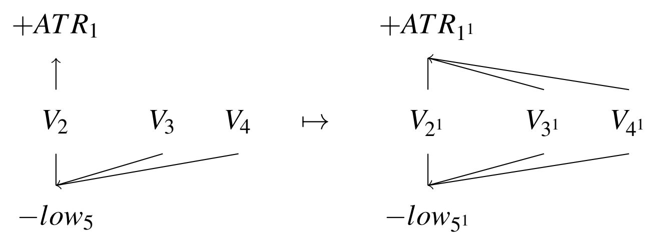
$$\mathscr{A}'_{low}(x,y) \stackrel{\text{def}}{=} \mathscr{A}_{low}(x,y) \vee [lfpR(x', p(y')) \wedge \ldots]$$

3 Association as a function

An alternative approach would be to describe the associations between the vowel tier and each feature tier as a function. Because multiple association is possible with multi-tiered ARs, association can only be a function if it is unidirectional. If you look back at the possible structures in (2), in which direction could a function that holds between tiers operate?

A separate association function (let's call it α) must be defined for each feature tier. Since featural associations are all the same type of function ($\alpha_F(x) \approx y$) they will work in the same way. An example transformation for the Akan-like pattern is given in (7) using the unidirectional association functions represented with arrows from vowels to a feature. In order to evaluate $\alpha_F(x) \approx y$, the variable x would be used for an element on the vowel tier and y for an element on a feature tier.

(7) Association as a unidirectional function



Can we define the two association functions for the transformation in (7)?

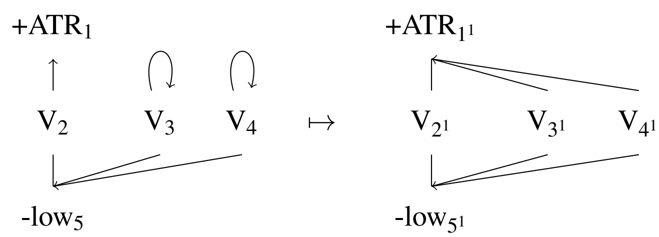
$$\alpha'_{ATR}(x) \approx y \overset{\text{def}}{=} \alpha_{ATR}(x) \approx y \vee [lfpR(p(x'),y')](x,y)$$

$$\alpha'_{low}(x) \approx y \overset{\text{def}}{=} \alpha_{low}(x) \approx y \vee [lfpR(p(x'),y')](x,y)$$

3.1 Total Function

Remember the string relations that we are now considering as functions: predecessor and successor. In the current system, these are both total functions over strings because each element in the input string has a predecessor and a successor, including the first and last one respectively. In other words, the first element in a string is its own predecessor and the last element in a string is its own successor. Could we extend this idea to ARs? For ARs, how could we make association a total function? Let's take a look at (7) again. First, all elements on the vowel tier must be associated to something. Notice the input AR is underspecified because the vowels 3 and 4 are not associated to any ATR feature. We can solve this in the same way that we did for strings. We can say that unspecified vowels in the input are associated to themselves and then our definitions for output association will overwrite the input associations to spread the feature to all vowels. This will make the unbounded spreading ARs look like (8)

(8) Association as a total function

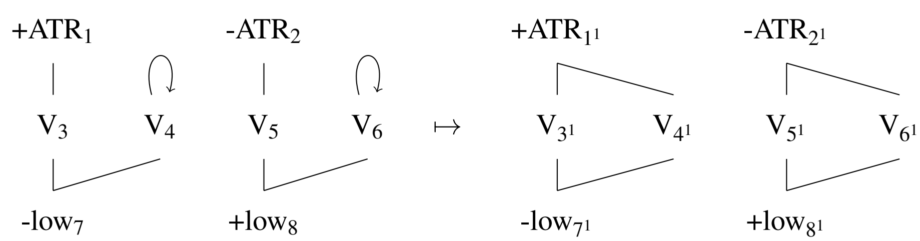


Including looping associations in the input will now allow us to refer to unspecified vowels, which we could not do with the binary association relation.

3.2 ATR spread with blocking

The major advantage of defining association as a function rather than a binary relation is that we can use QFLFP to describe ATR spreading with blocking. We can now write the complete AR transformation for blocking by adding to (5), as in (9).

(9) Blocking



Using QFLFP we can now describe a transformation that spreads a feature association from one vowel only to an adjacent *unspecified* vowel. First, we can define an unspecified element in the same way that we defined the first and last elements in a string. Since we define separate functions for each feature tier, we must do the same with this new predicate; the vowels in (9) are unspecified for ATR, but not low. How would you define the $\mathrm{unspec}_F(x)$ predicate?

$$\mathrm{unspec}_{ATR}(x) \stackrel{\text{def}}{=} \alpha_{ATR}(x) \approx x$$

$$\mathrm{unspec}_{low}(x) \stackrel{\text{def}}{=} \alpha_{low}(x) \approx x$$

Next, we can define the unary relations for each element in the same way we have been so far.

(10) $\langle$D; p, s, α, P_V, P_{+ATR}, P_{-ATR}, P_{+low}, $P_{-low}\rangle$

$$P'_V(x) \stackrel{\text{def}}{=} P_V(x)$$

$$P'_{+ATR}(x) \stackrel{\text{def}}{=} P_{+ATR}(x) \qquad P'_{-ATR}(x) \stackrel{\text{def}}{=} P_{-ATR}(x)$$

$$P'_{+low}(x) \stackrel{\text{def}}{=} P_{+low}(x) \qquad P'_{-low}(x) \stackrel{\text{def}}{=} P_{-low}(x)$$

Lastly using the predicate $\text{unspec}_F(x)$ defined above, how can we define the two association functions needed to describe the ATR harmony pattern with blocking?

$$\alpha'_{ATR}(x) \approx y \stackrel{\text{def}}{=} [lfp(\alpha_{ATR}(x) \approx y \wedge \neg unspec_{ATR}(x)) \vee (R(p(x'), y') \wedge unspec(x'))](x,y)$$

$$\alpha'_{low}(x) \approx y \stackrel{\text{def}}{=} \alpha_{low}(x) \approx y](x,y)$$

4 Further Questions

So we can use QFLFP to describe feature spreading with and without blocking when autosegmental association is a function. The next question I will investigate is: Can we use QFLFP and the association function to describe the behavior of other neutral vowels, i.e. transparent vowels?

5 References

Chandlee, J., & Jardine, A. (2019). Autosegmental input strictly local functions.

Clements, G. (1976). Vowel harmony in non-linear generative phonology: An autosegmental model. Bloomington, Indiana University Linguistics Club.

Goldsmith, J. (1976). *Autosegmental phonology* (PhD thesis). Massachusetts Institute of Technology.