27 Multi-linear approaches to vowel harmony

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27.1 Introduction

Autosegmental Phonology represents each feature as an ordered element on a separate tier (Goldsmith 1976), and this approach has been extensively used to capture vowel harmony. In particular, autosegmental representations can capture the distinction between the main types of segmental roles in vowel harmony: triggers, targets, transparent segments, and opaque segments (blockers). The core idea of this approach is that harmony exists because a feature of a trigger segment is extended to—or in the terminology of Autosegmental Phonology, becomes associated with—the target segment.

In section 27.2, this chapter explores how association works, and how targets are distinct from blockers, which terminate harmony. In most autosegmental approaches, there is no limit to how many segments can be associated with a particular feature, but some models restrict multiple associations; these proposals will be reviewed in section 27.3. Finally, we will look at Feature Geometry, which establishes relationships between features of each segment. Feature Geometry is particularly suited to capturing locality of vowel harmony, and these predictions will be explored in section 27.4.

27.2 Autosegmental Phonology and vowel harmony

In classic Generative Phonology (Chomsky & Halle 1968), segmental features were organized into matrices, meaning that each segment consists of its features that are listed (see Chapter 26, this volume). Autosegmental Phonology (Goldsmith 1976) introduced a way to represent segments and their featural content on more than one tier. While the model has been developed for tone, the similarity between tonal and vowel patterns allowed for concurrent extension of the model to capture vowel harmony (Clements 1976a,b; Goldsmith 1985).

Autosegmental Phonology represents relationships between segments and features using association lines. In (1a) we see a representation of a segment that has a feature [F]: the segment's root node ('×') is associated with the feature [F]. The segment in (1b), in contrast, does not contain [F]. Root nodes are ordered linearly with respect to other root nodes on the segmental tier, and the same is true for the features; effectively, each feature is on a separate tier where only other instances of that same feature exist.

(1) Autosegmental representations

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        [F]
         |
a.       ×          b.    ×
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Unlike the representation in (1a), where a feature is associated with one root node, assimilation represents a situation in which a feature is linked to multiple root nodes. To illustrate, we will first look at how autosegmental representations work for tonal patterns, for which they were first developed.

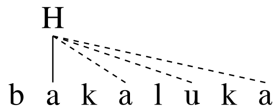
In many languages, a particular tone may extend from one vowel to other vowels within some domain, such as a word. Consider the data in (2), which comes from Bemba (Niger-Congo/Bantu; Bickmore & Kula 2013; Kula & Bickmore 2015; Kula & Braun 2015). In Bemba, the root 'explain' (2a) has no underlying High tone and surfaces as low when flanked by toneless affixes (transcribed without diacritics). The subject marker /bá-/ has an underlying High tone, which extends rightwards to all vowels within a word, including the root 'explain' (2b) and 'plait' (2c).

(2) Unbounded High tone spreading in Bemba (Kula & Braun 2015)

a. tu-ka-loondolol-a	b. bá-ká-lóóndólól-á	c. bá-ká-lúk-á
1PL-FUT3-explain-FV	2SM-FUT3-explain-FV	2SM-FUT3-plait-FV
'We will explain.'	'They will explain'	'They will plait.'

In Autosegmental Phonology, the vowel or another tone bearing unit that has a High tone is associated with this High tone. When the tone is realized over multiple vowels, as in Bemba, association lines are added between the High tone (marked simply as 'H') and the vowels, as indicated by dashed lines in (3). This operation is termed spreading.

(3) Bemba High tone spreading



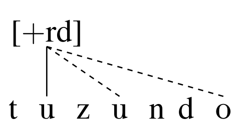
Vowel harmony appears to be very similar to tone spreading. Consider Kyrgyz (Turkic), which is detailed in Chapter 59, this volume, in which words may contain rounded or unrounded vowels, but not both. The initial vowel determines all subsequent vowels within the same word. In (4a) we see that an unrounded root vowel is followed by the ablative suffix containing an unrounded vowel. When the root contains a round vowel, the ablative suffix is realized with a round vowel as well (4b). The same pattern is observed with multiple suffixes in (4c).[1]

(4) Rounding and backness harmony in Kyrgyz (Comrie 1981)

a.	et	'meat-NOM'	et-ten	'meat-ABL'
	alma	'apple-NOM'	alma-dan	'apple-ABL'
b.	yj	'house-NOM'	yj-døn	'house-ABL'
	tuz	'salt-NOM'	tuz-don	'salt-ABL'
c.	ata-sɯn-da	'at his father'	tuz-un-do	'in his salt'
	ene-sin-de	'at his mother'	køz-yn-dø	'in his eye'

There is a clear similarity between tone spreading in Bemba and vowel harmony in Kyrgyz: in both cases a property of the initial vowel extends to subsequent vowels. This representation of vowel harmony as spreading is presented in (5). The [+round] autosegment (abbreviated as [+rd]) originating from the initial vowel becomes associated with all subsequent vowels within the word. The dashes are notational, indicating that the association lines are created by a rule.

(5) Kyrgyz [+round] spreading



The autosegmental mechanics can be extended to capture the basic asymmetries found in vowel

[1]Recent work suggests that the Kyrgyz facts may be more complex than presented here. In particular, the high back vowel does not seem to trigger harmony in most instances. See Chapters 5 and 59, this volume for further discussion.

harmony—including directionality, transparency and blocking—which will be reviewed in the remainder of this chapter.

Let us first turn to blocking, a situation in which a particular segment (a vowel) prevents vowel harmony from applying to further vowels. The main mechanism of blocking in autosegmental phonology is the *No Crossing Constraint* (Hammond 1988; Sagey 1988). This is a well-formedness condition that prohibits association lines between the root node and a particular feature from crossing.

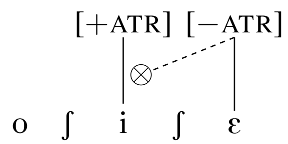
Consider ATR harmony in Standard Yoruba (Niger-Congo/Volta–Niger), which is further discussed in Chapters 7, 21 and 51, this volume. In Standard Yoruba, the vowels within a word generally match in tongue root position. Advanced tongue root (ATR) vowels are preceded by ATR prefix vowels (6a). Retracted tongue root (RTR) mid vowels are preceded by RTR prefix vowels (6b); low vowels display additional complications, which are not considered here. High vowels interrupt harmony: the root-final RTR vowel in (6c) would be expected to trigger retraction in the prefix vowel, but this is blocked by a high vowel, so the prefix surfaces as ATR. The same generalizations apply within roots (6d), demonstrating that harmony is regressive (right-to-left).

(6) Yoruba vowel harmony (Awobuluyi 1967; Archangeli & Pulleyblank 1989; Pulleyblank 1996)

a.	ʃewe	‘publish a book’	o-ʃewe	‘publisher’
	ɟowu	‘be jealous’	o-ɟowu	‘jealous person’
b.	kɔsɛ	‘refuse’	ɔ-kɔsɛ	‘person who refuses [. . .]’
	ɟɛũ	‘eat’	ɔ-ɟɛũ	‘glutton’
c.	iʃɛ	‘work’	o-ʃ-iʃɛ	‘workman’
	odi̠dɛ	‘Grey Parrot’	*ɔdidɛ	

Autosegmentally, the prefix vowels can be analyzed as underlyingly [+ATR] but become retracted due to [−ATR] spreading. Alternatively, the Yoruba prefix mid vowels lack the specification for [ATR], which they acquire from the closest root vowel (for further discussion of underspecification in vowel harmony, see Kiparsky 1985; Archangeli 1988; Steriade 1995; Chapter 14, this volume). High vowels are [+ATR] and act as blockers, making association of the prefix vowel impossible (7). Subsequent rules associate the initial vowel with the default or blocker's [+ATR].

(7) Yoruba high vowel blocking (no crossing permitted)



If we compare Yoruba with Kyrgyz, we see several typological differences that can be successfully captured in classic autosegmental phonology. In addition to the harmonizing feature and blockers, we also see a directional difference: Yoruba harmony is regressive, whereas Kyrgyz is progressive. This difference may have to do with the prefixing tendency of Yoruba as opposed to the suffixing tendency found in Kyrgyz.

Another aspect in which vowel harmony is similar to tonal patterns involves floating features (Tadejeu 1974; Clements & Ford 1979). Floating features are not associated with a segment in the underlying representation but can become associated with a segment due to a rule, and thus surface in morphologically complex words. Floating vowel place features can be used to account for exceptional behavior in some vowel harmony systems. Consider an example from Hungarian (Uralic), which is also discussed in Chapters 21, 36, and 67, this volume. Hungarian has backness harmony: when the root contains a front vowel, the suffixes surface with front vowels (8a). After roots with back vowels, the suffixes surface with back vowels (b). Front unrounded vowels [i iː ɛ eː] can be followed either by suffixes with front vowels (8c) or back vowels (d), and this choice is lexically determined.

(8) Hungarian vowel harmony (Siptár & Törkenczy 2000)

		'DATIVE'	'ABLATIVE'	
a.	tyːz	tyːz-nɛk	tyːz-tøːl	'fire'
	ørøm	ørøm-nɛk	ørøm-tøːl	'mirror'
b.	haːz	haːz-nɒk	haːz-toːl	'house'
	kosoruː	kosoruː-nɒk	kosoruː-toːl	'wreath'
c.	viːz	viːz-nɛk	viːz-tøːl	'water'
	kɛrt	kɛrt-nɛk	kɛrt-tøːl	'garden'
d.	hiːd	hiːd-nɒk	hiːd-toːl	'bridge'
	dɛreːk	dɛreːk-nɒk	dɛreːk-toːl	'waist'

A standard autosegmental way to represent Hungarian vowel harmony is to posit that the [back] feature of the root vowel spreads to all suffix vowels (Goldsmith 1985; Ringen 1988; Kirchner 1993; Ringen & Vago 1998). According to this analysis, the feature [+back] would spread from the roots with back vowels (8b), and the feature [−back] would spread from front vowels (8a). This includes the front unrounded vowels [i iː ɛ eː] in (8c), as shown in (9a) below. The exceptional roots that have front vowels that trigger backness harmony (8d) can be represented with a floating feature [+back] on the root that docks on suffix vowels (9b).

(9) Hungarian floating features

Floating features can capture the exceptional behavior of specific roots, as in Hungarian. The question that remains is whether floating features can be present on the surface or are always deleted by a subsequent rule. For surface floating tones, one proposal is that they can be used to represent downstep (Pulleyblank 1986; Stewart 1993; Snider 1999), but this is not without controversy (Odden 1986). There is no such proposal for surface floating segmental features, although Benus & Gafos (2007) show that the articulation of Hungarian front unrounded vowels [i, iː, eː, ɛ] differs very slightly depending on whether these vowels appear in roots that take front or back vowel suffixes, even when no suffixes are present (although these differences were not replicated by Markó et al. 2019). Benus & Gafos's results may constitute the most convincing evidence so far for the phonetic realization of floating segmental features.

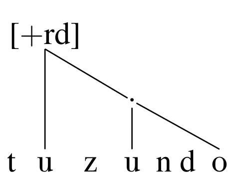
27.3 Binary-branching approaches

In most autosegmental approaches, there is no distinction among association lines linked to the same autosegment: they are all equivalent. Representationally, autosegmental approaches must rely on rules or constraints to capture the difference between spreading to one versus more targets.

The alternative approach to spreading is to restrict the branching to one or two associations. This approach originates from the metrical approaches to association lines (Vergnaud 1977; Zubizarreta 1979; Halle & Vergnaud 1980, 1981; Kaye 1982; Poser 1982; Leben 1982; Hagberg 2006). These approaches limit the branching of association lines to being unary or binary, with subsequent targets requiring additional feature nodes. Once these additional targets are considered the approaches differ in detail. In Vergnaud (1977, 1980), for instance, each target constitutes a binary domain to which the trigger associates, meaning that there is a feature node to which both root nodes link. Another approach, discussed immediately below, creates an unbounded domain with each additional target, so that adjacent vowels are within the same domain.

To illustrate, recall Kyrgyz rounding harmony, presented in (4). In the standard, non-hierarchical model in (5) a single autosegment is directly linked to the trigger and multiple targets. The same form can be also captured using a binary-branching alternative. This representation is presented in (10).

(10) Binary-branching representation of autosegmental spreading



The feature [+round] is linked to the initial [u] and a feature node (represented with '·'), which itself is further linked to two root nodes (the second [u] and [o]). In this representation, the binary domain created is asymmetrical, as indicated by the alignment of nodes: each vowel that is vertically aligned with a binary branching node is a head of [+round]. Thus, the first two vowels are headed, and the last one is not. Headedness has been used with respect to harmony in other approaches, such as in the Optimal Domains Theory (Cole & Kisseberth 1995; Cassimjee & Kisseberth 1998; Chapter 31, this volume), Headed Spans (McCarthy 2004), Dependency Phonology (Anderson & Ewen 1987; Chapter 29, this volume), Government Phonology (Charette & Göksel 1998; Ritter 1999), and Radical CV Phonology (Hulst 2018, 2020) albeit the details and the distribution of heads in these approaches differ.

Binary-branching representations allow for a surface distinction between different kinds of roles that segments can have in vowel harmony. The prediction of the binary-branching model is that two segments could be associated with the spreading feature, but only one would trigger harmony (Vergnaud 1980; Halle & Vergnaud 1980). For instance, in Turkish only high vowels can be targets of rounding harmony, but there is no height restriction on the triggers (Kaun 1995). In binary-branching approaches, the asymmetries between the triggers and targets can be represented by headedness. To illustrate, consider Baiyinna Oroqen (also known as Orochen; Tungusic; Zhang 1996; Walker 2014; Dresher & Nevins 2017; Chapters 5, 14, and 61, this volume). In Baiyinna Oroqen, initial short round vowels are followed by other round vowels, while unrounded vowels are followed by unrounded vowels (11a). Initial long round vowels do not trigger harmony: the following vowels are always unrounded (11b). Lastly, long vowels are targets of harmony in non-initial syllables (11c).

(11) Baiyinna Oroqen rounding harmony (Li 1996)

a.	olˈkok	'hazel'	ˈməktʃin-ə	'river bank'
	somˈsok-jo	'pasture-INDEF.ACC'	bɪra-ˈja	'river'
b.	ˈkoːməxə	'windpipe'	kɔːˈxan	'child'
c.	oˈloː-mo-tʃo	'to cook-INTEN-PT.T'	ɔpɔː-ˈlɔː	'rocky hillrock-DESTIN'

The descriptive generalization in this data is that only (initial) short vowels can trigger rounding harmony, while long vowels cannot. One way to capture this generalization representationally is to say that the binary-branching tree can only be built off a short round vowel, but not off a long vowel. Put differently, headed segments must be short, and because long vowels cannot be headed, they do not trigger vowel harmony.

Baiyinna Oroqen presents a distinction between triggers and targets, but the binary-branching approaches make a further distinction between the targets themselves. In the representation in (10), each binary branch distinguishes headedness. All segmental nodes but the very last are heads. This allows for a distinction between the targets that can allow further spreading and the ones that do not. The former can be heads of a feature, whereas the latter cannot and thus block further spreading.

The vast majority of targets in the world's languages have no effect on subsequent spreading, but there are cases of segments that can be targets of spreading while still blocking further spreading. This class of targets is termed *icy targets* (Jurgec 2011) or more recently, *absorbing vowels* (Hulst 2018). One of the clearest cases comes from u-umlaut in Icelandic (Indo-European/Germanic), which is further discussed in Chapter 68, this volume. Icelandic u-umlaut is triggered by a suffix containing [ʏ], targeting the root vowels. This can be characterized as concurrent fronting, rounding, and raising of [a]. The dative plural suffix fronts and rounds a single root vowel (12a).

(12) Icelandic u-umlaut (Anderson 1972, 1974; Orešnik 1975, 1977)

	'NOM.SG'	'DAT.PL'	
a.	b[a]rn	ˈb[œ]rn-[ʏ]m	'child'
	m[ɛ]ð[a]l	m[ɛ]ð[œ]lʏm	'medal'
b.	ˈh[ɛ]r[a]ð	ˈh[ɛ]r[ʏ]ˌð-[ʏ]m	'district'
	ˈ[ɔ]ð[a]l	ˈ[ɔ]ð[ʏ]ˌl-[ʏ]m	'allodium'
c.	ˈf[a]tn[a]ð	ˈf[œ]tn[ʏ]ˌð-[ʏ]m	'suit of clothes'
	ˈb[a]k[a]ˌri	ˈb[œ]k[ʏ]ˌr-[ʏ]m	'baker'
d.	ˈj[a]p[a]ˌni	ˈj[a]p[œ]ˌn-[ʏ]m	'Japanese'
	ˈ[a]lm[a]ˌn[a]k	ˈ[a]lm[a]ˌn[œ]k-[ʏ]m	'calendar'

U-umlaut interacts with vowel reduction, which raises unstressed/non-initial [œ] to [ʏ] (12b). In roots with multiple [a]'s, all vowels harmonize and the non-initial vowels further reduce to [ʏ] (12c). So, ˈf/a/tn/a/ð-/ʏ/m 'suit of clothes-DAT.PL' first shows umlaut of the root-final /a/ ˈf[a]tn[œ]ˌð[ʏ]m, followed by reduction ˈf[a]tn[ʏ]ˌð[ʏ]m, and finally umlauting of the first /a/, which cannot raise: ˈf[œ]tn[ʏ]ˌð[ʏ]m. In certain classes of words, including many loanwords, reduction fails to apply, which means that the root-final [a] turns to [œ], blocking further umlaut (12d). This suggests that if the vowel is not high, u-umlaut affects that vowel but is blocked from applying to preceding vowels. Put differently, in order for targets to propagate the umlaut, they need to be high. Because reduction does not apply to the class of loanwords in (12d), umlaut is blocked at the first target it encounters.[2]

It is worth noting that it is not sufficient to claim that the key distinction between icy and other targets is whether they are derived or not—all targets are derived in a harmony process. It has to be that there are two kinds of targets and they can be distinguished in terms of additional features. In Icelandic, triggers and non-icy targets are high (ʏ), whereas icy targets are non-high (a → œ). This captures the distinction between triggers and most targets on the one hand, and icy targets on

[2] As noted by Hansson & Wiese, Chapter 68, the pattern involves morphological exceptionality, such as suffixes without [ʏ] that trigger umlaut, suffixes with [ʏ] that fail to trigger it, and some variation across and within speakers.

the other hand in an intuitive representational model. In the binary-branching representation such as in (10), headedness is linked to the ability of segments to trigger or propagate the spreading feature. In Icelandic, heads must be [high], which means that high vowels can trigger harmony as well as pass it along to subsequent targets. When the target is not high, however, a head cannot be created on that vowel, which stops further spreading. Beyond Icelandic, icy targets have been found in a few other vowel harmony systems, such as Menominee (Algic/Algonquian; Walker 2018) and Karajá (also known as Iny rybè; Macro-Jê; Ozburn & Leduc 2022; Chapter 55, this volume).

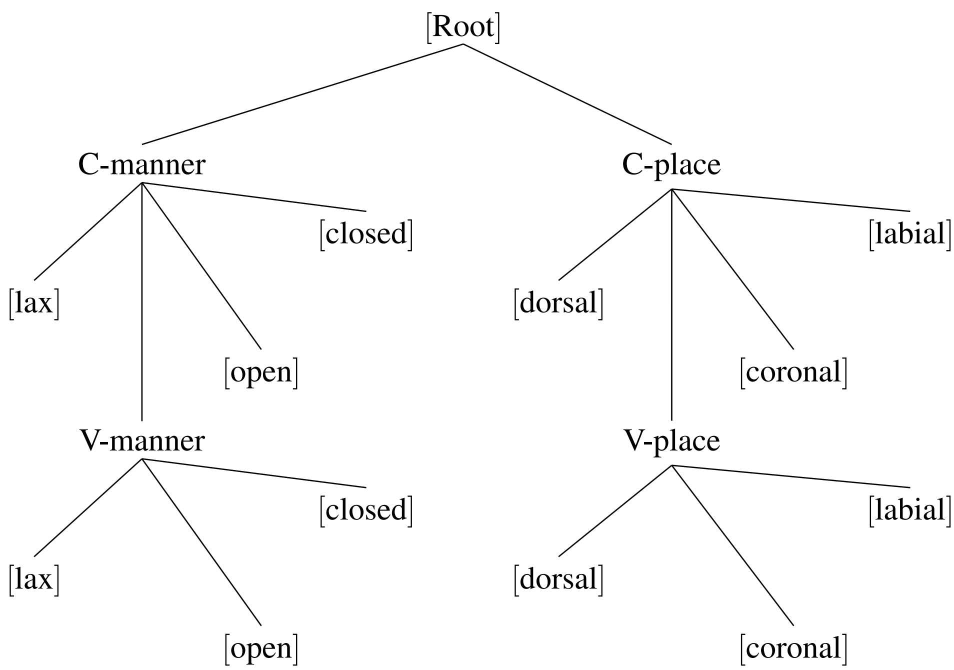
27.4 Feature geometry

Vowel harmony has also received numerous treatments within Feature Geometry, an autosegmental theory in which features are not linked to the root node directly but rather to other nodes within the representation (Clements 1985, 1991; Sagey 1990; Odden 1991, 1994; Clements & Hume 1995; Halle 1995; Halle et al. 2000). Particularly relevant to vowel harmony is the vowel place node to which place features, such as [labial], [coronal], and [dorsal], are associated. The feature geometric approach to vowel harmony has been successful at capturing several generalizations that previous autosegmental and other approaches cannot.

Analyses using feature geometries differ somewhat from one another. The differences include what the inventory of features is, how features are organized within the geometry, and to what extent phonetically similar segments from different languages can be treated differently. Here I adopt one of the most recent feature geometric instantiations, the Parallel Structures Model (henceforth, PSM; Morén 2003, 2006; Iosad 2012, 2017; Youssef 2013; Green & Hantgan 2019). PSM shares two ideas with most of the previous approaches. First, features are associated with their corresponding nodes, which can be place, manner or laryngeal (Sagey 1990; Clements & Hume 1995). Second, vowels and consonants share similar featural representations. For instance, the feature [labial], which is responsible for rounding of vowels, can also mark secondary labialization of consonants (Odden 1994). A [labial] autosegment can also be linked to either the vowel or consonant place node of a consonant, representing primary and secondary place of articulation respectively (labiality versus rounding).

A partial PSM feature geometry is presented in (13). The laryngeal features are omitted since vowel harmony involving those features is very rare (Paster 2004). Notice that there are two manner and place nodes. The nodes that are directly linked to the root node are termed C-nodes (or consonant nodes), and V-nodes are dependent on them. The same features can be linked to either node. In PSM, all phonological features are privative, but the model is also consistent with an approach that adopts binary features.

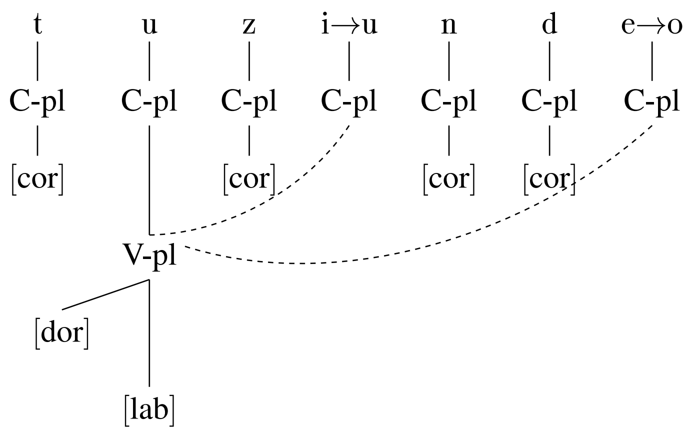
(13) Feature Geometry in the Parallel Structure Model (Morén 2003, 2006)



Let us now review the predictions that PSM makes about vowel harmony. The first such prediction is that multiple vocalic features can spread in unison (Odden 1991). This is captured by spreading of the entire V-node rather than individual features. Recall the vowel harmony pattern of Kyrgyz, which involves both rounding and backness (4). In many feature geometric approaches, the feature corresponding to backness is V-place[dorsal], while rounding corresponds to V-place[labial], which are adopted here, even though a full-blown analysis would have to consider other phonological patterns of Kyrgyz as well. Consonants are transparent in Kyrgyz:

while they contain various C-place features, they lack V-place features. Kyrgyz harmony thus involves spreading of the V-place node to all vowels, skipping consonants, which are transparent to the process. This is shown in (14) where the target root nodes include the input-output mapping for clarity and only place features are included. The assumption here is that the target vowel root nodes are not specified for V-place and acquire it from the triggering initial vowel. Vowel harmony in Kyrgyz, then, involves the spreading of the entire V-place node, together with its dependent features.

(14) Kyrgyz vowel harmony in PSM



I illustrate the second prediction of PSM on Turkish (Turkic) vowel harmony, which is detailed further in Chapters 14, 21, and 59, this volume. Turkish resembles Kyrgyz in its vowel inventory and the fact that it has both backness and rounding harmony, but there are some differences between the two languages: in Turkish only high vowels are targeted by rounding (backness targets all vowels) and consonants interact with vowel harmony. The key Turkish data is presented in (15).

(15) Turkish rounding and backness harmony (Clements & Sezer 1982; Kabak 2011)

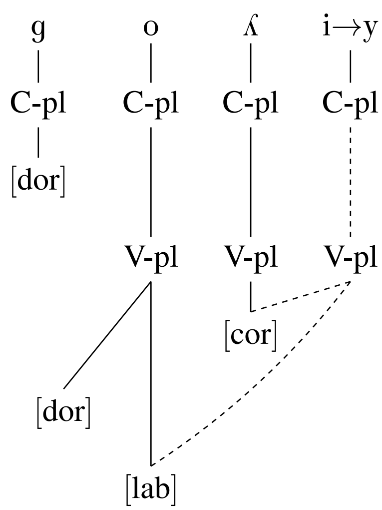
	'NOM'	'ACC'		
a.	ip	ip-i		'rope'
	kɯz	kɯz-ɯ		'girl'
	jyz	jyz-y		'face'
	cøj	cøj-y		'village'
b.	son	son-u		'end'
	pul	pul-u		'stamp'
c.	goʎ	goʎ-y	*goʎ-u	'goal'
	usuʎ	usuʎ-y	*usuʎ-u	'system'

The accusative suffix matches the root vowel in terms of backness and rounding in (15a). After back round vowels, the suffix surfaces as [-u] following most consonants, as seen in (15b). However, when the root-final consonant is [ʎ] (15c), the suffix is not back but rather front [-y]. This lack of backness harmony after [ʎ] is surprising from three perspectives. First, consonant interactions with vowel harmony are exceedingly rare, with the exception of secondary articulation. Turkish represents one of the best described cases: [ʎ] (as well as some other consonants, henceforth not discussed) can be seen as a blocker of backness harmony. In other languages, primary place can also block harmony: Nawuri (Niger-Kongo/Kwa) labialized and labial consonants block rounding harmony (Casali 1995). See Chapter 2, this volume, for a more complete list of consonant effects on vowel harmony. Second, Turkish [ʎ] blocks backness harmony but not rounding harmony: the accusative surfaces as round [-y] rather than [-i]. Third, palatal [ʎ] blocks backness harmony, but this is not the case for all palatal consonants: [j] does not block harmony (e.g., [cøj-y], not *[cøj-ɯ] 'village-ACC').

Now we move on to how feature geometry can capture the blocking pattern found in Turkish. As seen in section 27.2, blocking can easily be captured using a system of binary (also known as equipollent) features. Using unary (or privative) features, however, is more complex, as there is no way to use the No Crossing Constraint to enforce blocking; all features only have one value.

Instead, what this suggests is that Turkish involves all three V-place features: [labial] for rounding harmony, [dorsal] corresponding to back vowels, and [coronal] for front vowels. In such an analysis, back vowels spread V-place[dorsal], while front vowels and [ʎ] spread V-place[coronal], as shown in (16). Spreading of V-place[dorsal] to the suffix vowel is blocked indirectly, as Turkish does not allow segments that are both V-place[dorsal] and V-place[coronal]. Because there is no similar restriction for V-place[round], this feature spreads to the target vowel.

(16) Turkish vowel harmony blocking in PSM feature geometry



We have now seen two types of interactions between consonants and vowels: in Kyrgyz, consonants are always transparent, which can be analyzed as a lack of V-place features. In Turkish, most consonants are transparent, but some are blockers. In PSM feature geometry, this fact is captured by positing that only the blocking consonants have the relevant V-place feature. The representations here follow from a core PSM principle in which language-specific phonological behavior (such as vowel harmony patterns) rather than a universal phonological inventory based on the phonetic content of segments (such as the similarity between the Kyrgyz and Turkish vowel inventory) informs phonological analyses.

A central focus of research in feature geometry is locality of various phonological processes. When it comes to vowel harmony, perhaps the most common situation is that spreading affects all vowels, while consonants are transparent. However, in some languages vowels can be transparent as well. In Menominee, for example [a] is transparent to harmony, while [æ] blocks harmony (Bloomfield 1962; Nevins 2010; Rhodes 2011; Oxford 2015; Walker 2018).

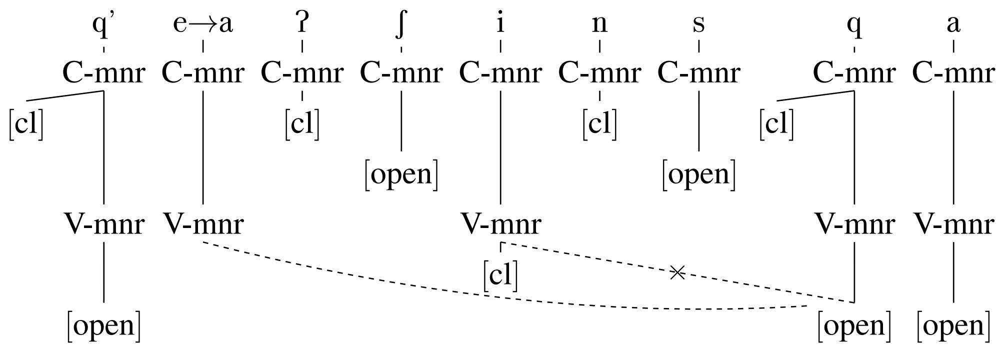
I illustrate how this type of transparency works in PSM in case of long-distance consonant-vowel interactions, because they present the most challenging type of spreading. Faucal harmony is a pattern in which uvulars lower or lax vowels. Bessell (1998) describes this for several Salish languages. For example, in Flathead, uvulars affect preceding [e, u], which become [a, ɔ]. High vowels are not affected and do not interfere with the process (17).

(17) Flathead faucal harmony (Bessell 1998:7)

q’eʔˈʃin	’shoe’	q’a̲ʔʃin-ˈsqa	‘horseshoe’
ˈʔupn	‘ten’	ˈʔɔ̲-ʔpn-ʧst-qn	‘thousand’

In PSM, features are assigned on a language-specific basis, even though there are certain tendencies. The analysis here is limited to manner features, with stops (and nasals) being specified as C-manner[closed], fricatives as C-manner[open], high vowels as V-manner[closed] and non-high vowels as V-manner[open]. Uvulars, which trigger faucal harmony, are specified as V-manner[open] in addition to their C-manner features. These representations are provided to demonstrate faucal harmony in (18), other features and nodes (place, laryngeal) are left out. As we can see, all vowels contain a V-manner feature, whereas non-uvular consonants do not. This allows for spreading to vowels across consonants. The spreading rule spreads the V-manner[open] feature from uvulars regressively to all vowels. However, because no vowel can be V-manner[closed] and V-manner[open] in Flathead, spreading to [i] is blocked, yet this does not interfere with spreading to the preceding [e] which turns into [a]. The spreading of V-manner[open] is thus discontinuous, skipping the intermediate vowel [i] to reach a distant target. This analysis captures the key generalizations in Flathead: uvular triggers, non-high vowel targets, and transparent high vowels.

(18) Flathead faucal harmony using the PSM



An inherent property of most feature geometric approaches is a distinction between C- and V-features, with consonants typically having only the former and vowels having the latter, although there could be language-specific deviations from this generalization. The main point of the asymmetry between vowels and consonants has to do with locality: vowel harmony is cross-linguistically common and varied, whereas consonant harmony is common only with specific features (Danis 2019). In this model, consonants that block harmony must necessarily have some V-feature, whereas transparent segments must lack it.

27.5 Conclusions

This Chapter provides an overview of multi-linear approaches to vowel harmony, including classic Autosegmental Phonology, binary-branching approaches, and Feature Geometry. These approaches can capture all principal classes of segments involved in harmony. Table 1 summarizes these segments and their autosegmental representations (assuming binary features). While these types of segments can be identified based on descriptive generalizations, it is Autosegmental Phonology that established such segments as a standard way to analyze vowel harmony.

Autosegmental approaches are consistent with both rule- and constraint-based approaches. Among the latter, parallel (Kirchner 1993; Ringen & Heinämäki 1999; McCarthy 2011; Jurgec 2011) or serial (Kimper 2011, 2012; McCarthy 2011) analyses vary significantly in terms of what representations are permitted and which constraints drive spreading. One of the key differences

Table 1: Types of segment roles in harmony and their feature representations. "[F]" denotes the harmonizing feature. Examples refer to languages discussed with respect to a particular segment role in this paper.

Segment role	Autosegmental representation	Examples
Trigger	Associated with [+F] underlyingly and on the surface	Kyrgyz
Target	Associated with [+F] on the surface, but not underlyingly	Kyrgyz, Turkish
Icy target	Like targets, except that it cannot be headed	Icelandic
Blocker	Associated with [−F]	Yoruba, Turkish
Transparent segment	Not associated with [F], flanked by vowels that are associated with [F]	Flathead

between rule- and constraint-based approaches is that locality, transparency and blocking in vowel harmony can have different motivations. For instance, blocking in rule-based phonology can mainly be attributed to the No Crossing Constraint, whereas in Optimality Theory, the No Crossing Constraint (either as a constraint or restriction of Gen) is only one source of blocking. Others include a constraint against transparent segments (NoGap), feature co-occurrence constraints or constraints that require similarity among segments associated with the same feature (see Chapter 30, this volume, for further discussion).

While autosegmental approaches differ considerably in their implementation, they all provide a successful account of the basic asymmetries found in vowel harmony. In this way, Autosegmental Phonology has contributed key insights into the inner workings of harmony systems.

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