Stepwise height harmony as partial transparency[*]

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1. Introduction

Harmony refers broadly to the spread of a phonological property from a trigger segment to one or more undergoer segments within some domain. Transparency to harmony refers to a situation in which some segments in a domain do not take on a harmonizing property but rather have apparently been skipped over by a harmony process. There are also cases in which segments in a harmony domain appear to have only partially undergone harmony. These partial undergoers assimilate to a trigger segment with respect to a harmonizing property, but do not necessarily take on that property completely.

This sort of partial harmony is most commonly exemplified by cases of partial height harmony, in which an undergoer vowel approaches the height of a trigger vowel without necessarily reaching it. Often, such partial height harmony proceeds in a stepwise fashion, with each undergoer taking one step toward the height of the trigger along a scale of vowel height. One such stepwise height harmony is the vowel raising harmony of Nzebi (Bantu; Gabon; Guthrie 1968, Clements 1991, Kirchner 1996, Parkinson 1996). In Nzebi, the suffix /-i-/ occurs immediately after verb stems in some tenses. This high vowel triggers single-step raising of preceding non-reduced stem vowels.[1] As part of this raising process, the high-mid vowels /e/ and /o/ surface faithfully when no high suffix vowel follows, as in (1a-c). However, they surface as [i] and [u], respectively, before suffix [i], as in (1d-f).

(1)	a.	[bet]	d.	[bit-i]	‘carry’
	b.	[βoːm]	e.	[βuːm-i]	'breathe’
	c.	[kolən]	f.	[kulin-i]	‘to go down’

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[1]Reduced vowels may occur in the second syllable of a stem and are fully raised to [i] before the /-i-/ suffix.

The low-mid and low vowels also undergo raising when followed by suffix [i], but do not surface as high vowels themselves. Underlying low-mid /ɛ/ and /ɔ/ surface faithfully in (2a-d), and as high-mid [e] and [o], respectively, before suffix [i] in (2e-h).

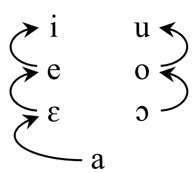
(2)	a.	[sɛ̲b]	e.	[se̲b-i]	‘laugh’
	b.	[suɛ̲m]	f.	[sue̲m-i]	‘to hide self’
	c.	[mɔ̲n]	g.	[mo̲n-i]	‘see’
	d.	[tɔ̲ːd]	h.	[to̲ːd-i]	‘to arrive’

Finally, underlying /a/ also undergoes single-step raising to surface as low-mid [ɛ] before suffix [i], as in (3c-d).

(3)	a.	[sa̲l]	c.	[sɛ̲l-i]	‘work’
	b.	[tsia̲t]	d.	[tsiɛ̲t-i]	‘trample’

The vowel raising pattern in Nzebi is summarized in (4), which makes clear that this is a case of partial, stepwise height harmony. Underlying high-mid vowels are raised to the height of the high trigger, while underlying low-mid and low vowels approach the trigger’s height rather than taking it on completely. These vowels are raised one step along the height scale toward the trigger.

(4) Vowel raising pattern in Nzebi height harmony



In this paper, I propose an analysis of Nzebi’s stepwise height harmony that is situated within the Gestural Harmony Model (Smith 2016, 2018, 2020). In this model, the subsegmental units of phonological representation are gestures, the goal-based, dynamically-defined units of the Articulatory Phonology framework (Browman and Goldstein 1986, 1989, et seq.). Harmony is the result of a gesture extending to overlap the gestures of other segments in a word, and transparency arises due to overlap between a harmonizing gesture and a gesture with a conflicting articulatory target, resulting in competition for control of the vocal tract. In this model of harmony and transparency, I propose that cases in which segments seem to partially undergo harmony be analyzed as cases of partial transparency, resulting from competition between conflicting gestures of similar strengths. This includes cases of stepwise, partial height harmony such as that exhibited by Nzebi.

The paper is organized as follows. Section 2 introduces gestures as units of subsegmental representation and outlines the Gestural Harmony Model. Section 3 presents the analysis of Nzebi height harmony within that model. Section 4 discusses issues that arise in alternative representational accounts of stepwise height harmony relying on featural representations. Section 5 concludes.

2. Representing harmony with gestures

2.1 Gestures as subsegmental units

In this paper, I assume that the units of subsegmental representation are gestures, as in the framework of Articulatory Phonology (Browman and Goldstein 1986, 1989, et seq.). Each of these goal-based units is specified for a target articulatory state, the achievement of which unfolds over time according to a dynamically-defined equation of motion. The length of time over which a gesture commands one or more articulators in the vocal tract to achieve its target state is its period of activation. When enough time has passed for its target state to be achieved, a gesture deactivates, allowing its articulators to return to their specified neutral positions until they are recruited by subsequent gestures.

A gesture's target articulatory state is specified in terms of a primary articulator, a constriction location, and a constriction degree. The constriction location of a consonantal gesture is specified as some point along the static surface of the vocal tract (e.g., alveolar ridge, palate, uvula). Constriction degree refers to the aperture of the constriction between the primary articulator and the constriction location.

I follow Smith (2020) in assuming that vowels are composed of two tongue body gestures whose constriction locations are specified for fairly wide regions of the vocal tract. One of these gestures has a target constriction location comprising much of the upper surface of the vocal tract, including the palate and velum. The target articulatory state of this gesture is to make a constriction anywhere in this region. Its constriction degree determines a vowel's height; a narrow constriction at the upper surface produces a high vowel, while a wide constriction produces a low vowel. The second of these vowel gestures has a target constriction location comprising much of the back surface of the vocal tract, including the uvula and pharynx. The constriction degree of a tongue body back surface constriction gesture determines a vowel's backness. A narrow constriction in this region produces a back vowel, while a wide constriction produces a front vowel. The target constriction locations for these vowel gestures are illustrated in (5).

(5) Tongue body position tasks for upper surface and back surface gestures

Adopting these constriction location regions for vocalic gestures allows for vowel height and backness to be encoded directly by gestural representations. The ability to gesturally represent vowel height is particularly important for formulating an analysis of Nzebi height harmony within the Gestural Harmony Model. This analysis is introduced in section 3.

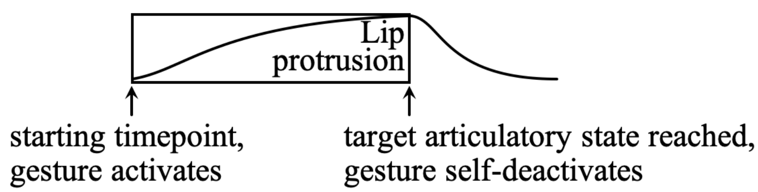
2.2 The Gestural Harmony Model

In the Gestural Harmony Model (Smith 2016, 2018), harmony is the result of a gesture extending its activation period to overlap the gestures of other segments in a domain. To achieve this extended activation, Smith proposes that a gestural representation includes parameters determining whether it self-activates at its specified starting point as well as whether it self-deactivates once it reaches its target articulatory state. These parameters determine whether a gesture is a trigger of harmony.

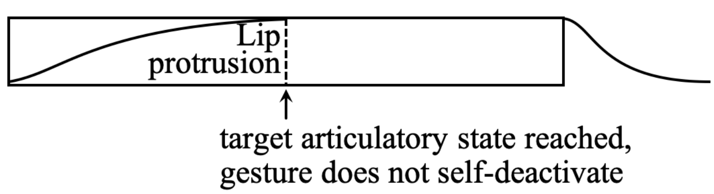
The effects of these gestural parameter specifications are illustrated in (6). The gesture in (6a) is a typical self-activating and self-deactivating lip protrusion gesture, which is used to represent rounding. When this gesture reaches its target articulatory state (protruded lips), it self-deactivates. The gesture in (6b) is a persistent gesture, which does not self-deactivate once it has reached its target articulatory state. Instead, it remains active, extending to overlap the gestures of following segments, thus triggering progressive (rightward) harmony. To illustrate this extension, the dashed line indicates the point at which the gesture reaches its target articulatory state but does not deactivate. The gesture in (6c) is an anticipatory, or early-activating, gesture. The dashed line indicates the point at which the gesture is scheduled to start according to its position in a word. However, since it is an anticipatory gesture it has activated before that point, extending to overlap the gestures of preceding segments, thus triggering regressive (leftward) harmony.

(6) Typical, persistent and anticipatory lip protrusion gestures

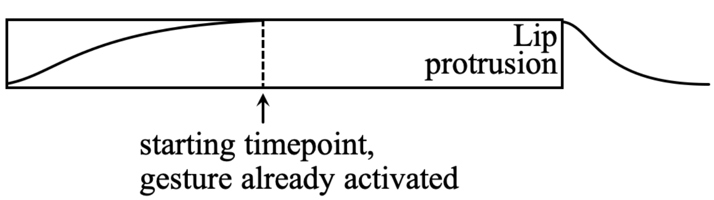
a. Typical gesture



b. Persistent gesture



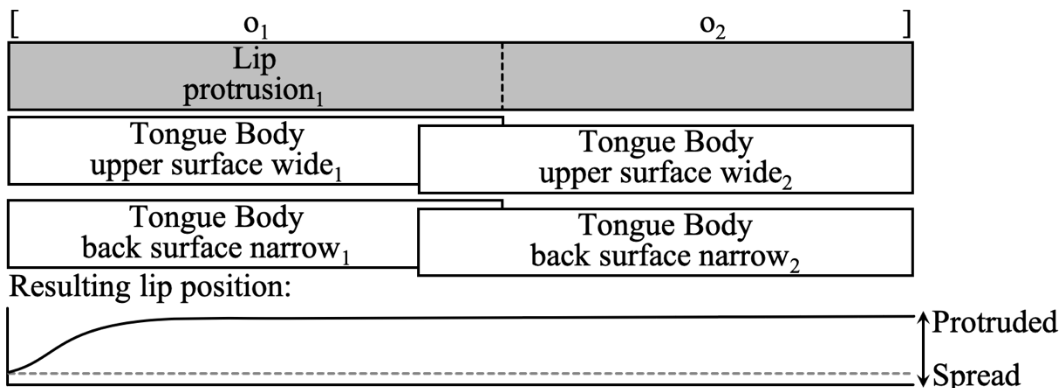
c. Anticipatory gesture



In the Gestural Harmony Model, harmony arises when a segment includes a gesture that is either persistent, anticipatory, or both; that segment is the trigger of harmony. Other segments undergo harmony when their composite gestures are overlapped by a harmonizing gesture.

The figure in (7) illustrates the workings of the model with a gestural score for an [o-o] sequence. In this gestural score, the first [o] is the trigger of rounding harmony, and the second [o] is an undergoer. The segmental transcription is provided along the top, and the subscript for each segment matches the subscripts of its composite gestures. The persistent lip protrusion gesture of the first vowel overlaps the gestures of the following vowel, which surfaces as rounded as a result. The time course of lip protrusion below the gestural score indicates that the lips reach their target protruded state and remain there throughout the word. This is the basic representation of harmony within this model: overlap by a single, uninterrupted harmonizing gesture with an extended period of activation.

(7) Rounding harmony due to overlap by a persistent lip protrusion gesture



To account for transparency, the Gestural Harmony Model takes advantage of the fact that gestures are goal-based units; while they are specified for a target articulatory state, they may not necessarily achieve it successfully. In this model, transparent segments are considered a special type of undergoer. Rather than being skipped over by a harmony process, transparent segments are overlapped by a harmonizing gesture just as typical undergoer segments are. Transparency arises when gestural overlap results in antagonism, a situation in which two concurrently active gestures have opposing target articulatory states. Examples of antagonistic pairs of gestures include concurrently active gestures for lip protrusion and lip spreading, velum opening and velum closure, and narrow and wide constrictions at the upper surface of the vocal tract.

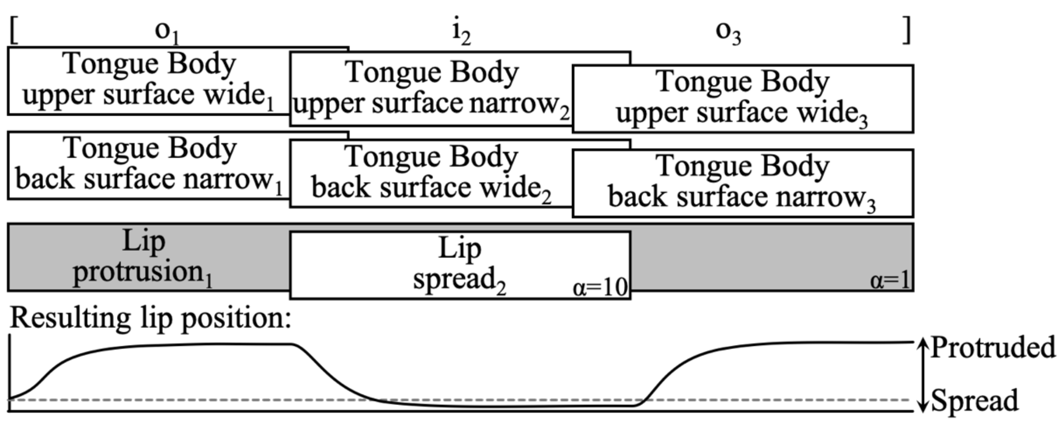
Because the concurrent achievement of two conflicting target articulatory states is not possible, antagonistic gestures are essentially in competition with one another for control of the vocal tract. The outcome of the competition between antagonistic gestures is determined by the relative strengths that are specified for each gesture. According to the Task Dynamic Model of speech production (Saltzman and Munhall 1989, Fowler and Saltzman 1993), when gestural antagonism occurs, it is resolved by blending the competing target articulatory states of these gestures to create an intermediate target state that holds during the period of their concurrent activation. This blended target state is the weighted average of two gestures' individual target articulatory states, and the weighting in this averaging function is contributed by the gestures' strength parameters, denoted α. The gestural blending function is provided in (8).

(8) Gestural blending function in the Task Dynamic Model of speech production

$$\text{Blended Target} = \frac{\text{Target}_1 \cdot \alpha_1 + \text{Target}_2 \cdot \alpha_2}{\alpha_1 + \alpha_2}$$

The figure in (9) contains the gestural score for an [o-i-o] sequence, illustrating transparency via gestural blending with another case of rounding harmony. The persistent lip protrusion gesture of the first [o] overlaps the gestures of all other vowels. The third vowel in the sequence surfaces as rounded [o] due to this overlap. However, the medial high front /i/ surfaces as [i] rather than [y], despite also being overlapped by the lip protrusion gesture. This is due to the representation of /i/ including a lip spreading gesture in addition to its tongue body gestures. This lip spreading gesture is antagonistic to the harmony-triggering lip protrusion gesture and is specified for a relatively high gestural strength. In this example, its strength is ten times the strength of the harmonizing gesture. This allows the lip spreading gesture to counteract the effect of the harmonizing lip protrusion gesture upon the state of the vocal tract during the period of their concurrent activation.

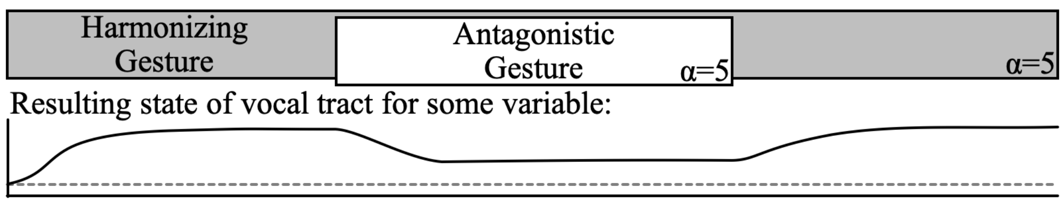
(9) Transparency due to relatively strong antagonistic lip spreading gesture active during production of relatively weak harmonizing lip protrusion gesture



There are several advantages to the representation of transparency to harmony as the result of coactivation of antagonistic gestures. First, it correctly predicts that only those segments that include a gesture that is antagonistic to a harmonizing gesture may be transparent within a given type of harmony. Smith (2016, 2018) claims that this prediction is important for typological reasons: in rounding harmony and in nasal harmony, the sets of cross-linguistically attested transparent segments are limited to the classes of segments that include gestures that are antagonistic to a harmonizing gesture, as suggested by instrumental study. In addition, this model provides a representation of harmony in which spreading is completely local; harmony does not skip segments, even those that surface as transparent.

The full transparency of high front [i] to rounding harmony in (9) is dependent on the strength of its antagonistic lip spreading gesture being much greater than that of the harmonizing lip protrusion gesture. However, their strengths are not categorically 'strong' and 'weak' but rather are defined numerically. In this example, the strength ratio between the two gestures is 10-to-1. Because of this numerical definition of gestural strength, there is no restriction within the Gestural Harmony Model dictating that for a given pair of overlapped gestures, one must be much stronger than the other. Another possible scenario predicted by the model is one in which a harmonizing gesture and an overlapped antagonistic gesture have similar or even identical strengths. When such a scenario arises, the model generates a case of blending resulting in partial transparency and partial undergoing of harmony, as illustrated in (10).

(10) Partial transparency resulting from equal strengths of harmonizing and antagonistic gestures



Following Smith (2020), I propose that partial, stepwise height harmony represents just such a case of partial transparency. The following section outlines an analysis of the partial, stepwise height harmony evident in Nzebi within the Gestural Harmony Model.

3. Analysis: height harmony as gestural overlap

As discussed in section 1, Nzebi exhibits a case of partial, stepwise vowel raising harmony. In this harmony pattern, high-mid undergoers fully assimilate to the height of high vowel triggers of harmony, while low-mid and low vowels only partially assimilate to the trigger height. I propose that this pattern be treated as a case of partial transparency to harmony and analyzed as the result of gestural blending within the Gestural Harmony Model. In contrast with full transparency, in which the antagonistic gesture of a transparent segment is much stronger than the harmonizing gesture, partial, stepwise height harmony represents a case in which the two blended gestures are closer in strength.

This analysis relies on blending of the target constriction degrees of tongue body upper surface gestures for vowels of different heights. Each of the four vowel heights observed in Nzebi is represented by a tongue body upper surface gesture with one of four possible constriction degrees: narrow, narrow-mid, wide-mid, and wide. I analyze the vowel raising harmony in Nzebi as the result of overlap by an anticipatory upper surface gesture with narrow constriction degree that is part of the representation of the suffix high vowel /i/. Under this analysis, vowels that are specified for a wide-mid or wide constriction and that appear to be partially transparent to this vowel raising harmony are able to partially resist the raising effect of the triggering narrow vowel gesture because they are of similar blending strengths. The weaker high-mid vowels, on the other hand, surface as high rather than resisting raising, suggesting that they have a relatively much lower blending strength.

In addition to being specified for a target constriction degree, the tongue body upper surface gesture of each vowel is specified for a strength value that is used to calculate the outcome of blending between antagonistic gestures. Rather than simply referring to 'relatively strong' and 'relatively weak' gestures, this analysis provides a set of precise gestural blending strengths that produce the desired surface vowel constriction degrees for Nzebi raising harmony when input to the blending function in (8). The table in (11) provides the vowels of each height with target constriction degrees for their upper surface gestures, as well as proposed strength values. The precise strength values proposed here are not crucial. Rather, it is the strength ratios between gestures that are important to the analysis.

(11) Target constriction degrees and gestural blending strengths for upper surface gestures of Nzebi vowels

Vowel	Target Constriction Degree	Strength (α)
/i/, /u/	4 mm	10
/e/, /o/	8 mm	1
/ɛ/, /ɔ/	12 mm	10
/a/	16 mm	20

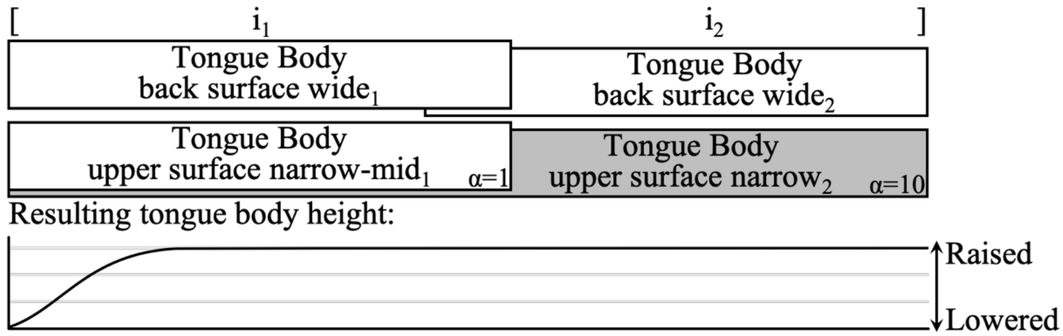
As a result of gestural blending, narrow-mid vowels /e/ and /o/ fully undergo harmony and surface as raised when overlapped by the upper surface gesture of suffix /i/. This is achieved by specifying that /e/ and /o/ have a much lower strength than /i/. As shown in (12), the gestural blending function produces a blended target constriction degree of 4.36 mm, very similar to the proposed 4 mm constriction degree of a narrow vowel trigger listed in (11).

(12) Gestural blending of narrow and narrow-mid vowels

$$4.36\text{ mm} = \frac{\overbrace{4\text{ mm}\cdot 10}^{/\text{i}/,\ /\text{u}/} + \overbrace{8\text{ mm}\cdot 1}^{/\text{e}/,\ /\text{o}/}}{10+1}$$

This blending is illustrated by the gestural score in (13) for the upper surface gestures of a word such as [bit-i] 'carry,' in which the first [i] is the result of raising of an underlying /e/. The accompanying time course of tongue body height indicates that the underlying narrow-mid vowel /e/ fully undergoes harmony and surfaces as [i] when it is overlapped by the anticipatory upper surface gesture of a following, stronger narrow vowel [i].

(13) Narrow-mid to narrow vowel raising



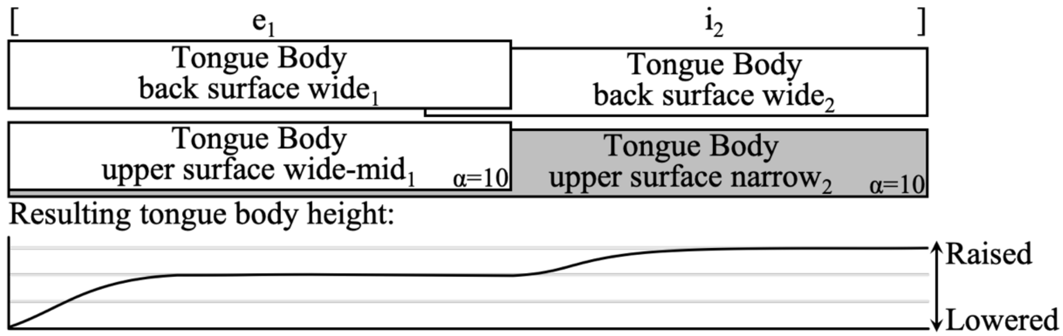
Wide-mid and wide vowels, on the other hand, resist fully undergoing harmony, but also do not surface as fully transparent to harmony. Focusing first on the wide-mid vowels, partial transparency is produced by providing narrow trigger /i/ and wide-mid undergoers /ɛ/ and /ɔ/ with equal strengths. The blending function does not favor the target articulatory state of one gesture over the other, but instead returns a target constriction degree of 8 mm, as in (14). This blended target is intermediate between the two vowels' antagonistic target constriction degrees and consistent with that of the underlying narrow-mid vowels, producing one-step raising.

(14) Gestural blending of narrow and wide-mid vowels

$$8\text{ mm} = \frac{\overbrace{4\text{ mm} \cdot 10}^{/\text{i}/,\ /\text{u}/} + \overbrace{12\text{ mm} \cdot 10}^{/\text{ɛ}/,\ /\text{ɔ}/}}{10 + 10}$$

As a result of this blending calculation, /ɛ/ and /ɔ/ only partially undergo harmony and surface as partially raised. The gestural score in (15) includes the upper surface gestures of a word such as [seb-i] 'laugh,' in which the [e] is the result of raising. The time course of tongue body height shows that the underlyingly wide-mid vowel /ɛ/ only partially undergoes harmony, surfacing as [e] when it is overlapped by the upper surface gesture of a following narrow vowel [i].

(15) Wide-mid to narrow-mid vowel raising



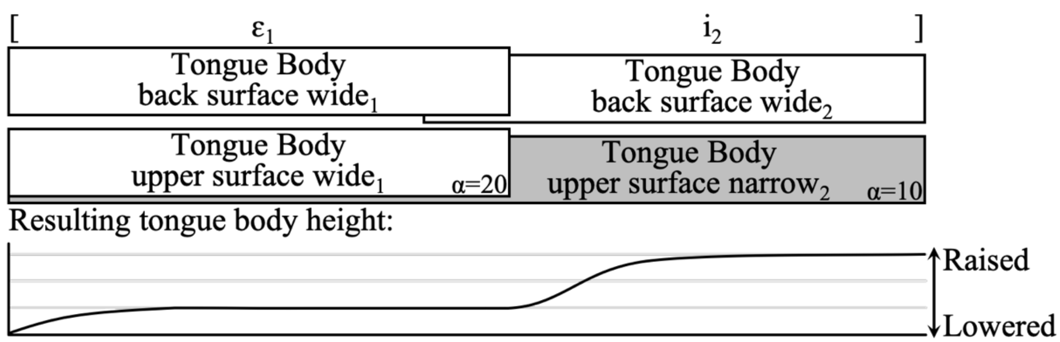
Finally, the low vowel /a/ also resists fully undergoing harmony and surfaces as partially transparent. However, rather than surfacing with a blended target constriction degree that is halfway between the two antagonistic target constriction degrees, the blending function in (16) favors the target articulatory state of the stronger low vowel. This produces a target constriction degree of 12 mm, consistent with the target of the wide-mid vowels.

(16) Gestural blending of narrow and wide vowels

$$12\text{ mm} = \frac{\overbrace{4\text{ mm} \cdot 10}^{/\text{i}/,\ /\text{u}/} + \overbrace{16\text{ mm} \cdot 20}^{/\text{a}/}}{10 + 20}$$

The somewhat higher blending strength of the upper surface gesture of wide /a/ relative to narrow /i/ is not sufficient to produce full transparency to harmony, but rather one-step raising. This is illustrated by the gestural score and time course of tongue body height in (17) for a word such as [sɛl-i] 'work.'[2]

(17) Low to wide-mid vowel raising



[2]The /a/ → [ɛ] mapping appears to involve not only raising but fronting of /a/. However, note that the representation of /a/ includes a gesture specifying a wide constriction degree between the tongue body and the back surface of the vocal tract. I assume that the apparent backness of [a] stems from the hinge-like movement of the jaw, with vowel backing occurring automatically for vowels that involve a lower jaw height.

This section has demonstrated that when vocalic upper surface gestures of different constriction degrees are provided with the proper strength values, the mechanism of gestural blending can be recruited by the Gestural Harmony Model to produce blended target constriction degrees that are consistent with the stepwise vowel raising pattern in Nzebi. Due to overlap by the anticipatory upper surface gesture of a harmony-triggering anticipatory narrow vowel, underlyingly narrow-mid vowels are fully raised and surface as narrow, while underlyingly wide-mid and wide vowels only partially undergo raising. All of these outcomes arise from their upper surface gestures' intrinsic specifications for constriction degree and blending strength.

4. Alternatives: height scales in feature-based phonology

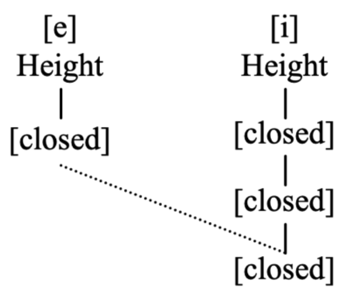
The analysis of partial height harmony as partial transparency fulfills a prediction made by the Gestural Harmony Model that intermediate strength values produce cases of partial undergoing and partial transparency due to overlap by a harmonizing gesture. In addition to fulfilling this prediction, the gestural analysis also provides solutions to issues that arise within featural analyses of partial, stepwise height harmony. Smith (2020) discusses the advantages of adopting the Gestural Harmony Model over feature-based analyses relying on additional grammatical mechanisms within Optimality Theory (Prince & Smolensky 1993/2004) and Harmonic Grammar (Legendre et al. 1990, Smolensky and Legendre 2006) to contend with the chain-shifting nature of stepwise height harmonies. Here, I focus on the advantages of the Gestural Harmony Model relative to representational approaches to stepwise height harmony within feature-based phonology.

One issue that arises in featural analyses of stepwise height harmony centers around how to featurally represent the scalar nature of vowel height with a set of non-scalar features. Assuming a set of binary features for height, a given stepwise height harmony system could involve the spreading or assimilation of two or more different features in a single harmony process. This is especially well illustrated in the four-height vowel system of Nzebi. Its height harmony comprises alternations between high and high-mid vowels, manipulating the feature [±high], between high-mid and low-mid vowels, manipulating [±ATR], and between low-mid and low vowels, manipulating [±low]. As a result, in order to account for Nzebi height harmony three rules or constraints are necessary, one for each feature change. While effective, such an approach does not capture the true spirit of the harmony process as a change along what can be conceptualized as a single height scale.

To remedy this issue, some feature-based analyses of stepwise height harmony have been proposed that rely on scalar height features. One autosegmental approach in this camp is Parkinson's (1996) Incremental Constriction Model, in which all vowel height features are replaced by the single privative feature [closed]. Multiple instances of [closed] can be stacked under a vowel's Height node; the more [closed] features are associated with the Height node, the higher a vowel is. In this model, stepwise raising is represented by the autosegmental spreading of a trigger vowel's terminal [closed] feature to an undergoer of harmony.

This is illustrated in (18). In a language with four vowel heights, such as Nzebi, a vowel whose Height node dominates three [closed] features is interpreted as high, while a vowel with two [closed] features is interpreted as high-mid. The single-step nature of vowel raising is achieved by stipulating that only a vowel's terminal [closed] feature may spread to another vowel.

(18) Vowel raising as [closed] spreading in the Incremental Constriction Model



The Incremental Constriction Model relies on a somewhat nonstandard interpretation of hierarchically organized features: a particular instance of the feature [closed] cannot be interpreted without knowing how many other [closed] features it dominates, or how many other [closed] features dominate it. Nevertheless, the model is successful in representing stepwise height harmony as a single, unified process of feature spreading. However, it incorrectly predicts that stepwise height harmony must always involve vowel raising, and not vowel lowering. This is because a vowel may either spread its terminal [closed] feature, resulting in single-step raising of the target vowel, or its entire Height node, resulting in either full raising or full lowering of the target vowel to the height of the trigger vowel. Single-step lowering is predicted not to occur.

While stepwise vowel lowering harmony is uncommon, it is attested in some Bantu languages such as Pende and Herero. In Herero (Bantu; Namibia, Botswana; Kula 2002, Kula and Marten 2000), the non-high vowels /e/, /o/, and /a/ trigger lowering of high suffix vowels /i/ and /u/ to [e] and [o], respectively.[3] The data in (19) illustrate this stepwise, partial vowel lowering harmony: underlying /i/ of the applicative suffixes surfaces as [e] following an [a], approaching the height of the trigger without reaching it.

(19) Herero stepwise vowel lowering harmony

a.	[pit-ir-a]	'go out (appl.)'
b.	[tuk-ir-a]	'shake (appl.)'
c.	[vet-er-a]	'hit by throwing (appl.)'
d.	[ror-er-a]	'taste (appl.)'
e.	[pat-er-a]	'close (appl.)'

The Gestural Harmony Model is able to account for both the stepwise raising harmony of Nzebi and the stepwise lowering harmony of Herero. Its representation of harmony is based only on gestural blending and the relative strengths of overlapped gestures. Therefore, the model makes no predictions as to whether partial, stepwise height harmony should involve either raising or lowering. A high vowel triggers raising harmony if its upper surface

[3]As is typical of many Bantu height harmonies, the front vowel /e/ does not trigger lowering of the back vowel /u/. Hyman (1999) refers to this patterning as 'prototypical' Bantu height harmony.

gesture extends to overlap the weaker upper surface gesture of a lower vowel in a word. Likewise, a low vowel triggers lowering harmony if its upper surface gesture extends to overlap the weaker upper surface gesture of a higher vowel in a word.

One non-autosegmental approach to representing the scalar nature of vowel height comes from Gnanadesikan (1997). She proposes that various phonological properties be formalized as ternary feature scales, with specific feature values being represented by positions along these scales. For instance, the features for voicing, nasality, and sonority are reconceptualized as the Inherent Voicing scale, with values Voiceless Obstruent = 1, Voiced Obstruent = 2, and Sonorant = 3. Similarly, the Vowel Height scale is built around values High = 1, Mid = 2, and Low = 3. Stepwise height harmony in this framework is modeled as a one-step shift along the Vowel Height scale.

This approach to vowel representation successfully captures the scalar nature of vowel height. However, a crucial aspect of this framework is the ternary nature of the proposed feature scales. Nzebi represents just one example of a language with more than three vowel heights, which cannot be represented by the proposed Vowel Height scale. Gnanadesikan acknowledges this, and notes that it is not trivial to simply add another position to create a quaternary vowel height scale; a drastic restructuring of the accompanying Optimality Theoretic constraint set would also be necessary in order to generate stepwise vowel height alternations. This is in part due to the chain shifting nature of many stepwise height harmonies, including that of Nzebi. By contrast, the Gestural Harmony Model encounters no difficulty with the four-height vowel system of Nzebi, as illustrated in section 3, or with chain shifting height harmonies, as discussed by Smith (2020).

5. Conclusion

In this paper, I have provided an analysis of partial, stepwise height harmony in Nzebi as partial transparency within the Gestural Harmony Model. This analysis relies on the theoretical mechanism of gestural blending, adopted from the Task Dynamic Model of speech production. By relying on a continuous specification of strength rather than a categorical distinction between ‘strong’ and ‘weak,’ this single mechanism is able to produce several different outcomes of harmony via gestural overlap in Nzebi: full raising by high-mid vowels and partial raising to different degrees by low-mid and low vowels. In addition to fulfilling a prediction of the Gestural Harmony Model, the analysis of partial height harmony as partial transparency provides a means of representing the scalar nature of vowel height and the stepwise nature of partial height harmony, while avoiding the issues that arise among analyses built around feature scales.

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