Nontransparent Stressed Syllables in Vowel Harmony: A Gestural Account

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1. Introduction

A recent crosslinguistic study of positional privilege in vowel harmony observed that although patterns exist in which prominent positions uniquely block harmony, no pattern was found in which they are singled out for transparency (Kaplan & Walker to appear). However, this typological gap is not predicted under a traditional set of assumptions in Optimality Theory (OT; Prince & Smolensky 2004). If transparent vowels are skipped by harmony, a grammar is predicted that enforces positional faithfulness in the stressed syllable (Beckman 1998) over a constraint that serves as the spreading imperative, which drives spreading to all vowels in the word (Walker 2012), which in turn dominates the constraint that penalizes skipping (e.g. *SKIP, Uffmann 2004). This ranking, illustrated in (1), generates harmony that operates among unstressed vowels but skips stressed vowels with the opposing feature value, as shown schematically for progressive harmony for [-F]. The constraint hierarchy selects (1a), with spreading that skips the vowel in the stressed penult, over alternatives in which the stressed vowel blocks harmony (1b) or undergoes harmony (1c). Note that in (1), [+F]/[-F] simply signify values for each vowel without commitment to specifics about autosegmental representation.

(1) ˈσ-Faithfulness >> "Spreading Imperative" >> *SKIP

V V ˈV V [-F] [+F] [+F] [+F]	ˈσ-Faithfulness	"Spreading Imperative"	*SKIP
☞ a. V V ˈV V [-F] [-F] [+F] [-F]		*	*
b. V V ˈV V [-F] [-F] [+F] [+F]		**! W	L
c. V V ˈV V [-F] [-F] [-F] [-F]	*! W	L	L

The unwanted prediction arising from the constraint ranking in (1) relies, in part, on an assumption that harmony can skip a vowel. This work adopts a different assumption, namely, that harmony does not skip segments, framed in the representations of gestural phonology (e.g. Browman & Goldstein 1986, 1995, Gafos 1999, Benus 2005, Smith 2018). Positional faithfulness therefore cannot drive harmony to skip a stressed vowel. Following Smith (2018), "coactivation transparency" may arise when vowels have overlapping directly opposing gestures with the presence of one of those gestures being perceptually covert. Building on this approach, this work focuses on the interaction of positional prominence with the potential for gestural overlap. It is proposed that stressed vowels are not receptive to coactive antagonistic gestures because they are a locus of hyperarticulation due to the presence of a prosodic μ-gesture associated with a metrically prominent position. A stressed vowel with a vocal tract constriction gesture that is antagonistic to the harmonizing gesture can thus uniquely block harmony but not uniquely exhibit coactivation transparency. On the other hand, among harmony patterns with stress-sensitive asymmetries, unstressed vowels may display coactivation transparency in contrast to stressed vowels.

The issues involving transparency and stress are probed and exemplified in this paper in relation to the pattern of vowel RTR harmony in the variety of Eastern Andalusian Spanish spoken in Granada

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(EASG). The paper is organized as follows. Section 2 presents data illustrating harmony in EASG. Section 3 reviews the approach to harmony in gestural phonology and makes a proposal about integrating interaction with prosodic μ-gestures. Section 4 presents a constraint-based analysis of harmony among nonhigh vowels in EASG. Section 5 compares an autosegmental alternative, and section 6 concludes.

2. RTR harmony in the Eastern Andalusian Spanish variety spoken in Granada

Vowel RTR (laxing) harmony in EASG exhibits interactions between prosodic position and transparency. EASG data and the harmony description are based on Jiménez & Lloret (2007, 2020) and Lloret & Jiménez (2009). EASG has five vowel phonemes /i, e, a, o, u/. Aspiration or loss of word-final /s/ causes a final vowel to become allophonically lax or open; a final low vowel also fronts, as in (2).

(2)	*ves*	[ˈbɛ$^{(h)}$]	'you-SG see'
	vas	[ˈbæ̟$^{(h)}$]	'you-SG go'
	mis	[ˈmɪ$^{(h)}$]	'my.PL'

A final lax vowel triggers RTR harmony in preceding nonhigh vowels. Stressed nonhigh vowels always show harmony (3a). Nonfinal post-tonic nonhigh vowels optionally harmonize, as do nonhigh pretonic vowels (3b). However, if pretonic nonhigh vowels display harmony, so do post-tonic nonhigh vowels if there are any present in the word (3c).

(3)	a.	*nenes*	[ˈnɛnɛ$^{(h)}$]	'boys'
		asas	[ˈa̟sæ̟$^{(h)}$]	'handles'
		lejos	[ˈlɛhɔ$^{(h)}$]	'far'
		tesis	[ˈtɛsɪ$^{(h)}$]	'thesis'
	b.	*tréboles*	[ˈtrɛβɔlɛ$^{(h)}$] ~ [ˈtrɛβ**o**lɛ$^{(h)}$]	'clovers'
		comemos	[k**ɔ**ˈmɛmɔ$^{(h)}$] ~ [k**o**ˈmɛmɔ$^{(h)}$]	'we eat'
		abetos	[**a̟**ˈβɛtɔ$^{(h)}$] ~ [**a**ˈβɛtɔ$^{(h)}$]	'firs'
		revés	[rɛˈβɛ$^{(h)}$] ~ [r**e**ˈβɛ$^{(h)}$]	'other side'
	c.	*recógelos*	[rɛˈkɔhɛlɔ$^{(h)}$] ~ [r**e**ˈkɔhɛlɔ$^{(h)}$] ~ [r**e**ˈkɔh**e**lɔ$^{(h)}$] *[rɛˈkɔh**e**lɔ$^{(h)}$]	'gather them-MASC'

The focal issue for this paper is that while unstressed nonhigh vowels can be transparent, stressed nonhigh vowels must audibly harmonize.[1] As for high vowels, they are reported to be transparent to harmony in all nonfinal syllables (Jiménez & Lloret 2020), whether they are unstressed or stressed. Because high vowels' transparency is determined by vowel quality rather than being metrically conditioned, it is not analyzed in this paper.

3. Harmony in gestural phonology

3.1. The Gestural Harmony Model

The Gestural Harmony Model (Smith 2018) is a model of harmony situated in the framework of OT in which gestures are the atomic units of phonological representation.[2] Gestures are specified for a goal articulatory state for which the achievement unfolds dynamically over the gesture's interval of activation (e.g. Browman & Goldstein 1986, 1995). Vowel harmony results when a vocalic gesture's period of activation is extended so that it overlaps other segments. In this approach, harmony cannot skip a segment, because a gesture's activation interval is continuous. Transparent segments are undergoers of harmony, that is, they are overlapped by the harmonizing gesture. Nevertheless, the nature of gestures is such that they are specified for a *goal* articulatory state, which allows that they might not necessarily achieve their target. This makes possible an analysis of transparent segments as undergoers of harmony

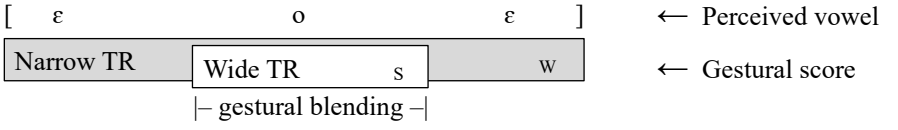
[1] For details about variation in words with longer sequences of pretonic or post-tonic vowels, see Jiménez & Lloret (2007, 2020) and Lloret & Jiménez (2009).

[2] For related gestural approaches to vowel harmony, see Gafos (1999) and Benus (2005).

for which the target of the harmonizing gesture is not achieved due to a simultaneously active opposing gesture. When overlapping gestures impose opposing demands on an articulator, their goal states are blended. The outcome is based on the blending strengths specified for each gesture (Saltzman & Munhall 1989, Fowler & Saltzman 1993, Benus 2005, Gafos & Benus 2006, Smith 2018). If one of the gestures has a much higher blending strength, its target state may be achieved at the cost of the weaker opposing gesture, a scenario that Smith calls *coactivation transparency*.

The gestural score for coactivation transparency in RTR harmony is illustrated in (4a) for vowels in the variant [ˈtrɛβ**o**lɛ$^{(h)}$] 'clovers'. Here, and in what follows, only the tongue root (TR) gestures are shown, with the word's perceived vowels indicated above the gestural score. The narrow TR gesture, which gives rise to a lax (RTR) articulation, is active throughout the word. In the penult, a wide TR gesture, responsible for nonlax articulation, is also active. The wide TR gesture has a high blending strength, denoted by "S" for strong, while the narrow TR gesture has a low blending strength, denoted by "W" for weak. The resulting articulatory state, in (4b), is a wide TR articulation during the penultimate vowel, even though the narrow TR gesture is active at the same time.[3]

(4) a.



b.

For the analysis in gestural phonology, the following terminology is adopted in this paper (chiefly following Smith 2018). *Incompatible gestures* are articulatorily or perceptually marked when concurrently active. *Antagonistic gestures* are specified for directly opposing articulatory states; these are a proper subset of incompatible gestures. Segments that *undergo* harmony are those in which the harmonizing gesture is concurrently active. There are two kinds of undergoers of harmony. *Audibly harmonizing* vowels are those in which the harmonizing gesture is perceptibly audible. An audibly harmonizing vowel might or might not have a concurrently active antagonistic gesture; however, if it does, the gestures blend in such a way that the harmonizing gesture is audibly present. On the other hand, *transparent* vowels are undergoers in which the harmonizing gesture is not audibly perceived, which may arise due to blending with an antagonistic gesture.[4]

3.2. Integrating prosodic gestures

For stress, prosodic gestures come into play (Byrd & Krivokapić 2021). A prosodic $\mu_{\text{PROMINENT}}$-gesture (henceforth μ_{PROM}) is associated with the stress peak (Katsika & Tsai 2021, Bennett et al. 2023).[5] With respect to spatial effects, a μ_{PROM}-gesture modulates spatial target parameters of coactive gestures, causing them to become hyperarticulated.[6]

In the Gestural Harmony Model, *OVERLAP constraints penalize forms with concurrently active gestures that are incompatible to some degree, as formulated in (5a) (Smith 2018). I propose to employ μ-gestures in *OVERLAP constraints to integrate stress sensitivity, as in (5b). This constraint has the effect of prohibiting overlap of gestures X and Y in the context of a stressed vowel. The rationale is that overlapping incompatible gestures are hypothesized to be dispreferred in a context of hyperarticulation.

(5) a. *OVERLAP(Gest_X, Gest_Y): Assign a violation mark for a pair of gestures of type X and type Y that are concurrently active.

[3] Research that posits transparency without skipping, based in articulatory-acoustic relations, makes related insights. See Gafos & Dye (2011) for an overview.

[4] There can be other causes giving rise to a harmonizing gesture not being audibly perceived; however, the focus here is on the scenario of coactivation transparency.

[5] The "μ" in a μ-gesture is distinct from a μ used to represent a mora. Only the former usage of μ is employed here.

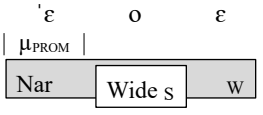
[6] μ-gestures may also have temporal effects; however, the focus here is on spatial effects only.

b. *OVERLAP(μ_{PROM}, $Gest_X$, $Gest_Y$): Assign a violation mark for a triplet of gestures of type μ_{PROM}, type X and type Y that are concurrently active.

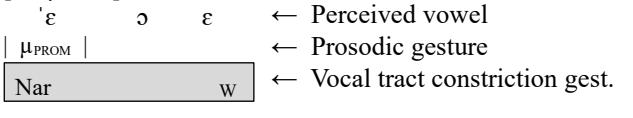
In the Gestural Harmony Model, segments to which the harmonizing gesture may potentially extend are bifurcated into blockers and undergoers. With respect to blocking, the constraint-type in (5b) can prevent overlap of a harmonizing gesture X and a gesture Y in the context of stress, giving rise to blocking by a stressed vowel (e.g. in Serviglianese post-tonic harmony; Mascaró 2011, Walker 2011, Kaplan & Walker to appear). On the other hand, this same constraint-type can be satisfied if gesture Y is deleted in the stressed vowel to permit it to undergo harmony with gesture X. Neither of these stress-specific scenarios involve transparency in the stressed vowel. Nevertheless, because *OVERLAP(μ_{PROM}, $Gest_X$, $Gest_Y$) is active only in the context of stress, it does not prevent harmony in unstressed vowels that involves overlapping antagonistic gestures. This opens the possibility for coactivation transparency that is restricted to unstressed vowels, consistent with the focus of this study.

For variation between transparency and audible harmony in post-tonic vowels in RTR harmony in EASG, two kinds of optimal outputs will be relevant in the present account with the addition of the μ_{PROM}-gesture. These are illustrated in (6) for [ˈtɾɛβ**o**lɛ$^{(h)}$] ~ [ˈtɾɛβ**ɔ**lɛ$^{(h)}$] 'clovers'. The gestural score for the vowel tract constriction gestures is shown at the bottom in (6), with the prosodic μ_{PROM}-gesture indicated immediately above, affiliated the stressed vowel. In these and later illustrations, "Nar" and "Wide" are short forms for narrow and wide TR gestures, respectively. As in (4a), the resulting perceived vowel is notated, although it is not part of the phonological representation.

(6) a. [ˈtɾɛβolɛ$^{(h)}$]



b. [ˈtɾɛβɔlɛ$^{(h)}$]



In (6a) and (6b), the narrow TR gesture, which gives rise to a lax (RTR) vowel, is present in the final vowel, due to word-final /s/-deletion or aspiration, and it has extended through all vowels in the word. Recall that lax vowels are allophonic in EASG. In the absence of final laxing and RTR harmony, vowels are not lax, corresponding to the presence of a wide TR gesture. In (6a), the wide TR gesture in the penultimate vowel is present alongside a concurrently active narrow TR gesture. The wide TR gesture has a high blending strength, while the narrow TR gesture has a low blending strength, resulting in a nonlax transparent [o] (see (4)). However, a version of the constraint in (5b) that prohibits overlap of narrow TR and wide TR gestures in the context of a μ_{PROM}-gesture (i.e. *OVERLAP(μ_{PROM}, Nar TR, Wide TR)) will favor a single TR gesture in the stressed vowel. In (6a), the stressed vowel only has a narrow TR gesture, resulting in audible harmony for this vowel. As for the final vowel, I assume that final laxing supplants a wide TR gesture in this vowel, though I do not develop the details of final laxing here.

In (6b), which corresponds to the variant in which the penultimate vowel displays audible harmony, the difference from (6a) is that the wide TR gesture is absent. In other words, overlap of antagonistic TR gestures is avoided as the product of harmony in all nonfinal vowels in (6b), resulting in no transparency. On the other hand, in (6a) it is avoided only in stressed vowels, yielding transparency in post-tonic nonfinal vowels. It is noteworthy that a representation in which wide and narrow TR gestures are allowed to overlap in stressed vowels but not elsewhere is not predicted, because of the stringency relation between the constraints in (5). This is consistent with the desired prediction that a stressed vowel will not be singled out for transparency. I return to this point in the next section, in which I discuss the constraint rankings that select the outputs in (6) for EASG.

4. Analysis of EASG

In previous foundational analyses, Jiménez & Lloret (2007, 2020) have analyzed harmony in EASG as spreading of a feature [RTR] (or [-ATR]). To address patterns of optionality in pretonic versus post-tonic syllables, they propose more than one spreading imperative, based on prosodic domains (cf. Kaplan 2018), with variants associated with different constraint rankings. The spreading imperatives include (i) a positional licensing constraint that requires [RTR] to be licensed by affiliation with the stressed syllable, and (ii) a constraint that requires [RTR] to be affiliated with all vowels in the word. Building

on their proposal, gestural versions of these constraints are formulated in (7), driving extension of a narrow TR gesture.[7] The positional licensing constraint in (7a) conforms with the schema proposed by Smith (2018:32), with the introduction of a μ_{PROM}-gesture as the licensing "position." Consistent with Jiménez & Lloret (2020), the constraint that drives harmony to all vowels is formulated as a maximal licensing constraint, in (7b) (Walker 2011, cf. Smith 2018). Violations are assigned for each primary vocalic gesture with which the narrow TR gesture is not concurrently active. Following Smith (2018), vowels are considered to have primary and secondary vocalic gestures. For EASG, I assume each syllable is headed by a vowel with a primary vocalic tongue body gesture; TR gestures are secondary.

(7) a. LICENSE(Narrow TR, μ_{PROM}): Assign a violation mark to a narrow TR gesture that is not concurrently active with a μ_{PROM}-gesture.[8] (LIC(Nar TR, μ_{PROM}) for short.)

b. LICENSE(Narrow TR, $\forall$V): For each narrow TR gesture in a word, assign a violation mark to each primary vocalic gesture in that word with which the narrow TR gesture is not concurrently active. (LIC(Nar TR, $\forall$V) for short.)

In the featural account of Jiménez & Lloret (2020), transparent post-tonic vowels are skipped by harmony via feature duplication. The present account differs in assuming goal-based gestures as the phonological units, and transparency is treated without skipping. These differences are motivated by the typological issue of predicting that stressed syllables are not singled out for transparency.

I focus first on harmony that operates only as far as the stressed vowel, which shows variation in nonfinal post-tonic vowels, as in [ˈtɾɛβ**o**lɛ$^{(h)}$] ~ [ˈtɾɛβ**ɔ**lɛ$^{(h)}$] 'clovers', [reˈkɔh**e**lɔ$^{(h)}$] ~ [reˈkɔh**ɛ**lɔ$^{(h)}$] 'gather them-MASC'. I attribute variation to different rankings of the constraints in (8) and (9). The first prohibits overlap of antagonistic TR gestures, following the schema in (5a), while the second penalizes deletion of gestures (Hall 2003).

(8) *OVERLAP(Narrow TR, Wide TR): Assign a violation mark for a pair of gestures narrow TR and wide TR that are concurrently active.

(9) MAX-GESTURE: Assign a violation mark for a gesture in the input that lacks a correspondent in the output. (MAX-G for short.)

Three further constraints are relevant: those in (7a-b) and *OVERLAP(μ_{PROM}, Nar TR, Wide TR). The latter prohibits overlap of opposing TR gestures with a μ_{PROM}-gesture, a constraint that is always enforced in EASG, as is the positional licensing constraint in (7a), LIC(Nar TR, μ_{PROM}). On the other hand, the maximal licensing constraint in (7b), LIC(Nar-TR, $\forall$V), is ranked below MAX-G and *OVERLAP(Nar TR, Wide TR) to prevent harmony preceding the stressed vowel. For the variant in which the post-tonic vowel is transparent, MAX-G dominates *OVERLAP(Nar TR, Wide TR). This ranking is shown in (10).

Before discussing the constraint interactions, I address some preliminaries about inputs and output candidates in tableaux. Output candidates are displayed as gestural scores for vocal tract constriction gestures (specifically TR gestures) plus a μ_{PROM}-gesture always affiliated with the stressed vowel, similar to the forms in (6).[9] For ease of interpretation, the perceived vowels and full word are provided alongside each candidate. Inputs and candidate outputs considered here are further limited along some lines, with the corresponding surface patterns owing to constraint interactions not examined here. In candidate outputs, I assume all wide TR gestures have a high blending strength and all narrow TR gestures have a low blending strength; these strengths are not annotated in candidates.[10] In the inputs under

[7] Jiménez & Lloret (2020) propose a third constraint that requires licensing of [RTR] ([-ATR]) by association with the main foot; however, a counterpart of this constraint is not required in the present account.

[8] Kaplan (2018, 2019) identifies pathologies that arise in the interaction between negative positional licensing constraints and faithfulness in Harmonic Grammar. Whether those issues arise in a gestural model of harmony in OT remains to be investigated.

[9] Smith (2018) includes both coupling graphs for gestures and the resulting gestural scores in candidates. With the focus here on overlap in harmony, the gestural scores are easier to interpret visually. See Smith (2018) for discussion of how constraints such as *OVERLAP and LICENSE have the capacity to manipulate coupling graphs for harmony.

[10] See Smith (2018) on evidence for gradient and contrastive gestural strength in some harmony systems.

consideration, each vowel is specified for a wide TR gesture. In candidate outputs, the final vowel has a narrow TR gesture and no wide TR gesture, due to /s/-aspiration or deletion. The final vowel thus incurs a violation of MAX-G for the loss of the wide TR gesture in the output.

Turning to the tableau in (10), the winner is (10a), which exhibits coactivation transparency in the penultimate vowel. This candidate incurs two violations of MAX-G, for deletion of wide TR gestures in the stressed and final vowels, and it incurs a violation of *OVERLAP(Nar TR, Wide TR) for concurrently active TR gestures in the penult. The competitor without transparency in (10b), which obeys *OVERLAP in all vowels due to deletion of all wide TR gestures, is ruled out by a third violation of MAX. The alternative in (10c), which displays coactivation transparency in the stressed vowel, violates *OVERLAP(μ_{PROM}, Nar TR, Wide TR). Importantly, this candidate incurs a superset of the violations incurred by (10a), owing to the stringency relation between the two *OVERLAP constraints. This is a desirable result, as it indicates that no ranking of these constraints will single out the stressed vowel for transparency. Finally, (10d) has no RTR harmony, which is ruled out by the positional licensing constraint, LIC(Nar TR, μ_{PROM}).

(10) Transparent nonfinal post-tonic vowel: MAX-G >> *OVERLAP(Nar TR, Wide TR)

tre bo les Wide Wide Wide	LIC (Nar TR, μ_{PROM})	*OVERLAP (μ_{PROM}, Nar TR, Wide TR)	MAX-G	*OVERLAP (Nar TR, Wide TR)	LIC (Nar TR, ∀V)
☞ a. [ˈtrɛβolɛ$^{(h)}$] ˈɛ o ɛ | μ_{PROM} | Nar Wide			**	*	
b. [ˈtrɛβɔlɛ$^{(h)}$] ˈɛ ɔ ɛ | μ_{PROM} | Nar			***! W	L	
c. [ˈtreβɔlɛ$^{(h)}$] ˈe ɔ ɛ | μ_{PROM} | Wide Nar		*! W	**	*	
d. [ˈtreβolɛ$^{(h)}$] ˈe o ɛ | μ_{PROM} | Wide Wide Nar	*! W		* L	L	** W

The tableaux in (11) shows the same set of candidates with the opposite ranking of MAX-G and *OVERLAP(Nar TR, Wide TR). In this case, candidate (b) is the winner, with no transparency and audible harmony in all vowels. This candidate satisfies the positional licensing constraint and both *OVERLAP constraints at the cost of MAX-G. The difference in constraint ranking for a pattern with transparency in a nonfinal post-tonic vowel (in (10a)) versus audible harmony (in (11b)) thus comes down to demotion of MAX-G below *OVERLAP(Nar TR, Wide TR) for the audible harmony variant.

The option of harmony in the full word domain can similarly be obtained by a further demotion of MAX-G, below the maximal licensing constraint, LIC(Nar TR, ∀V). This ranking is shown in (12). Recall that when harmony persists to a pretonic vowel, all nonhigh vowels display audible harmony, as in [r**ɛ**ˈkɔh**ɛ**lɔ$^{(h)}$], *[r**ɛ**ˈkɔh**e**lɔ$^{(h)}$] ‘gather them-MASC’. This scenario results from dual enforcement of LIC(Nar TR, ∀V) and *OVERLAP(Nar TR, Wide TR) at the cost of MAX. This ranking is supported by comparing the winner, in (12a), with competitors in (12c-d). In (12a), RTR harmony operates to all vowels with no overlap of TR gestures, violating only MAX. In (12c), harmony operates only as far as the stressed syllable, saving a violation of MAX, but violating higher-ranked LIC(Nar TR, ∀V). In (12d), harmony operates to all vowels, but the penult displays coactivation transparency. This again saves a violation of MAX, but it violates higher-ranked *OVERLAP(Nar TR, Wide TR). Other candidates in (12) also incur fewer violations of MAX than the winner, but they violate higher-ranked constraint(s).

(11) Audibly harmonizing nonfinal post-tonic vowel: *OVERLAP(Nar TR, Wide TR) >> MAX-G

tre bo les Wide Wide Wide	LIC (Nar TR, μ_{PROM})	*OVERLAP (μ_{PROM}, Nar TR, Wide TR)	*OVERLAP (Nar TR, Wide TR)	MAX-G	LIC (Nar TR, ∀V)
a. [ˈtrɛβolɛ(h)] ˈɛ o ɛ μ_{PROM} Nar Wide			*! W	** L	
☞ b. [ˈtrɛβɔlɛ(h)] ˈɛ ɔ ɛ μ_{PROM} Nar				***	
c. [ˈtreβɔlɛ(h)] ˈe ɔ ɛ μ_{PROM} Wide Nar		*(!) W	*(!) W	** L	
d. [ˈtreβolɛ(h)] ˈe o ɛ μ_{PROM} Wide Wide Nar	*! W			* L	** W

(12) Full word domain harmony: LIC(Nar TR, ∀ V) >> MAX-G

re ko he los Wide Wide Wide Wide	LIC (Nar TR, μ_{PROM})	*OVERLAP (μ_{PROM}, Nar TR, Wide TR)	*OVERLAP (Nar TR, Wide TR)	LIC (Nar TR, ∀V)	MAX-G
☞ a. [rɛˈkɔhɛlɔ(h)] ɛ ˈɔ ɛ ɔ μ_{PROM} Nar					****
b. [reˈkɔhelɔ(h)] e ˈɔ e ɔ μ_{PROM} Wide Nar Wide			*(!) W	*(!) W	** L
c. [reˈkɔhɛlɔ(h)] e ˈɔ ɛ ɔ μ_{PROM} Wide Nar				*! W	*** L
d. [rɛˈkɔhelɔ(h)] ɛ ˈɔ e ɔ μ_{PROM} Nar Wide			*! W		*** L
e. [reˈkɔhelɔ(h)] e ˈɔ e ɔ μ_{PROM} Wide Nar Wide			*!* W		** L
f. [reˈkohelɔ(h)] e ˈo e ɔ μ_{PROM} Wide Wide Wide Nar	*(!) W			*(!)** W	* L

To summarize, variation involving unstressed vowels in EASG can be attained in the gestural account simply by different rankings of MAX-G, as presented in (13).

(13) a. RTR harmony to stressed vowel, nonfinal post-tonic vowel is transparent:
LIC(Nar TR, μ_{PROM}), *OVERLAP(μ_{PROM}, Nar TR, Wide TR) >> **MAX-G** >> *OVERLAP(Nar TR, Wide TR) >> LIC(Nar TR, $\forall$ V)

b. RTR harmony to stressed vowel, no transparency:
LIC(Nar TR, μ_{PROM}), *OVERLAP(μ_{PROM}, Nar TR, Wide TR), *OVERLAP(Nar TR, Wide TR) >> **MAX-G** >> LIC(Nar TR, $\forall$ V)

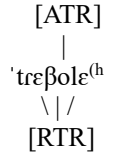
c. RTR harmony to all vowels in the word, no transparency:
LIC(Nar TR, μ_{PROM}), *OVERLAP(μ_{PROM}, Nar TR, Wide TR), *OVERLAP(Nar TR, Wide TR), LIC(Nar TR, $\forall$ V) >> **MAX-G**

To review, this account sets out to explain why unstressed vowels may be singled out for transparency, but not stressed vowels, amongst harmony patterns with stress-sensitive asymmetries. This property arises from some key interconnected facets of the gestural analysis. First, harmony does not skip segments, and transparency arises through the presence of coactive opposing gestures, following the Gestural Harmony Model. Second, stressed vowels are claimed to not be receptive to coactive antagonistic gestures, which is attributed to the presence of a prosodic μ_{PROM}-gesture, which gives rise to hyperarticulation. The dispreference for transparency in stressed vowels is formalized with the introduction of constraints of the form *OVERLAP(μ_{PROM}, $Gest_X$, $Gest_Y$), which can drive asymmetric transparency in unstressed vowels but not stressed vowels.

5. Comparing autosegmental representations

Before concluding, I briefly consider autosegmental representations in relation to the themes of this work. Recall the source of the unwanted prediction that was identified at the outset, namely, that transparency could be restricted to the stressed syllable with the ranking: ˈσ-Faithfulness >> Spreading Imperative >> *SKIP. The approach developed in this paper employs gestural representations that do not involve skipping transparent vowels. We can ask if the issue could instead be adequately addressed using featural representations if autosegmental feature spreading were not permitted to skip a segment.

The idea that the phonological unit that spreads in harmony is temporally continuous is indeed not unique to gestural representations. For example, Ní Chiosáin & Padgett (2001) have proposed that featural entities are continuous and uninterrupted, In addition, there is other work on autosegmental feature spreading claiming that gapped configurations, in which associations of a feature skip an intervening segment, are ill-formed or disallowed (e.g. Levergood 1984, Archangeli & Pulleyblank 1994, Walker 2000). An autosegmental representation that is similar in spirit to the account proposed here with respect to the assumption of a continuous spreading element could posit that a transparent vowel is associated with both [ATR] and [RTR], as shown in (14).

(14)


The challenge for such an approach is understanding how and why the penultimate vowel is realized as [o] rather than [ɔ]. It is conceivable that an account could be developed in combination with Turbidity Theory in which the [RTR] feature is not pronounced on the penultimate vowel, because it is not in a pronunciation relationship with this vowel, despite being in a form of projection relationship with it (e.g. Goldrick 2000, Revithiadou 2007, Finley 2008, van Oostendorp 2008). In turbid representations, a feature that is not in a pronunciation relation with a segment is not expected to factor into that segment's surface realization. While this kind of enriched theory of the relationships between segments and features can potentially yield transparency, the gestural account provides several advantages that may be difficult to replicate in a featural approach.

In the gestural analysis, the goal-based nature of gestures provides a formal understanding of how coactive opposing gestures blend and can give rise to transparency, as discussed in section 3.1. Furthermore, the account proposed here appropriately predicts the potential for asymmetric transparency in unstressed vowels but not those that are stressed by employing a markedness constraint based on the articulatory spatial effects of μ_{PROM}-gestures overlapping with concurrently active opposing vocal tract constriction gestures. This view of markedness of coactivation transparency in stressed vowels involves the opposing vocal tract constriction gestures being present and factoring into the calculation of the articulation. However, this source of explanation does not carry over to a representation of transparency in which a harmonizing feature is not in a pronunciation relation with a transparent segment.

In other research, a gestural approach to transparency has been shown to further benefit understanding of the typology of transparent segments. Studies on the nature of coactive gestures and articulatory-acoustic interactions have identified typologically fitting predictions about which vowel qualities can potentially be transparent in a given type of harmony (e.g. Benus 2005, Gafos & Benus 2006, Smith 2018). Furthermore, different blending strengths for coactive opposing gestures predict the possibility for an intermediate articulatory realization of an undergoer of harmony, beyond a simple binary distinction between achievement of the goal articulatory state of one opposing gesture versus the other (Benus 2005). Smith (2020a, b) characterizes a scenario in which an intermediate realization is perceptible as *partial transparency*, which she argues to be evidenced in patterns of stepwise height harmony. Partial transparency involves a type of gradient outcome that is not expected if a feature is not pronounced on a segment. Importantly, the aforementioned insights stem from predicted outcomes of gestural blending, which is made possible by the characterization of gestures as goal-based units.

6. Conclusion

The chief goal of this paper is to shed light on the observation that vowel harmony patterns with stress-sensitive asymmetries may single out unstressed vowels for transparency but not stressed vowels. It has examined this issue with exemplification in relation to the RTR harmony of EASG, in which stressed vowels consistently audibly harmonize but unstressed vowels may optionally exhibit harmony. A focal claim of this work is that transparent vowels actually undergo harmony, represented with coactive opposing gestures following the Gestural Harmony Model. Extending this approach, a proposal was made that incorporates prosodic μ_{PROM}-gestures in constraints governing gestural overlap. Importantly, *OVERLAP constraints of the form *OVERLAP(μ_{PROM}, $Gest_X$, $Gest_Y$), where gestures X and Y are antagonistic to one another, can prevent coactivation transparency in stressed vowels, limiting transparency to unstressed vowels only. An articulatory basis is hypothesized, namely, the hyperarticulation caused by a μ_{PROM}-gesture is what gives rise to avoidance of antagonistic gestures in this context. A further benefit of *OVERLAP constraints that include μ_{PROM}-gestures is that they can generate patterns with blocking of harmony by stressed vowels, but they do not single out unstressed vowels for blocking behavior. The representations of gestural phonology are thus argued to shed light on positional privilege and transparency in harmony patterns.

Several avenues nevertheless remain open for further investigation and development. In the gestural analysis of EASG, a treatment of the transparency of high vowels was set aside, but it warrants attention in a more complete account. In addition, future experimental investigation of articulatory properties of EASG and stress-sensitive harmony in other languages could test aspects of the proposed gestural representations, particularly with respect to the spatial effects of μ_{PROM}-gestures, differences in gestures' blending strengths, and blending outcomes. Another issue that merits further consideration is the status of positional faithfulness. The problem raised at the outset of the paper revolved around transparent vowels satisfying positional faithfulness, which makes it possible for stressed vowels alone to be transparent. Positional faithfulness constraints were not employed in the analysis of EASG harmony presented here. Nevertheless, positional faithfulness constraints are argued to play a role in the typology of position-sensitive harmony in designating privileged positions as a trigger for harmony (e.g. Walker 2011, McCarvel & Kaplan 2019, Kaplan & Walker to appear). To maintain the typological implications of the account proposed here, in which coactivation transparency in a stressed vowel is harmonically bounded by transparency of an unstressed vowel, it will be necessary to ensure that a gestural version of positional faithfulness does not favor transparent stressed vowels. This points to an interpretation of faithfulness such that it is not satisfied when a vowel acquires overlap with a harmonizing gesture in the output, even if that vowel is transparent. Examination of the surrounding issues remains for future work.

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