Why mid vowels are not always mid vowels*

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1. Introduction

Partial height harmonies are phonological processes in which underlying low vowels map onto surface mid vowels and underlying mid vowels map onto surface high vowels in the very same context but, crucially, underlying low vowels do not become surface high vowels. Thus, partial height harmonies contrast with palatal harmonies or rounding harmonies in which the target **fully** assimilates with the trigger with respect to backness or roundness.

In this paper, I will analyze the puzzles posed by *partial height harmonies* using Containment-based Optimality Theory (Prince and Smolensky 1993, Goldrick 2001, van Oostendorp 2006, Revithiadou 2007, Trommer 2011, Trommer and Zimmermann 2014, Zimmermann 2017). Moreover, I will show that it is not necessary to stipulate an additional mechanism to prevent total height harmonies arguing that independently motivated markedness constraints that can make reference to both input and output features prevent low vowels from becoming high vowels as this would result in an illicit combination of features on a single segment.

This paper is structured as follows: In section 2, I will show why partial height harmonies are problematic for standard versions of OT. In section 3, I will present my own analysis using Containment Theory. In the following section, I will compare my analysis to previous approaches by Kirchner (1996) and Łubowicz (2012) and discuss the advantages of my analysis before I finally conclude in section 5.

2. Why partial harmonies are problematic for SPOT

A well-known example of partial height harmonies is found in Lena Spanish, presented here in (1). In Lena Spanish, the high vowel *-u* in the masculine singular suffix causes the preceding vowels to become higher than their underlying variants in the feminine singular

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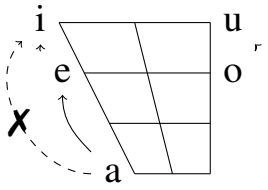
paradigm. Thus, an underlying mid vowel /e/ becomes [i] in the context of *-u*. An underlying low vowel /a/, however, surfaces as a mid vowel [e] and **not** as a high vowel [i].

(1) *Lena Spanish (Hualde 1989, Parkinson 1996)*

	FEM.SG	MASC.SG	
a → e	gata	getu	'cat'
e → i	nena	ninu	'child'
o → u	bona	bunu	'good'



Partial height harmonies are instances of counter-feeding: /a/ does not become [i], even though the shift /a/ → [e] would create the context for /e/ → [i] to apply. Hence, partial height harmonies are instances of *Chain Shifts*, where /A/ becomes [B] and /B/ becomes [C] in the output but /A/ ↛ [C]. Thus, they result in a ranking paradox in Standard Parallel Optimality Theory (SPOT) using harmony-driving constraints and faithfulness constraints as listed in (2) (Prince and Smolensky 1993)[1] . The following tableaux show that the harmony-triggering constraints need to outrank the respective faithfulness constraints in order to account for the shift from /e/ to [i] (see (3)). This ranking, however, wrongly predicts a shift from /a/ to [i] (see (4)) (Kirchner 1996).

(2) *List of constraints (SPOT)*

FTH$_F$ Corresponding segments have identical values for the feature [±F].

HARM$_F$ Adjacent segments have the same value for the feature [±F].

(3) *Shift from /e/ to [i] SPOT*

/e/ - /u/	HARM$_{HI}$	HARM$_{LO}$	FTH$_{HI}$	FTH$_{LO}$
a. e-u	*!			
b. ☞ i-u			*	

(4) *Shift from /a/ in SPOT, wrongly predicting [i] as the optimal candidate*

/a/ - /u/	HARM$_{HI}$	HARM$_{LO}$	FTH$_{HI}$	FTH$_{LO}$
a. a-u	*!	*!		
b. ☛ e-u	*!			*
c. ☞ i-u			*	*

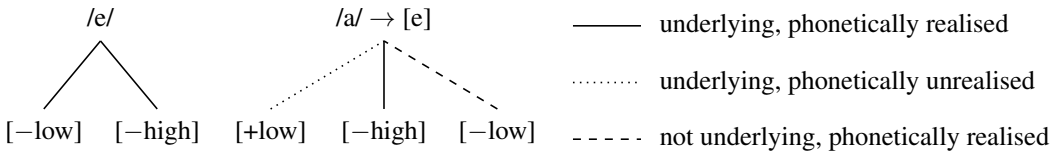
3. Chain Shifts in Containment Theory

In the previous section, I have shown that partial height harmonies lead to a ranking paradox in OT. In the following section, I will demonstrate that all types of partial height harmonies can easily be analysed within Containment Theory by means of a number of independently motivated constraints.

[1] In this paper, I remain agnostic about the exact nature of the harmony-driving constraints. As far as I can see, my analysis is compatible with SPREAD (Walker 1998, Padgett 2002), ALIGN (McCarthy and Prince 1993, Kirchner 1993) and AGREE (Baković 2000) constraints.

Containment Theory (Goldrick 2001, van Oostendorp 2006, Revithiadou 2007, Trommer 2011, Trommer and Zimmermann 2014, Zimmermann 2017) has previously been shown to be able to account for different instances of phonological opacity like incomplete neutralization (van Oostendorp 2008), grandfather effects (Zimmermann and Trommer 2016) or metaphony (Torres-Tamarit, Linke, and del Mar Vanrell 2017). These cases are typically instances of counter-feeding or counter-bleeding on environment (McCarthy 1999), i.e. a whole segment is deleted and yet influences the output by either blocking or triggering a process. In this paper, I will show that Containment Theory can also be applied to Chain Shifts as instances of counter-feeding on focus (McCarthy 1999). In the case of Chain Shifts, it is not a whole segment but subsegmental structure that influences the output. In Containment Theory, deletion of phonological elements from the input is impossible. Rather, phonological features may **be phonetically unrealised** (e.g. as a result of a phonological process) but they are **still present in the phonological structure**. As a consequence of this assumption, an underlying segment has a different featural specification than a derived segment but the same surface interpretation. Concretely, it follows automatically that an underlying vowel /e/ is specified [−low,−high], while an [e] that is derived from vowel raising is specified [−low,−high,**+low**] as the [+low] feature of the input vowel /a/ remains in the phonological structure. Phonetic uninterpretability arises from deassociation, illustrated in (5) with a dotted line, following Trommer (2001).

(5) *Featural compositions of underlying and derived mid vowel* e (Trommer 2011)



Another consequence of Containment Theory is that markedness constraints appear in two clones, following the *Cloning Hypothesis* by Trommer (2011). Thus, a constraint is able to make reference **either** only to phonetically visible features (P-Clones) **or** to all features present in the phonological structure (I-Clones).[2] In my analysis, I implement these assumptions to partial height harmonies. Concretly, I assume that the partial height harmony in Lena Spanish (see section 2) is triggered by a high vowel which is specified as [+high, −low, +ATR] (Kirchner 1996). Furthermore, I claim that low vowels can never become high vowels due to a constraint *[+low,+high]$_{\text{I}}$ that has access to **all** phonological features. Thus, the illicit combination of the [+low] feature of the underlying sound /a/ and the [+high] feature of the resulting sound [i] makes the shift from /a/ to [i] impossible. Crucially, the constraint *[+low,+high]$_{\text{I}}$ is not stipulative but builds on compelling phonological evidence, as it has previously been argued that the feature combination [+high, +low] is articulatorily impossible (Chomsky and Halle 1968, Sagey 1986, Hall 2000, Pulleyblank 2011).

I will now show how this approach can be implemented to account for the partial height harmony in Lena Spanish using the constraints listed in (6). Note that the faithfulness

[2] In this paper, I will mark P-Clones with an indexed $_{\text{P}}$ and I-Clones with an indexed $_{\text{I}}$.

constraints are usually considered to be MAX-Constraints in Containment Theory as input features are not changed but invisible.

(6) *List of constraints (Containment)*

$*[+\text{LOW},+\text{HIGH}]_I$	No [+low,+high] vowels.
MAX[F]	Features of [±F] should not be phonetically invisible.
HARM[F]	Adjacent segments have the same value for the feature [±F].

The tableaux in (7) illustrates how the ranking paradox is resolved. Crucially, the harmony-driving constraints, which have access **to phonetically visible features only**, outrank the MAX-constraints to trigger vowel raising. The top-ranked constraint $*[+\text{LOW},+\text{HIGH}]_I$ becomes crucial in (7) ruling out [i] as it penalizes a combination of a [+low] and [+high] feature on a single vowel and exactly such a combination arises if an underlyingly low vowel is raised to a high vowel.

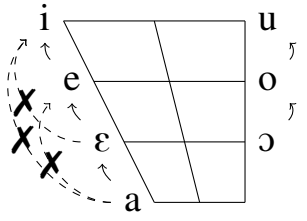
(7) *Shift from /a/ to [e] in Containment, correctly predicting [e] as the optimal output*

/a/ - /u/	$*[+\text{LO},+\text{HI}]_I$	HARM[HI]_P	HARM[LO]_P	MAX[HI]_P	MAX[LO]_P
a. /a/ → [a] - /u/ (+low −high −ATR − −low +high +ATR)		*	*!		
b. ☞ /a/ → [e] - /u/ (+low −ATR −high −low +ATR − −low +high +ATR)		*			*
c. /a/ → [i] - /u/ (+low −ATR −high −low +ATR +high − −low +high +ATR)	*!			*	*

So far, I have shown that Containment Theory can be successfully employed to account for partial height harmonies in languages with three different vowel heights, such as Lena Spanish. The data from Nzɛbi in (8) illustrate an example of a partial height harmony including four different vowel heights.

(8) *Nzɛbi (Bantu, Gabon) (Clements 1991, Parkinson 1996)*

	simple	yotized	
e → i	bet-ə	bit-i	'carry'
o → u	βoom-ə	βuum-i	'breathe'
ɛ → e	sɛb-ə	seb-i	'laugh'
ɔ → o	tɔɔd-ə	tood-i	'arrive'
a → ɛ	sal-ə	sɛl-i	'work'



Nzɛbi exhibits a harmony triggered by a high vowel *-i* in the yotized paradigm whereby vowels raise by one step, just like Lena Spanish (Clements 1991). In Nzɛbi, however, the low vowel /a/ does not become the close mid vowel [e] but the open mid vowel [ɛ]. To account for languages with more than three different vowel heights, it is therefore necessary to have a closer look at the correlation of vowel height and [±ATR]. It is a well-known and wide-spread assumption that low vowels tend to be unmarked as [−ATR] vowels while high vowels are unmarked if they are [+ATR]. Evidence for these assumptions can be taken from

the typological variation within vowel inventories (Casali 2014), phonogical processes such as the [+ATR] harmony in Pulaar which does not spread onto [+low] segments (Archangeli and Pulleyblank 1994) or the phonetic correlation of raised and advanced tongue roots Lulich and Cavar (2018). While the status of mid vowels remains unclear, I conclude that there is compelling evidence to expand the list of constraints in (6) by two more constraints:

(9) *List of constraints (four-height-systems)*
*[+LOW,+ATR]$_I$ No [+ATR,+low] vowels.
*[+HIGH, −ATR]$_I$ No [−ATR,+high] vowels.

The following two tableaux show that the two new constraints are crucial for predicting the correct output candidate. In (10), *[+LOW,+ATR]$_I$ rules out [e] which would have become optimal otherwise. In (11), *[+HIGH, −ATR]$_I$ prevents /ɛ/ from shifting to [i].

(10) *Nzɛbi, a → ɛ*

/a/ - /i/	*[+LO,+HI]$_I$	*[+LO,+ATR]$_I$	*[+HI, −ATR]$_I$	HARM[HI]$_P$	HARM[LO]$_P$	HARM[ATR]$_P$	MAX[HI]$_P$	MAX[LO]$_P$	MAX[ATR]$_P$
a. ☞ /a/ → [ɛ] - /u/ (+low −high +ATR −low / −low +high +ATR)				*		*		*	
b. /a/ → [e] - /u/ (+low −ATR −high −low +ATR / −low +high +ATR)		*!		*				*	*
c. /a/ → [i] - /u/ (+low −ATR −high −low +ATR +high / −low +high +ATR)	*!	*!	*!				*	*	*

(11) *Nzɛbi, ɛ → e*

/ɛ/ - /i/	*[+LO,+HI]$_I$	*[+LO,+ATR]$_I$	*[+HI, −ATR]$_I$	HARM[HI]$_P$	HARM[LO]$_P$	HARM[ATR]$_P$	MAX[HI]$_P$	MAX[LO]$_P$	MAX[ATR]$_P$
a. /ɛ/ → [ɛ] - /u/ (−low −high −ATR / −low +high +ATR)				*		*!			
b. ☞ /ɛ/ → [e] - /u/ (−ATR −low −high +ATR / −low +high +ATR)				*					*
c. /ɛ/ → [i] - /u/ (+low −ATR −high −low +ATR / −low +high +ATR)			*!				*		*

All attested patterns can easily be captured within my analysis, as seen in the following table based on the collection of Chain Shifts by Moreton (2010) and Neasom (2016). [3]

[3]Note that Neasom's 2016 corpus includes a chain shift in Kashubian Polish (Łubowicz 2003) that can shortly be described as a → e → ɪ. I excluded this chain shift from the table in (12) following Neasom (2016) who shows that the empirical basis of this chain shifts relies on fragile and daring theoretical assumptions by Łubowicz (2003) that severely question the existence of this chain shift as part of the synchronic grammar of Kashubian Polish.

(12) *List of attested partial height harmonies* (Moreton 2010, Neasom 2016)

Languages	**Shifts**
Basaá (Schmidt 1996, Parkinson 1996), Bengali (Ghosh 1996, Mahanta 2007) [+LO,+HI], *[+HI, −ATR] » HARM » MAX » *[+LO,+ATR]	a, ɛ → e → i, ɔ → o → u a ↛ ɛ,i, ɛ ↛ i, ɔ ↛ u
Gbanu, Kikuria, Servigliano Italian (Parkinson 1996) MAX_{lo} » *[+HI, −ATR] » HARM » MAX_{hi}, MAX_{ATR}	ɛ → e → i, ɔ → o → u a ↛ ɛ,e,i, ɛ ↛ i, ɔ ↛ u
Bari (Yokwe 1987) MAX_{ATR} » *[+HI, −ATR] » HARM » MAX_{hi}, MAX_{lo}	e → i, o → u a ↛ ɛ,e,i, ɛ ↛ e,i, ɔ ↛ o,u
Lena Spanish (Hualde 1989, Parkinson 1996) [+LO,+HI] » HARM » MAX	a → e → i, o → u a ↛ i
Nzɛbi (Clements 1991, Parkinson 1996) [+LO,+HI], *[+LO,+ATR], *[+HI, −ATR] » HARM » MAX	a → ɛ → e → i, ɔ → o → u a ↛ e,i, ɔ ↛ u

Even though this paper focuses on partial height harmonies, it is easily conceivable that my analysis can be extended to other instances of Chain Shifts, such as the partial sonorization in Nzema, where the negative prefix /ɔn-/ triggers a harmony process, such that /t/ → [d] and /d/ → [n] but /t/ ↛ [n] (Clopper 2001). It is obvious that these data can easily be derived in my analysis by assuming a constraint $*[-\text{VOICED}, +\text{NASAL}]_{\text{I}}$ that prohibits a shift from /t/ to [n], as it is commonly assumed that voiceless nasals are more marked than voiced nasals (Hall 2000).

4. Comparison to previous approaches

Several analyses of Chain Shifts have been suggested in the literature. Representational approaches (Clements 1991, Parkinson 1996), faithfulness-based approaches (Kirchner 1996) and contrast-based approaches (Łubowicz 2012). Representational approaches build purely on vowel height and can therefore not be considered to be a general theory of opacity. Since Neasom (2016) has argued that Chain Shifts do not form a coherent phenomenon, it seems theoretically superfluous to stipulate a theory specific to Chain Shifts. Thus, I will focus on discussing the more recent OT-based approaches by Kirchner (1996) and Łubowicz (2012).

4.1 Local conjunction by Kirchner (1996)

Kirchner (1996) suggests to face the opacity problem within Parallel OT using Local Conjunction (Smolensky 1993). In local conjunction, a new constraint is formed by conjoining two other constraints, which means that the constraint is violated if and only if both of its parts are violated. Thus, Kirchner (1996) can derive the observation that raising in Chain Shifts happens stepwise as raising /a/ to [i] would violate two faithfulness constraints and therefore also the top-ranked conjoined constraint, as seen in the tableau in (13).

(13) *Chain Shifts in Local Conjunction (simplified, following Kirchner (1996))*

/a/	PARSE$_{high}$ & PARSE$_{low}$	RAISING	PARSE$_{low}$	PARSE$_{high}$	PARSE$_{ATR}$
a. a		∗∗∗!			
b. ☞ e		∗	∗		∗
c. i	∗!		∗	∗	∗

Kirchner (1996) argues that Local Conjunction is a very powerful tool that would fatally overgenerate if it can apply without further restrictions. For example, a conjunction of a constraint on complex onsets and a constraint on heavy syllables would predict languages in which only light syllables may have complex onsets. The analysis forwarded in this paper does not face this problem as it is less powerful and makes reference to markedness constraints that are independently motivated. To avoid overgeneralization, Kirchner (1996) suggests restricting Local Conjunction by allowing only a conjunction of two constraints that make reference to the same *dimension*, e.g. vowel height. However, the restricted version of Constraint Conjunction undergenerates, as it cannot derive patterns where two processes affecting different phonological dimension interact. One example is the counterfeeding case in Woleaian (Sohn 1975). In this language, long vowels shorten and short vowels devoice in word-final position (shortly: VV $\rightarrow$ V $\rightarrow$ V̥). However, long vowels do not devoice. Henceforth, this is problematic since there is no obvious dimension that would unify vowel length and voicing. However, the case of Woleaian can easily be captured in Containment Theory: Since the second mora of the long vowel always remains accessible in the phonological structure, the context for the devoicing rule never arises.[4]

Altogether, it can be concluded that the Containment-based analysis that I suggest in this paper is superior to Constraint Conjunction by Kirchner (1996) since his mechanism overgenerates without restrictions and undergenerates with restrictions.

4.2 PRESERVE CONTRAST by Łubowicz (2012)

Łubowicz (2012) proposes an analysis that makes use of a new type of constraints, PRESERVECONTRAST (PC), which ensures that phonological distinctions in the input are preserved in the output. In contrast to Standard Parallel OT, GEN does not generate single phonological forms but phonological scenarios, see (14). PC is violated if a distinction between two phonological forms has been neutralized in the output. In the case of partial height harmonies, neutralization is enforced by the constraint RAISING. The PC constraint is now used to prevent /a/ from shifting to [i]: In the input, there is a phonemic distinction between /a/ and /e/. If both vowels surfaced as [i], this distinction would be lost leading to a fatal violation of PC$_{a\text{-}e}$.

[4]Note that Local Conjunction has previously been criticised, mainly because of its power to generate unattested grammatical systems (Pater, Bhatt, and Potts 2007). Instead, Harmony Grammar (Smolensky and Legendre 2006) was proposed in order to derive cumulative effects. However, Harmonic Grammar cannot derive Chain Shifts, as shown by Farris-Trimble (2008).

(14) *Chain Shifts in* PRESERVECONTRAST *(simplified, following Łubowicz (2012))*

		$PC_{a\text{-}e}$	RAISING	$PC_{e\text{-}i}$
a. ☞	a → e, e → i		*	*
b.	a → a, e → e		**!	
c.	a → i, e → i	*!		*

Even though her account succeeds in deriving a large number of different Chain Shifts, her account is theoretically controversial. McCarthy (1999), argues that her approach fatally overgenerates as it predicts scenarios that are fundamentally unnatural. He takes up the case of the interaction between place assimilation and deletion in Ojibwa, as seen in (15).

(15) *Counterbleeding in Ojibwa (Kaye 1974, McCarthy 2007)*

Underlying representation	*takossin-k*
1. Place assimilation	*takoššiŋk*
2. Deletion	*takoššiŋ*

McCarthy (1999) criticizes her analysis for not linking contrast preservation to place assimilation as an existing phonological process in Ojibwa. In other words, it is accidental in her approach that the contrast in Ojibwa is preserved via place assimilation and not, e.g. via rounding of the preceding vowel. Thus, she predicts contrast-preserving scenarios that are phonologically unnatural. This is in strong contrast to the analysis I put forward in this paper as it makes reference to markedness constraints that build on strong independent motivation thus predicting only natural scenarios. Moreover, McCarthy (1999) shows that not all cases of opacity are contrast-preserving. One example comes from Tiberian Hebrew (see (16)) where the output form *deše* itself does not allow any conclusion to the input, as there are other sources of final *-e* in the language apart from epenthesis. Note that the data from Tiberian Hebrew are unproblematic for Containment-based approaches: Since *ʔ* remains in the phonological structure, the context for epenthesis persists.

(16) *Counterbleeding in Tiberian Hebrew (McCarthy 1999)*

Underlying representation	*dešʔ*
1. Epenthesis	*dešeʔ*
2. Deletion	*deše*

5. Conclusion

In this paper, I have analysed the opacity problems posed by partial height harmonies within Containment Theory. Concretely, I have shown that three independently motivated markedness constraints that can make reference to both input and output features of a segment prevent unobserved shifts as this would result in illicit combinations of features. Thus, my analysis is formally superior to previous approaches by Kirchner (1996) and Łubowicz (2012), who need to stipulate powerful machinery and face overgeneralization problems.

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