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Servigliano revisited: An examination from constraint-based serialism

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This paper examines a metaphonic chain shift in Servigliano (Italo-Romance), in which /ɛ, ɔ/ raise to [e, o] and /e, o/ raise to [i, u] when stressed and followed by inflectional /i, u/. The paper also explores pre-tonic metaphony, whereby /ɛ, ɔ/ raise all the way up to [i, u] when followed by a stressed high vowel. First, an analysis of the data is developed using Optimality Theory with Candidate Chains (OT-CC), taking as a starting point the parallel OT analysis developed in Mascaró (2011). Second, it is shown that OT-CC causes one analytical problem and no gain in terms of economy. On the one hand, the metaphony-triggering constraint AGREE(+high,+ATR) proposed in Mascaró (2011) needs to be split into two different constraints, one of which needs a more complicated formulation that requires a conditional clause. On the other hand, positional faithfulness is needed, as in the parallel OT analysis by Mascaró (2011), to explain the asymmetry between one-step metaphony and fell-swoop pre-tonic metaphony; OT-CC provides no inherent advantage in explaining this asymmetry.

1. Preliminary considerations

Phonological opacity remains one of the most controversial topics in theoretical phonology (see Baković 2007 for a revised classification of opaque phenomena, and Baković 2011 and Mascaró 2011a for recent overviews). Opacity is the result of counter-feeding and counter-bleeding interactions between phonological processes. Among all types of opaque interactions, synchronic chain shifts represent a subset of counter-feeding interactions (see Kirchner 1996, Parkinson 1996, Łubowicz 2011, 2012, among others). In a regular chain shift, underlying /A/ maps onto surface [B], and underlying /B/ maps onto surface [C] (1).[1] In other words, underlying /B/ and derived [B] are not equally sensitive to the linguistic generalization banning B.

(1) a. /A/ → [B]
    b. /B/ → [C]

Crucially, underlying /A/ never maps onto surface [C] (2).

(2) */A/ → [C]

In parallel Optimality Theory (OT, Prince & Smolensky 1993/2004), regular chain shifts cannot be accounted for. Both types of input-output mappings (/A/ → [B] and /B/ → [C]) are the result of a markedness over faithfulness constraint ranking (M ≫ F). To be more precise, some markedness constraint prohibiting [A], *A, must outrank some faithfulness constraint penalizing the mapping /A/ → [B], *A→B. The same holds for the mapping /B/ → [C]. Some markedness constraint against [B], *B, must dominate some faithfulness constraint disfavoring the mapping /B/ → [C], *B→C (3).[2]

(3) a.

/A/	*A	*A→B
a. [A]	*W	L
b. ☞ [B]		*

b.

/B/	*B	*B→C
a. [B]	*W	L
b. ☞ [C]		*

However, in OT nothing prevents underlying /A/ from mapping onto surface [C], contrary to the facts. It must be assumed that the mapping /A/ → [C] incurs one violation of each of the faithfulness constraints. The transparent candidate [C] wins because it satisfies both high-ranked markedness constraints, *A and *B (4).

(4)

/A/	*A	*B	*A→B	*B→C
a. [A]	*			
b. ☹ [B]		*	*	
c. ☞ [C]			*	*

Within the framework of OT, synchronic chain shifts have been accounted for through an enrichment of the theory of faithfulness constraints (Kirchner 1996, Gnanadesikan 1997). Kirchner (1996), for instance, applies local constraint conjunction (Smolensky 1995) to chain shifts. His solution is to conjoin two faithfulness constraints in a specific domain. A locally conjoined faithfulness constraint is violated if the two faithfulness constraints that compose it are both violated for a specified domain (5).

(5) $\{{*}A{\rightarrow}B \& {*}B{\rightarrow}C\}_{Segment}$
Assign one violation mark for every segment that violates both *A→B and *B→C.

Chain shifts are explained as a consequence of ranking the locally conjoined faithfulness constraint, in this case $\{*A{\rightarrow}B\&*B{\rightarrow}C\}_{Segment}$, above the markedness constraint against the intermediate stage of the chain, *B. With this ranking, the desired opaque output [B] is obtained, instead of transparent [C] (6).

(6)

/A/	*A	$\{*A{\rightarrow}B\&B{\rightarrow}C\}_{Segment}$	*B	*A→B	*B→C
a. [A]	*W		L	L	
b. ☞ [B]			*	*	
c. [C]		*W	L	*	*W

Nevertheless, local conjunction raises some theoretical problems including the domain issue and what constraints can be conjoined (see Alderete 1997, Spaelti 1997, Łubowicz 2000, 2005, Moreton & Smolensky 2002, Itô and Mester 2003, McCarthy 2003, Miglio 2005, Walker 2005).[3]

This paper examines a chain shift involving tonic metaphony in Servigliano (Italo-Romance, Marche region, Camilli 1929, Kaze 1989, Maiden 1991, Dyck 1995, Parkinson 1996, Nibert 1998, Calabrese 2011, Mascaró 2011b, Walker 2011). In Servigliano, underlying [−ATR] root mid vowels (/ɛ, ɔ/) raise to [+ATR] mid vowels ([e, o]), and underlying [+ATR] mid vowels (/e, o/) raise to [+high] vowels ([i, u]) when stressed and followed by high vowel inflectional suffixes (/-i, -u/). The paper also explores pre-tonic metaphony, whereby [−ATR] mid vowels raise all the way up to [+high] when followed by a stressed high vowel, and addresses the question why tonic metaphony operates step-wise and pre-tonic metaphony operates in one fell swoop.

The main goal of the paper is twofold: first, to develop an analysis of the data using Optimality Theory with Candidate Chains (OT-CC, McCarthy 2007), taking as a starting point the parallel OT analysis developed in Mascaró (2011b); second, to show that serialism, an intrinsic property of OT-CC, causes one analytical problem. On the one hand, in OT-CC the metaphony-triggering constraint Agree(+high,+ATR) proposed in Mascaró (2011b) needs to be split into two different constraints, one of which needs a more complicated formulation that requires a conditional clause. On the other hand, in order to explain the asymmetry between tonic metaphony, which operates step-wise, and pre-tonic metaphony, which operates as a fell-swoop change, positional faithfulness in OT-CC is needed, as in the parallel OT analysis by Mascaró (2011b); OT-CC has no inherent advantage in explaining this asymmetry, even if the fell-swoop raising in the pre-tonic domain is attributed to two different operations that violate different types of faithfulness constraints, as this paper proposes. In the light of the comparison between the two approaches, the paper concludes that the parallel OT analysis in Mascaró (2011b) is more elegant than an analysis in terms of a constrained-based derivational theory like OT-CC; the analysis in Mascaró (2011b) keeps the metaphony-triggering constraint a lone constraint, and the OT-CC analysis cannot explain fell-swoop pre-tonic metaphony without exempting from using positional faithfulness.

The paper is organized as follows. §2 illustrates the data on tonic metaphony in Servigliano and summarizes the parallel OT analysis developed in Mascaró (2011b), which is based on local conjunction. §3 shows that Harmonic Serialism fails in accounting for the metaphonic chain shift in Servigliano. §4 explains the basics of OT-CC and develops an analysis that makes explicit the problems that this serial theory raises when accounting for a metaphonic chain shift. §5 presents the data on pre-tonic metaphony in Servigliano and the need for using positional faithfulness as in Mascaró (2011b). §6 concludes.

2. Tonic metaphony and local constraint conjunction (Mascaró 2011b)

Servigliano, as is common in Romance languages, has a seven-vowel system in stressed position ([i, e, ɛ, a, ɔ, o, u]), with an [ATR] distinction in the mid vowel region (7).[4]

(7) Servigliano seven-vowel system in stressed position

[ˈfin-e]	‘end’	[ˈmut-a]	‘very-FEM.SG.’
[ˈmett-e]	‘(s)he puts’	[ˈfonn-a]	‘deep-FEM.SG.’
[ˈpɛd-e]	‘foot’	[ˈmɔrt-a]	‘dead-FEM.SG.’
[ˈrap-a]	‘turnip’		

In this paper, distinctive binary features are assumed, and vowels are assigned their feature values as in (8) for four features: [high], [low], [ATR] and [back].

(8) Feature specifications

	[high]	[low]	[ATR]	[back]
i	+	−	+	−
e	−	−	+	−
ɛ	−	−	−	−
a	−	+	−	+
ɔ	−	−	−	+
o	−	−	+	+
u	+	−	+	+

The distribution of [−ATR] mid vowels in stressed position depends on the following inflectional suffix. In the presence of a high vowel inflectional suffix ([-i, -u]), [−ATR] mid vowels are prohibited (*[ˈɛ,ˈɔ - i, u]); when underlying, [−ATR] mid vowels alternate with [+ATR] mid vowels (9).

(9) Mid vowel alternations

[ˈpɛd-e]	'foot'	[ˈped-i]	'feet'
[rrepˈprɛtsː-o]	'I take care'	[rrepˈpretsː-i]	'you take care'
[tʃeˈrɛʃ-a]	'wild cherry tree'	[tʃeˈreʃ-u]	'grafted cherry tree'
[ˈmɔrt-a]	'dead-FEM.SG.'	[ˈmort-u]	'dead-MASC.SG.'
[ˈmɔr-e]	'(s)he dies'	[ˈmor-i]	'you die'
[ˈbɔn-a]	'good-FEM.SG.'	[ˈbon-i]	'good-MASC.PL.'

The very same high vowel inflectional suffixes also cause raising of [+ATR] mid vowels, which alternate with [+high] vowels (10).

(10) Mid-high vowel alternations

[ˈmett-e]	'(s)he puts'	[ˈmitt-i]	'you put'
[ˈpes-a]	'heavy-FEM.SG.'	[ˈpis-u]	'heavy-MASC.SG.'
[ˈkred-o]	'I think'	[ˈkrid-i]	'you think'
[ˈfjor-e]	'flower'	[ˈfjur-i]	'flowers'
[ˈbott-e]	'cask'	[ˈbutt-i]	'casks'
[ˈkorm-a]	'heaped-FEM.SG.'	[ˈkurm-u]	'heaped-MASC.SG.'

These metaphonic alternations are a case of a productive, synchronic chain shift, in which [−ATR] mid vowels acquire [+ATR], and [+ATR] mid vowels acquire [+high] from high vowel inflectional suffixes, but in which [−ATR] mid vowels do not get both [+ATR] and [+high]. In Mascaró (2011b), a parallel OT analysis is developed for this metaphonic chain shift. According to him, tonic metaphony is triggered by the satisfaction of an agreement constraint AGREE(+high,+ATR) (11).

(11) AGREE(+high,+ATR) (Mascaró 2011b)
For every pair of adjacent vowels one of which is [+high,+ATR], assign one violation mark if they are not linked to the same token of [+high] and [+ATR].

By ranking AGREE(+high,+ATR) above IDENT(VF) (12), [+ATR] root mid vowels acquire [+high] from a high vowel inflectional suffix, as illustrated in tableau (14). Leftwards directionality (*i.e.* the fact that suffixes are triggers but not targets of tonic metaphony) is due to IDENT-SUFFIX(VF) (13), a positional version of IDENT(VF) relativized to protect only suffixal morphs.

(12) IDENT(VF) (Mascaró 2011b)
Assign one violation mark for any feature in an output vowel that does not have the same value as its correspondent vowel in the input.

(13) Ident-Suffix(VF) (Mascaró 2011b)
Assign one violation mark for any feature in a suffixal vowel that does not have the same value as its correspondent vowel in the input.

(14) /pes-u/ → [ˈpis-u] (Mascaró 2011b)

/ˈpes-u/	Ident-Suffix(VF)	Agree(+high,+ATR)	Ident(VF)
a. ☞ [ˈpis-u]			*
b. [ˈpes-u]		*W	L
c. [ˈpes-o]	*W		*

This constraint ranking, however, does not prevent [−ATR] mid vowels to raise all the way up as [+ATR,+high] vowels (15).

(15) /mɔr-i/ → *[ˈmur-i] (Mascaró 2011b)

/ˈmɔr-i/	Ident-Suffix(VF)	Agree(+high,+ATR)	Ident(VF)
a. ☹ [ˈmor-i]		*	*
b. ☞ [ˈmur-i]			**
c. [ˈmɔr-i]		**	
d. [ˈmɔr-e]	*		*

Mascaró (2011b) solves this problem by resorting to local conjunction. By locally conjoining two Ident faithfulness constraints as in (16), and ranking this constraint above Agree(+high,+ATR), the one-step raising from [−ATR] mid vowels to [+ATR] mid vowels is accounted for (17).[5]

(16) Ident(high&ATR)[6] (Mascaró 2011b)
Assign one violation mark for any segment that violates both Ident(high) and Ident(ATR), *i.e.* for any high vowel that derives from a non-high-non-ATR vowel.

(17) /ˈmɔr-i/ → [ˈmor-i] (Mascaró 2011b)

/mɔr-i/	Ident(high&ATR)	Agree(+high,+ATR)	Ident(VF)
a. ☞ [ˈmor-i]		*	*
b. [ˈmɔr-i]		**W	L
c. [ˈmur-i]	*W	L	**W

3. Harmonic Serialism

Harmonic Serialism (HS, McCarthy 2010) is a variant of OT that combines constraint ranking with serial derivations. Gen in HS generates only those candidates that differ from the input by one single operation, often defined in terms of one violation of a basic faithfulness constraint. The winning candidate is then fed back to Gen as a new input for another round of evaluation. This loop is then repeated until the fully faithful parse of the latest input wins. As argued for in McCarthy (2000), HS is in fact inadequate to deal with counter-feeding opaque interactions. If each step of an HS derivation shows harmonic improvement, there is no way to stop an intermediate representation B derived from underlying /A/ to map onto surface [C]. HS gradualness, in this respect, does not help solving the problem. Mascaró (2013) has already shown that the Servigliano chain shift is as challenging in HS as it is in parallel OT. As shown in (18), at the second step of a HS derivation, an opposite ranking between Agree(+high,+ATR) and Ident(VF) would be needed in order to converge at this derivational stage. A ranking paradox in HS is fatal, as constraint re-ranking at different derivational steps is incompatible with harmonic improvement.

(18) a. Step 1: /ˈpɔr-u/ → ˈpor-u 'poor-MASC.SG.' (Mascaró 2013)

/pɔr-u/	Agree(+high,+ATR)	Ident(VF)
a. ☞ ˈpor-u	*	*
b. ˈpɔr-u	**W	L

b. Step 2: ˈpor-u → *[ˈpur-u]

por-u	Agree(+high,+ATR)	Ident(VF)
a. ☹ [ˈpor-u]	*	
b. ☞ [ˈpur-u]		*

As it becomes evident, local conjunction is superfluous in HS because the set of candidates can never violate more than one faithfulness constraint, in compliance with the gradualness requirement on Gen.

4. Optimality Theory with Candidate Chains

As opposed to HS, in which evaluation is serial (*i.e.* it can apply n times until convergence), in Optimality Theory with Candidate Chains (OT-CC, McCarthy 2007) Eval only applies once. Instead, serialism in OT-CC is implemented within candidates. Candidates in OT-CC are chains that connect an input to an output through intermediate representations each of which represent a one-step change from the previous one. Candidate chains therefore show the property of gradualness (*i.e.* only one operation at a time is permitted) and harmonic improvement (*i.e.* each successive form in a chain must improve harmony according to the language-particular hierarchy of constraints). The definition of candidate chains provided in McCarthy (2007) is as follows (19).

(19) Candidate chain definition (McCarthy 2007:62)
A candidate chain associated with an input /in/ in a language with the constraint hierarchy $\mathfrak{H}$ is an ordered n-tuple of forms C = <f_0, f_1, ..., f_n> that meets the following conditions:
a. Initial form: f_0 is the faithful parse of /in/ that is most harmonic according to $\mathfrak{H}$.
b. Gradualness: In every pair of immediately successive forms in C, <..., f_i, f_{i+1}, ...> ($0 \leq i < n$), f_{i+1} has all of f_i's localized unfaithful mappings (LUMS) relative to /in/, plus one more.
c. Local optimality (harmonic improvement + best violation): For every pair of immediately successive forms in C, <..., f_i, f_{i+1}, ...> ($0 \leq i < n$), where F is the basic faithfulness constraint violated by the LUM that distinguishes f_{i+1} from f_i, f_{i+1} is more harmonic according to $\mathfrak{H}$ than f_i and every other form that differs from f_i by a different F-violating LUM.

Parallel OT has a natural bias towards transparency; only feeding and bleeding interactions between processes can be accounted for because markedness constraints can only make statements about surface representations. In OT-CC, on the contrary, the existence of intermediate forms and a specific type of constraints, PRECEDENCE (PREC) constraints, allow for referring to these intermediate representations absent in parallel OT, and therefore account for opaque interactions. PREC constraints are a particular type of constraints in OT-CC that demand a specific ordering relation between faithfulness violations (20).

(20) PREC(A,B) constraints (McCarthy 2007)
Let A' and B' stand for forms that add violations of the faithfulness constraints A and B, respectively.
To any chain of the form <X, B', Y>, if X does not contain A', assign a violation mark, and
to any chain of the form <X, B', Y>, if Y contains A', assign a violation mark.

A PREC(A,B) constraint assigns a violation mark under two different conditions: (a) a violation of a faithfulness constraint B is not preceded by a violation of a faithfulness constraint A, and (b) a violation of a faithfulness constraint A follows a violation of a faithfulness constraint

B. McCarthy (2007) illustrates how a Prec constraint can account for counter-feeding opacity with an example from Bedouin Arabic. In Bedouin Arabic, complex codas are prohibited and fixed *via* vowel epenthesis (*Complex-Coda $\gg$ Dep), and underlying /a/ raises to [i] in open syllables (Raise $\gg$ Ident(low)). However, vowel epenthesis counter-feeds raising, as underlying /gabr/ maps onto surface [gabur] 'a grave', not *[gibur]. Parallel OT is unable to select the actual opaque form (21).

(21) /gabr/ → *[gibur] (McCarthy 2007)

/gabr/	Raise	*Complex-Coda	Ident(low)	Dep
a. ☹ [gabur]	*			*
b. ☞ [gibur]			*	*
c. [gabr]		*		

In OT-CC, due to gradualness, the output *[gibur] necessarily follows an intermediate representation in which vowel epenthesis and no raising has applied. Valid chains from /gabr/ are shown in (22).

(22) Valid chains from /gabr/ (McCarthy 2007)
a. <gabr>
b. <gabr → gabur>
c. <gabr → gabur → gibur>

The candidate chain that should be selected is candidate chain (b) in (22). In OT-CC terms, a Prec constraint must block the application of raising after the application of vowel epenthesis. In a counter-feeding interaction of this type, a constraint like Prec(Ident(low),Dep) ranked below *Complex-Coda and above Raise is enough to discard the transparent candidate chain (c) (23). Both the winning candidate chain (a) and the transparent candidate chain (b) violate Prec(Ident(low),Dep), but only candidate chain (b) violates this constraint twice. This is so because not only Dep is violated without being preceded by a violation of Ident(low), as in candidate chain (a), but because Dep is also followed by a violation of Ident(low).

(23) /gabr/ → [gabur] (McCarthy 2007)

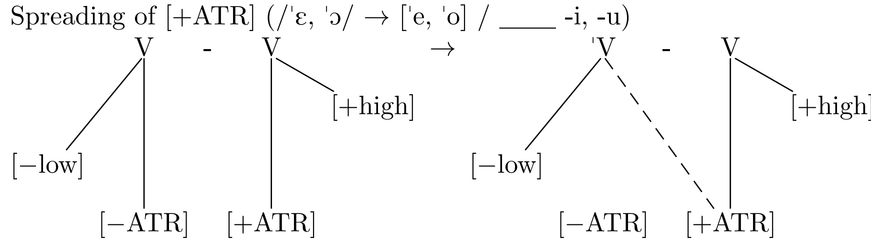
/gabr/	*Com-Cd	Prec	Raise	Id(low)	Dep
a. ☞ <gabr, gabur>		*	*		*
b. <gabr, gabur, gibur>		**W	L	*W	*
c. <gabr>	*W	L	L		L

Therefore, for counter-feeding interactions in OT-CC, the constraint that triggers the counter-fed process, in this case Raise, must be dominated by the Prec constraint.[7]

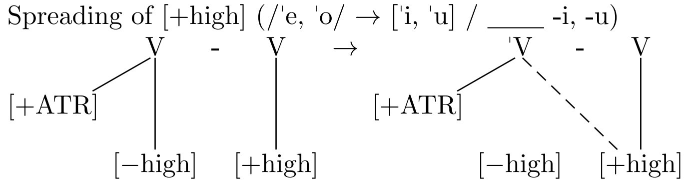
5. OT-CC and the metaphonic chain shift in Servigliano

From a serial perspective, it must be assumed that metaphonic raising is the result of two different spreading processes: (i) for the mappings /ɛ/ → [e], /ɔ/ → [o], leftward spreading of the feature [+ATR] underlyingly linked to an inflectional [+high] vowel suffix to an adjacent [−ATR] stressed mid root vowel, and (ii) for the mappings /e/ → [i], /o/ → [u], leftward spreading of the feature [+high] to a [+ATR] mid root vowel in the same condition.[8] In terms of OT-CC, the candidate chains in (24) must be gradual and harmonically improving according to the Servigliano constraint hierarchy. As in standard autosegmental phonology, I also assume that the feature [αF] linked to the target vowel, that occupies the same tier as feature [βF] linked to the trigger vowel, automatically delinks after spreading, and that this is a one-step operation in a candidate chain.

(24) a. Spreading of [+ATR] (/ˈɛ, ˈɔ/ → [ˈe, ˈo] / _____ -i, -u)



b. Spreading of [+high] (/ˈe, ˈo/ → [ˈi, ˈu] / _____ -i, -u)



I propose that the one-step operation of spreading plus delinking in OT-CC violates a Dep-Link(F) constraint *à la* Morén (1999).

(25) Dep-Link(F)

Let s_i be a segment in the input in correspondence with s_o in the output; and let $[\mathrm{F}]_i$ be a feature in the input in correspondence with $[\mathrm{F}]_o$ in the output.

Assign one violation mark for every $[\mathrm{F}]_o$-to-s_o link in the output with no $[\mathrm{F}]_i$-to-s_i link in the input.

The constraint Dep-Link(F) is violated when a new association line connects a feature with a root node if and only if the feature and the root node are already present in the input. If the feature is inserted and has no correspondent in the input, for instance, Dep-Link(F) is not violated. Crucially, spreading plus delinking does not induce violations of a different type of faithfulness constraints, namely Ident(F). This is so because once spreading plus delinking takes place, the identity of a feature is not altered with respect to a segment, as the segment acquires a new feature that is not underlyingly linked to it. The constraint Ident(F) is violated when the input linking between a feature and a segment is maintained in the output and the value of the feature is changed (26).

(26)

		Dep-Link(αF)	Ident(F)
a.	$s_i \rightarrow s_o$ $[\alpha F]_i \quad [\alpha G]_o$	*	✓
b.	$s_i \rightarrow s_o$ $[\alpha F]_i \quad [\beta F]_o$	✓	*

where ($\alpha \neq \beta$)

The metaphony-triggering constraint proposed in Mascaró (2011b), Agree(+high,+ATR), ranked above Dep-Link(+high), accounts for spreading of [+high] to [+ATR] mid vowels (27).

(27)

/ˈe-i/	Agr(+high&+ATR)	Dep-Link(+high)
a. ☞ ˈe - i [−high] [+high] → ˈi - i [−high] [+high]		*
b. ˈe - i [−high] [+high]	*W	L

However, Agree(+high,+ATR), which collapses the two features, makes the wrong prediction with respect to [−ATR] mid vowels. This constraint, being undominated, does not prevent [−ATR] mid vowels from raise all the way up to high in a step-wise manner, through [+ATR] spreading and then [+high] spreading (29). A transparent candidate chain like this should be ruled out (28).[9] For reasons of space, candidate chains are simplified; features on a separate tier are not represented. The constraint Dep-Link(+Fs) is used as a cover constraint for Dep-Link(+high) and Dep-Link(+ATR).

(28) Transparent chain

ˈɛ - i	→	ˈe - i	→	ˈi - i
[−ATR] [+ATR]		[−ATR] [+ATR]		[−high] [+high]

(29)

/ˈɛ-i/	Agr(+high&+ATR)	Dep-Link(+Fs)
a. ☹ ˈɛ-i → ˈe-i	*	*
b. ☞ ˈɛ-i → ˈe-i → ˈi-i		**
c. ˈɛ-i	**	

At first sight, one could think that a Prec constraint should explain the metaphonic chain shift. In counter-feeding interactions, a Prec constraint must always force the counter-feeding process to be preceded by the counter-fed process, that is, Prec(Dep-Link(+high),Dep-Link(+ATR)) (30).

(30) Prec(Dep-Link(+high),Dep-Link(+ATR))
Let A' and B' stand for forms that add violations of the faithfulness constraints Dep-Link(+high) and Dep-Link(+ATR), respectively.
To any chain of the form <X, B', Y>, if X does not contain a faithfulness violation of Dep-Link(+high), assign a violation mark, and
to any chain of the form <X, B', Y>, if Y contains a violation of Dep-Link(+high), assign a violation mark.

The candidate chain <ˈɛ-i → ˈe-i → ˈi-i> violates Prec(Dep-Link(+high),Dep-Link(+ATR)) one more time than the candidate chain <ˈɛ-i → ˈe-i>. This is so because the former violates the two premises of the Prec constraint; a violation of the faithfulness constraint Dep-Link(+ATR) is not preceded by a violation of the faithfulness constraint Dep-Link(+high) (first violation), and the violation of Dep-Link(+ATR) is followed by a violation of Dep-Link(+high) (second violation). With respect to <ˈɛ-i → ˈe-i>, only the first premise of the Prec constraint is violated. Although the candidate chain <ˈɛ-i → ˈe-i → ˈi-i> violates Prec(Dep-Link(+high),Dep-Link(+ATR)) one more time than the candidate chain <ˈɛ-i → ˈe-i>, the former still satisfies Agree(+high,+ATR) more than the latter. This is why the candidate chain with fell-swoop raising is again wrongly selected as the most harmonic candidate (31).

(31)

/ˈɛ-i/	Agr(+high&+ATR)	Prec	Dep-Link(+Fs)
a. ☞ ˈɛ-i → ˈe-i → ˈi-i		**	**
b. ☹ ˈɛ-i → ˈe-i	*	*	*
c. ˈɛ-i	**		

An opposite ranking between Agree(+high,+ATR) and Prec(Dep-Link(+high),Dep-Link(+ATR)) would still select the wrong candidate, in this case the faithful one, <ˈɛ-i>, which vacuously satisfies the Prec constraint as it violates no faithfulness constraints (32).

(32)

/ˈɛ-i/	Prec	Agr(+high&+ATR)	Dep-Link(+Fs)
a. ˈɛ-i → ˈe-i → ˈi-i	**		**
b. ☹ ˈɛ-i → ˈe-i	*	*	*
c. ☞ ˈɛ-i		**	

For counter-feeding interactions, the Prec constraint must always be outranked by the markedness constraint that triggers the counter-feeding process, and dominate the markedness constraint that triggers the counter-fed process. As exemplified for Bedouin Arabic, in which vowel epenthesis counter-feeds open syllable raising, *Complex-Coda dominates Prec(Ident(low),Dep), which dominates Raise. This ranking allows for the counter-feeding process to apply.

It is now clear that for OT-CC to account for counter-feeding interactions, the two processes involved in the opaque interaction must be different, and as such they must result in violations of different faithfulness constraints. One possible solution is to split Mascaró's (2011b) constraint into Agree(+ATR) (33) and Agree(+high). With the ranking Agree(+ATR) ≫ Prec(Dep-Link(+high),Dep-Link(+ATR)) ≫ Agree(+high), the actual output forms for both underlying [+ATR] and [−ATR] mid vowels are obtained (34).

(33) Agree(+ATR)
For every pair of adjacent vowels one of which is [+ATR], assign one violation mark if they are not linked to the same token of [+ATR].

(34) a.

/ˈe-i/	Agree(+ATR)	Prec	Agree(+high)	Dep-Link(+high)
a. ☞ ˈe-i → ˈi-i				*
b. ˈe-i			*W	L

b.

/ˈɛ-i/	Agree(+ATR)	Prec	Agree(+high)	Dep-Link(+ATR)
a. ☞ ˈɛ-i → ˈe-i		*	*	*
b. ˈɛ-i → ˈe-i → ˈi-i		**W	L	*
c. ˈɛ-i	*W	L	*	L

However, there is a problem with the constraint Agree(+ATR). This constraint erroneously predicts that [+ATR] mid vowel suffixes also trigger [+ATR] tonic metaphony if defined as in (33). However, this is not the case (35).

(35) No [+ATR] metaphony from mid vowels
[ˈmɔɾ-o] ‘I die’ *[ˈmoɾ-o]
[ˈdɛnt-e] ‘tooth’ *[ˈdent-e]

For an analysis in OT-CC, an appropriate formulation of Agree(+ATR) should be like in (36).

(36) Agree(+ATR)*if* [+high]
For every pair of adjacent vowels one of which is [+high,+ATR], assign one violation mark if they are not linked to the same token of [+ATR].

This constraint presupposes a condition in its formulation: if [+high], then agree for [+ATR]. Although this formulation works empirically, it raises one major problem regarding its explanatory power: why is it the case that [+high] is in the if-clause and [+ATR] in the consequent-clause of the constraint? In other words, what prevents from having Agree-type constraints demanding, for instance, that a vowel containing [−high] must agree for, let’s say, [+back]? If the possibility for including a conditional clause in the formulation of an Agree-type constraint exists, then the set of Agree-type constraints increases undesirably.[10] In the parallel OT analysis in Mascaró (2011b), however, the metaphony-triggering constraint refers to two features that must both be spread; no splitting and no if-clause are necessary.[11]

6. Pre-tonic metaphony in Servigliano

Servigliano also displays another process of vowel harmony, distinct from tonic metaphony, in which the trigger is not an unstressed high vowel inflectional suffix, but a stressed high vowel. This process can be referred to as pre-tonic metaphony to differentiate it from tonic metaphony. In pre-tonic metaphony, a stressed high vowel raises all pre-tonic [+ATR] mid vowels to high (37).

(37) Pre-tonic metaphony targeting [+ATR] mid vowels

[ˈverd-e]	'green'	[virˈd-u]	'deep green-MASC.PL.'
[ˈrreʃʃ-o]	'I go out'	[rriʃˈʃ-i]	'to go out'
[ˈfjor-e]	'flower'	[fjuˈr-i]	'to flower'
[ˈmoʃk-e]	'fly-PL.'	[muʃˈk-itt-u]	'small fly, midge'

Interestingly, pre-tonic metaphony, as opposed to tonic metaphony, also raises [−ATR] mid vowels to high; no chain shift is observed in the pre-tonic domain (38).

(38) Fell-swoop pre-tonic metaphony targeting [−ATR] mid vowels

[ˈʃtɛnn-e]	'(s)he extends'	[ʃtinˈn-i]	'to extend'
[kaˈnɛʃtr-a]	'basket'	[kaniʃˈtr-i]	'basket-DIM.'
[beˈsɔɲɲ-a]	'need (N)'	[bisuɲˈɲ-imo]	'we need'
[ˈpɔr-a]	'poor (prenom.)-FEM.SG.'	[puˈr-itt-u]	'poor (postnom.)-MASC.SG.'

Mascaró (2011b) interprets this situation as an asymmetry between tonic metaphony and pre-tonic metaphony; tonic metaphony shows step-wise raising, whereas pre-tonic metaphony shows fell-swoop raising. As a possible solution in parallel OT, he proposes to relativize the local conjoined constraint IDENT(high&ATR) to affect only stressed positions (39). If this constraint is ranked above AGREE(+high,+ATR), it blocks fell-swoop raising in tonic metaphony, and allows it in pre-tonic metaphony.

(39) IDENT-STRESS(high&ATR) (Mascaró 2011b)
Assign one violation mark for any stressed vowel that violates both IDENT(high) and IDENT(ATR), *i.e.*, for any stressed high vowel that derives from a non-high-non-ATR vowel.

For the OT-CC analysis explored in this paper, the PREC constraint predicts that fell-swoop raising is blocked not only in stressed positions, but also in pre-tonic positions. However, we can claim that pre-tonic metaphony from [−ATR] mid vowels to [+high] vowels is not a case of fell-swoop raising, but a two-step operation of first vowel reduction and then vowel harmony. Actually, vowel reduction targets [−ATR] mid vowels in the absence of high vowels, which map onto [+ATR] mid vowels (40).

(40) Vowel reduction

[ˈɲɛl-o]	'I cool down'	[ɲeˈl-a]	'to cool down'
[meˈrɛnn-a]	'lunch'	[merenˈn-ett-a]	'afternoon snack'
[ˈgɔl-o]	'I fly'	[goˈl-a]	'to fly'
[beˈsɔɲɲ-a]	'need (N)'	[besoɲˈɲ-a]	'to need'

We can claim, in accordance with Mascaró (2011b), that vowel reduction feeds one-step raising from a [+ATR] mid vowel, the result of vowel reduction, to a [+high] vowel. However, from the OT-CC perspective adopted here, it is clear that vowel reduction has nothing to do with a violation of Dep-Link(+ATR), as the examples in (40) suggest, because no spreading is involved in vowel reduction. On the contrary, vowel reduction is the result of applying an operation of feature value change (/−ATR/ → [+ATR]), that violates Ident(ATR) (26b).

If vowel reduction incurs no violation of Dep-Link(+ATR), the candidate chain with vowel reduction and then harmony in (41) does not violate Prec(Dep-Link(+high),Dep-Link(+ATR).

(41) Candidate chain with pre-tonic metaphony fed by vowel reduction

ɛ - ˈi → e - ˈi → i - ˈi

[−ATR] [+ATR] [+ATR] [+ATR] [−high] [+high]

The right candidate chain showing fell-swoop raising is thus selected in OT-CC (42).

(42)

/ɛ-ˈi/	Prec	Agree(+high)	Id(ATR)
a. ☞ ɛ-ˈi → e-ˈi → i-ˈi			*
b. ɛ-ˈi → e-ˈi		*W	*
c. ɛ-ˈi → e-ˈi → i-ˈi	*W*		L

Candidate a's LUMs: <Ident(ATR), Dep-Link[+high]>
Candidate b's LUMs: <Ident(ATR)>
Candidate c's LUMs: <Dep-Link[+ATR], Dep-Link[+high]>

LUMs, or localized unfaithful mappings, are faithfulness violations at a particular spot in the input. It is precisely a difference in LUMs that makes candidate (a) and candidate (c) different. Although both candidates share the same final form in the chain, their first LUM is different. Candidate (a) violates Ident(ATR) when mapping /ɛ/ to [e], in which the value for the feature [ATR] is altered. Candidate (c), however, violates Dep-Link(+ATR) when mapping /ɛ/ to [e], in which an operation of spreading plus delinking has taken place.

Consider now the cases of tonic metaphony. In metaphonic contexts, however, the possibility of first violating Ident(ATR) and then Dep-Link(+high) must be excluded. On the one hand, to discard a candidate with that sequence of LUMs, we need a constraint like Ident(ATR) to be ranked above Prec(Dep-Link(+high),Dep-Link(+ATR). However, this ranking would also block the candidate chain for pre-tonic metaphony in (41). To solve this ranking paradox, one possible solution is to relativize the Ident(ATR) constraint to refer to the stressed position (Ident-Stress(ATR)), along the lines of Mascaró (2011b).

To recapitulate, pre-tonic metaphony does not violate Prec(Dep-Link(+high),Dep-Link(+ATR)), but context-free Ident(ATR), which is dominated by the former, and shows raising to [+high] as the result of changing the value for the feature [ATR]. In metaphonic contexts, the value for the feature [ATR] cannot be changed because this operation violates context-dependent Ident-Stress(ATR), which is undominated and ranked above Agree(+high) (43).

(43) Servigliano OT-CC grammar as a Hasse diagram

Ident-Stress(ATR) Agree(+ATR) *if* [+high]

Prec

Agree(+high) Ident(ATR) Dep-Link(+ATR)

Dep-Link(+high)

The fact that OT-CC helps discovering a distinction between vowel reduction and harmony as two different processes each of which violates a different faithfulness constraint, does not mean that OT-CC solves the asymmetry between metaphonic and pre-tonic contexts. Still, the use of positional faithfulness, as in Mascaró (2011b), is needed to account for the data. Therefore, OT-CC does not seem to represent any gain in terms of economy.

The other relevant analysis of Servigliano couched within parallel OT is the one in Walker (2011). In Walker (2011), two different constraints are used to explain tonic metaphony and pre-tonic metaphony, respectively. For tonic metaphony, a prominence-based licensing constraint for the class of height features ([high] and [ATR]) belonging to a high post-tonic vowel is used: License([Height]$\sigma_{post-tonic}$,ˈσ). To account for step-wise raising, local conjunction of faithfulness constraints is also used, as in Mascaró (2011b). As opposed to Mascaró (2011b), however, Walker (2011) assumes that the two harmony processes, tonic metaphony and pre-tonic metaphony, are two distinct processes triggered by different constraints. One argument in favor of this is typological: other Romance languages have tonic metaphony but not all of them show the effects of pre-tonic metaphony. The other factor to assume two distinct processes is the fact that the two processes have different domains of application, as only tonic metaphony can span across a boundary between a stem and a clitic. For pre-tonic metaphony, which also targets [−ATR] mid vowels, a maximal licensing constraint is proposed in Walker (2011), LICENSE([+high], $\forall V_{Left}$). This constraint disfavors vowels that do not harmonize for [+high] with a following high vowel. As Mascaró (2011b) points out, the two adduced arguments in favor of assuming two different processes are weak. First, different Romance languages can have different extensions for the same phenomenon. Second, it seems reasonable to believe that the boundary between proclitics and stems and between stems and enclitics is different, both morphologically and prosodically. Implementing the analysis of Walker (2011) in OT-CC is possible, as two different raising-triggering constraints are posited. However, explaining both tonic metaphony and pre-tonic metaphony using the same constraint is desirable, as in Mascaró (2011b).[12]

7. Conclusions

This paper has revisited data from Servigliano, which are particularly interesting for two reasons: first, Servigliano has a metaphonic chain shift, a particular case of counter-feeding opacity, that maps underlying [−ATR] stressed mid vowels onto [+ATR] mid vowels, and underlying [+ATR] mid vowels onto [+high] vowels if followed by high vowel inflectional suffixes; second, Servigliano displays an asymmetry between tonic metaphony, that operates in a step-wise manner, and pre-tonic metaphony, which is fed by vowel reduction and therefore shows fell-swoop raising. This paper has taken the parallel OT analysis developed in Mascaró (2011b) as a starting point to explore an analysis in terms of OT-CC. Gradualness forces the analyst to inspect closely the operations behind metaphony and vowel reduction. The conclusion is that OT-CC does not offer a better solution than parallel OT for different reasons. First, OT-CC needs to split the metaphony-triggering constraint AGREE(+high&+ATR) proposed in Mascaró (2011b) into two different constraints to interact correctly with the PRECEDENCE constraint, which is responsible for preventing the transparent candidate chain from being selected by the grammar. Second, in splitting the constraint, wrong predictions arise that force a more complicated definition of one of the split AGREE constraints, which must include a conditional clause, AGREE(+ATR)*if*[+high]. Third, in order to explain the asymmetry between tonic metaphony and pre-tonic metaphony, OT-CC must make use of positional faithfulness as is suggested in Mascaró (2011b). To conclude, this paper shows that OT-CC, although being a specific theory of phonological opacity, complicates the analysis of metaphonic chain shift in Servigliano.

REFERENCES

Alderete, John. 1997. Dissimilation as local conjunction. In Kiyomi Kusumoto (ed.), *The North East Linguistics Society* (NELS) 27, 17–32. Amherst, MA: GLSA.

Baković, Eric. 2007. A revised typology of opaque generalisations. *Phonology* 24(2), 217–259.

Baković, Eric. 2011. Opacity and ordering. In John Goldsmith, Jason Riggle & Alan C. L. Yu (eds.), *The handbook of phonological theory: Second edition*, 40–67. Malden, MA: Wiley-Blackwell.

Becker, Michael. 2006. CCamelOT. Amherst, MA: University of Massachusetts Amherst. [Java program. Accessed at http://becker.phonologist.org/CCamelOT/about.cgi.]

Calabrese, Andrea. 2011. Romance metaphony. In Marc van Oostendorp, Colin Ewen, Beth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1717–1735. Malden, MA: Wiley-Blackwell.

Camilli, Amerindo. 1929. Il dialetto di Servigliano. *Archivum Romanicum* 13, 220–251.

Dyck, Carrie. 1995. *Constraining the phonology-phonetics interface with exemplification from Spanish and Italian dialects*. Ph.D. dissertation, University of Toronto.

Gnanadesikan, Amalia E. 1997. *Phonology with ternary scales*. Ph.D. dissertation, University of Massachusetts Amherst.

Itô, Junko & Armin Mester. 2003. *Japanese Morphophonemics. Markedness and Word Structure*. Cambridge, MA: MIT Press.

Kaze, Jeffrey W. 1989. *Metaphony in Italian and Spanish dialects revisited*. Ph.D. dissertation, University of Illinois.

Kirchner, Robert. 1996. Synchronic chain shifts in Optimality Theory. *Linguistic Inquiry* 27(2), 341–350.

Łubowicz, Anna. 2000. Derived Environement Effects in Optimality Theory. *Lingua* 112(4), 243–280.

Łubowicz, Anna. 2005. Locality of Conjunction. In John Alderete, Chung-hye Han & Alexei Kochetov (eds.), *Proceedings of the 24th West Coast Conference on Formal Linguistics*. Somerville, MA: Cascadilla Press.

Łubowicz, Anna. 2011. Chain shifts. In Marc van Oostendorp, Colin Ewen, Beth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1717–1735. Malden, MA: Wiley-Blackwell.

Łubowicz, Anna. 2012. *The phonology of contrast*. London: Equinox.

Maiden, Martin. 1991. *Interactive morphonology: Metaphony in Italy*. New York: Routledge.

Mascaró, Joan. 2011a. Rule ordering. In Marc van Oostendorp, Colin Ewen, Beth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1736–1760. Malden, MA: Wiley-Blackwell.

Mascaró, Joan. 2011b. An analysis of stress-dependent harmony in Servigliano. *Probus* 23(1), 21–55.

Mascaró, Joan. 2013. A chain shift paradox for classic OT and Harmonic Serialism. Presented at the 10th Old World Conference in Phonology, Boğaziçi University.

McCarthy, John J. 2000. Harmonic Serialism and parallelism. In Masako Hirotani, Andries Coetzee, Nancy Hall & Ji-yung Kim (eds.), *The North East Linguistic Society* (NELS) 30, 501–524. Amherst, MA: GLSA.

McCarthy, John J. 2003. Comparative markedness. *Theoretical linguistics* 29(1-2), 1–51.

McCarthy, John J. 2007. *Hidden generalizations: Phonological opacity in Optimality Theory*. London: Equinox.

McCarthy, John J. 2009. Harmony in Harmonic Serialism. Ms., University of Massachusetts Amherst.

McCarthy, John J. 2010. An introduction to Harmonic Serialism. *Language and Linguistics Compass* 4(10), 1001–1018.

Miglio, Viola. 2005. *Markedness and Faithfulness in Vowel Systems*. New York: Routledge.

Morén, Bruce T. 1999. *Distinctiveness, coercion and sonority: A unified theory of weight*. Ph.D. dissertation, University of Maryland, College Park.

Moreton, Elliott & Paul Smolensky. 2002. Typological consequences of local constraint conjunction. *West Coast Conference on Formal Linguistics* 21: 306–319.

Nibert, Holly J. 1998. Processes of vowel harmony in the Servigliano dialect of Italian: A comparison of two non-linear proposals for the representation of vowel height. *Probus* 10(1), 67–101.

Parkinson, Frederick B. 1996. *The representation of vowel height in phonology.* Ph.D. dissertation, Ohio State University.

Prince, Alan. 2002. Arguing optimality. In Andries Coetzee, Angela Carpenter & Paul de Lacy (eds.), *Papers in Optimality Theory II*, 1–33. Amherst, MA: GLSA.

Prince, Alan & Paul Smolensky. 1993. Optimality Theory: Constraint interaction in generative grammar. Ms., Rutgers University & University of Colorado, Boulder. Published 2004, Malden, MA & Oxford: Blackwell.

Smolensky, Paul. 1995. On the Internal Structure of the Constraint Component of UG. Presented at the University of California Los Angeles. [ROA-86]

Spaelti, Philip. 1997. *Dimensions of variation in multi-pattern reduplication.* Ph.D. dissertation, University of California Santa Cruz.

Walker, Rachel. 2011. Weak triggers in vowel harmony. *Natural Language and Linguistic Theory* 23(4), 917–989.

Walker, Rachel. 2011. *Vowel patterns in language.* Cambridge: Cambridge University Press.

Wolf, Matthew. 2008. *Optimal interleaving: Serial phonology-morphology interaction in a constraint-based model.* Ph.D. dissertation, University of Massachusetts Amherst. [ROA-996]

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Footnotes

1 The term 'regular chain shift' is borrowed from Łubowicz's work on chain shifts. The reader is referred to her work for detailed analyses of other types of chain shifts.

2 Throughout this paper, most tableaux are presented in comparative format (Prince 2002), and also include traditional violation marks. A capital W is entered into the cell of a particular loser row if the winner is favored over that loser by the constraint in that column. A capital L is inserted in the opposite situation, that is, if that loser is favored over the winner. Nothing is inserted if neither the winner nor a particular loser are favored by a specific constraint. Every L must be dominated by at least one W in comparative tableaux, meaning that every loser-favoring constraint is dominated by at least one winner-favoring constraint.

3 It is not the purpose of this paper to address the theoretical problems that constraint conjunction poses for phonological theory.

4 All data come from Mascaró (2011b).

5 Tonic metaphony in Servigliano is very similar to the chain shift of the Bantu language Nzebi analyzed in Kirchner (1996). In Nzebi, certain verbal high vowel suffixes cause a one-step raising in root vowels including the low vowel (/a/ → [ɛ]; /ɛ/ → [e]; /e/ → [i]; etc). Kirchner's (1996) account of the Nzebi chain shift makes use of a constraint Raising, which is defined as "maximize vowel height". This constraint prefers fell-swoop raising, for instance, mapping /a/ all the way up to [i]. To implement the chain shift, Kirchner (1996) resorts to local constraint conjunction of Parse(F) constraints. The fell-swoop candidate fatally violates a conjoined faithfulness constraint because it always incurs more than one faithfulness violation, and this is why the one-step candidate wins. The constraint used in Mascaró (2011b), Agree(+high,+ATR), has the same effect as the Raising constraint in Kirchner (1996), although it is defined in a way that triggers a feature-sharing configuration. Both approaches resort to local conjunction of faithfulness constraints in order to block fell-swoop raising.

6 As one anonymous reviewer points out, this constraint is not represented in the traditional way (as in Smolensky's 1995 proposal). The domain of application is the segment and the two conjuncts are Ident(high) and Ident(ATR).

7 Besides phonological opacity, OT-CC has also been applied to the morphology-phonology interface in Wolf (2008) and implemented computationally in Becker (2006).

8 I will not discuss cases where stress falls on the third syllable from the right, in which an unstressed vowel mediates between the metaphony-triggering suffix and the targeted root vowel. In these cases, the intermediate unstressed vowel undergoes a process of total assimilation by which it acquires all features from the suffix vowel (['prɛdok-o] 'I preach' *cf.* ['predik-i] 'you preach'; ['torvad-a] 'turbid-FEM.SG.' *cf.* ['turvud-u] 'turbid-MASC.SG.'). Tonic metaphony in these cases is also attested, and it can be accomplished through iterative local spreading after all features from the suffix have spread onto the intermediate unstressed vowel (/torvad-u/ → ... → torvud-u → ['turvud-u]). For more details, see Mascaró (2011b).

9 A chain in which first [+high] spreads is not harmonically improving because a vowel containing both [−ATR] and [+high] is ruled out based on independent reasons; in Romance, [−ATR], or lax, high vowels are inexistent (a feature co-occurrence constraint like *[−ATR,+high] at the top of the hierarchy rules out this feature cluster configuration and makes a chain in which first [+high] spreads onto a [−ATR] mid vowel impossible to generate).

10 The same argument would persist for other types of harmony-triggering constraints based on ALIGN, SPREAD or SHARE (see McCarthy 2009 for a discussion of harmony in HS where the latter is proposed).

11 One anonymous reviewer suggests that the AGREE constraints in the OT-CC analysis could be expressed as markedness constraints against adjacent sequences of clusters of features with opposing values, *ɛ-i/*ɔ-i and *e-i/*o-i, or *[−ATR,−high]-[+ATR,+high] and *[−high]-[+high], respectively, if features are used as a way to express stringency relations. This reformulation of the constraints could certainly avoid including the conditional clause overtly. Nevertheless, the purpose of using AGREE is to make a comparison between the parallel OT analysis in Mascaró (2011b) and the OT-CC analysis developed here.

12 For a review of previous rule-based analysis of Servigliano, see Mascaró (2011b).