The typology of opacity and Containment Theory

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Abstract

In this paper, we provide the first step to the general argument that Containment Theory is a general representational solution to the opacity-problems standard correspondence-theoretic OT faces. More concretely, we show that a specific and restrictive version of Containment Theory employing the so-called 'Cloning Hypothesis' (Trommer 2011, 2014, Trommer & Zimmermann 2014) is empirically most adequate with respect to the typology of attested counterfeeding and counterbleeding patterns and is hence superior to rule-based alternatives.

1. Introduction

Phonological opacity is the pervasive phenomenon that the context for phonological processes can be obscured by the interaction with other processes. The classical definition by Kiparsky (1973) is given (1) and enriched with the terms of McCarthy (1999) after the arrows.

(1) Opacity

A phonological rule $\mathbb{P}$ of the form A $\rightarrow$ B / C_D is opaque if there are surface structures with either of the following characteristics:

a. instances of A in the environment C_D.
➞ non surface true = underapplication

b. instances of B derived by $\mathbb{P}$ that occur in environments other than C_D.
➞ non surface apparent = overapplication

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As Bakovic (2011) rightly summarizes, there are '[f]ew notions in phonological theory have received as much attention in the literature as opacity.' (p.40) One of the most prominent starting points is the observation that standard parallel correspondence-theoretic OT can not predict opacity whereas an SPE system based on ordered phonological rules can (see, for example, Bakovic (2011) for an overview and relevant citations).

In this paper, we add another theoretical perspective to this discussion: The claim that Containment Theory restricted by the Cloning Hypothesis is able to predict attested opacity cases and systematically excludes imaginable but unattested patterns.

Many of the existing theoretical discussions of opacity focus on possible interactions that arise between two processes and equate opacity with the process interactions of counterfeeding (1a) and counterbleeding (1b). That this is a simplification in both directions (there can be overapplication/underapplication without counterfeeding/counterbleeding respectively and there can be counterfeeding and counterbleeding without opacity) is the argument in, for example, Bakovic (2007) where the most complete typology of opaque interactions is given that we are aware of. In this contribution we also start with an investigation of classical counterfeeding and counterbleeding cases and hope that our theoretical argument can be extended to other types of opacity in future research.

Two classical examples of counterfeeding and counterbleeding that are repeated in the theoretical literature and will also serve as illustrations for our theoretical model are counterfeeding in Lomongo and counterbleeding in Tiberian Hebrew, given in (2) and (3).

In Lomongo, there are surface forms that violate the generalization that high vowels directly followed by another vowel are repaired via gliding [oina]. These surface forms arise if the context for gliding is only created by another process of /b/-deletion. The account for this underapplication opacity based on ordered rules is given in (2): Although deletion creates the context for gliding, it is too late for this process since the former is ordered after the latter.

(2) Counterfeeding in Lomongo (Bakovic 2011: 45)

	/o-isa/	/ba-bina/	/o-bina/
1. Gliding	wisa	–	–
2. Deletion	–	baina	oina
	'you (sg)'	'hide'	'they dance'

In Tiberian Hebrew, both final /ʔ/-deletion and /ə/-epenthesis to avoid final clusters can apply to underlying forms like /deʃʔ/. Since the context for epenthesis is already destroyed as soon as the /ʔ/ is deleted, this is an instance of opaque overapplication. The account for Tiberian Hebrew in a system based on ordered rules is given in (3): Although deletion destroys the context for epenthesis, it comes too late since the former follows the latter.

(3) Counterbleeding in Tiberian Hebrew (McCarthy 1999: 333)

	/melk/	/qaraʔ/	/deʃʔ/
1. Epenthesis	melex	–	deʃeʔ
2. ʔ-Deletion	–	qara	deʃe
	'king'	'he called'	'tender grass'

This paper is structured as followed: After we present our theoretical model of Two-Level-Containment in section 2.1, we show how it can predict counterfeeding and counterbleeding of the type illustrated with Lomongo and Tiberian Hebrew in section 2.2 and 2.3. That this model is restrictive and systematically excludes certain opacity types that are possible in a system based on ordered rules is shown in section 3. Section 4 takes a first look at the empirical reality of attested opacity patterns and concludes that one can be very optimistic that the predictions of Two-Level-Containment are empirically borne out. Section 5 concludes.

2. Proposal: Two-Level-Containment

2.1. Background Assumptions

Our central theoretical assumptions are identical to the original implementation of Optimality Theory (=OT) proposed by Prince & Smolensky (1993), namely the assumption of hierarchical autosegmental representations and the Containment restriction on candidates. This latter assumption excludes any literal deletion from the phonology: All elements that are 'deleted' are simply marked as not realizable for the phonetic interpretation. In a system based on autosegmental representations, the material that remains unrealized by the phonetic component equals the material that remains un-integrated into the overall prosodic structure. This exclusion of literal deletion crucially distinguishes our system from classical Correspondence Theory (McCarthy & Prince 1995).

The two minimal departures from Classical OT we assume are the implementation of epenthesis by reference to morphological affiliation of phonological material and the generalization of the Containment assumption to autosegmental association lines. The central assumptions of our system that we term Two-Level-Containment (=2LC) can hence be summarized as in (4).

(4) Two-Level-Containment: Assumptions

a. Radical Containment:
No erasure of phonological elements or association lines.
(Trommer & Zimmermann 2014, Trommer 2011, Zimmermann 2017)

b. Hierarchical Nonlinear Representations:
Prosodic Phonology and Feature Geometry.
(e.g. Nespor & Vogel 1986, McCarthy 1981)

c. Colors:
Each morpheme has a unique color characterizing all of its underlying nodes and association lines.
(van Oostendorp 2003, 2008, 2007, Revithiadou 2007)

The assumption (4a) implies that the marking of association lines as invisible is the only counterpart to deletion operation in non-Containment approaches. Together with the assumption of autosegmental representations (4b), this means that phonetic realization of a phonological element can be specified as in (5).

(5) Axiom of Phonetic Visibility (Trommer & Zimmermann 2014)
A phonological node is visible to phonetics if and only if it is dominated by the designated root node of the structure through an uninterrupted path of phonetic association lines

The third assumption (4c) means that morphological structure is minimally reflected in phonological representations since every morpheme has its own unique 'color' that is present on all phonological material that is underlyingly part of this morpheme. The phonology is thus able to distinguish whether 1) phonological elements are part of the same morpheme or not and 2) whether elements were underlyingly present or are epenthetic (=colourless). The assumption of colours is hence an explicit formalization for the morphemic affiliation of elements which is implicitly assumed in Correspondence-theoretic OT as well. Our notational conventions are illustrated in (6) and (7). Non-realized association lines are struck out (6b) whereas epenthetic association lines are given as dotted (6c).

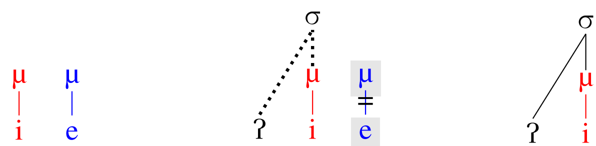
(6) Notation of association lines (Trommer & Zimmermann 2014)

a. Morphological phonetically visible	b. Morphological phonetically invisible	c. Epenthetic phonetically visible
		

The depiction in (7) also introduces the three different structural levels that are implied in 2LC: the morphological structure (=M) that equals the underlyingly present input into the phonology, the integrated structure (=I) that equals the phonological output structure that contains all realized and non-realized elements, and the phonetic structure (=P) that is interpreted by the phonetics. To ease readability of the I-structures, non-realized phonological elements like segments, features, or tones are marked with a grey background in the following. The actual colours distinguishing elements with different morphemic affiliations are omitted in the following but all epenthetic elements are marked as underlined.

(7) Deletion as non-realization in 2LC: Three different structures

Morphological = M   Integrated = I   Phonetic = P



In 2LC, there is no principled division into faithfulness and markedness constraints: Only information present in the output candidates is penalized by constraints; there is hence no comparison with an 'input' anymore. In 2LC, the family of faithfulness constraints penalizing deletion in classical correspondence-theory, namely MAX, are constraints against non-realized material in line with (5). Since the name MAX is so well-established for this type of constraints, we will stick to it in the following. And constraints against insertion are simply constraints against colourless material, called DEP in the following for reasons of familiarity as well.

In Containment Theory, deleted elements hence remain in the structure and constraints can in principle refer to it. In 2LC, this reference is restricted by the Cloning Hypothesis in (8) that distinguishes it from other possible systems based on Containment: Constraints can either be evaluated on the I-structure and hence take into account all phonological elements (including phonetically unrealized ones) or they can be evaluated on the P-structure and hence only restrict phonetically realized material (Trommer 2011, Trommer & Zimmermann 2014).

(8) The Cloning Hypothesis
Every markedness constraint exists in 2 incarnations:
a. The general clone refers to all structure in I.
b. The phonetic clone refers only to structure in P.

In the following, the name of P-constraints will be underlined to distinguish them from their I-clone. The Cloning Hypothesis explicitly excludes any constraints that only refer to M-structure. Such a constraint type is, for example, possible in the correspondence-theoretic OT model proposed in McCarthy (1996) where all constraint parameters are specified for whether they apply on the 'surface', to the 'underlying' structure or whether they are 'indifferent'.

In the next two subsections, we illustrate how this 2LC system predicts counterfeeding and counterbleeding patterns.

2.2. Counterfeeding in Two-Level-Containment

Recall that in Lomongo gliding underapplies although its context is created on the surface by /b/-deletion. In an account based on ordered rules, this was taken to follow since gliding applies after /b/-deletion applied, cf. (2). The 2LC account is based on the intuition that /b/-deletion does not create the context for gliding since deletion is not true deletion. The relevant markedness constraints for this account are given in (9). Gliding is triggered by (9a) which penalizes adjacent vowels and /b/-deletion by (9b) which penalizes any postvocalic /b/. Both are P-constraints. Importantly, there is another constraint (9b) which bans adjacent consonants and this is now an I-constraint that takes into account all structure, including the non-realized one.

(9) a. *VV: Assign a violation mark for every pair of adjacent vowels (=segments specified for [-cons]) in P.
b. *Vb: Assign a violation mark for every postvocalic voiced sonorant in P.
c. *CC: Assign a violation mark for every pair of adjacent consonants (=segments specified for [+cons]) in I.

Tableau (10) optimizes a transparent gliding context where two vowels are expected to be adjacent after prefixation. Candidate (10a) without any repair violates *VV and both gliding in (10b) and non-realization of one of the vowels in (10c) avoids this violation. Since non-realization of a vowel (10b) violates both MAXS and MAX[-cons], gliding (10c) which only violates MAX[-cons] is optimal.

(10) Gliding

o-isa	*CC	*Vb	*VV	MAXS	MAX[-CONS]
a. oisa			*!		
☞ b. wisa					*
c. o isa				*!	*

Tableau (11) adds the context of transparent /b/-deletion. Since MAXS is ranked below *Vb, the candidate non-realizing the /b/ (11b) is optimal

(11) Deletion

ba-bina	*CC	*Vb	*VV	MAXS	MAX[-CONS]
a. babina		*!			
☞ b. ba b ina				*	

The opaque context where a /b/ is underlyingly preceded by a high vowel is optimized in (12). The absence of any repair processes in (12a) results in a fatal violation of *Vb. Non-realization of the /b/ in (12b) avoids this violation but induces a new violation of *VV since a new pair of adjacent vowels is created in the P-structure. This violation can be avoided by additional gliding in (12c) but this now induces a violation of *CC since the new glide, formed by non-realization of underlying [-cons] and insertion of epenthetic [+cons], is adjacent to another [+cons] segment in the I-structure, namely the non-realized /b/.

(12) Deletion but no gliding

o-bina	*CC	*Vb	*VV	MaxS	Max[-cons]
a. obina		*!			
☞ b. o b ina			*	*	
c. w b ina	*!			*	*

This minimal interaction of five constraints already suffices to illustrate the logic of a 2LC account of counterfeeding: It is based on the insight that the context for a process might be given in P but is not given on I, summarized in (13). In Lomongo, the context for gliding is restricted to high vowels that are directly followed by a [-cons] segment in the I-structure and is hence not given if the vowel that could undergo gliding is followed by a (non-realized) consonant.

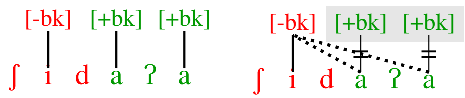
(13) Counterfeeding in 2LC
The context for a process is present in P but not in I.

Another example for a pattern where deletion counterfeeds another process is Sea Dayak where vowel nasalization triggered by a preceding nasal consonant does not apply if this adjacency is created by deletion of a voiced stop or affricate after a nasal: /naŋga/ –> [nãŋaʔ], *[nãŋãʔ] 'set up a ladder' (Kenstowicz & Kisseberth 1979: 298). A 2LC account based on a constraint *NV penalizing oral vowels after nasal segments which is sensitive to I-structure readily predicts this pattern. The non-realization of an element simply does not create the necessary adjacency relation of a nasal and non-nasal element in the I-structure for a case like /naŋ g a/. If vowel length is represented with moras, vowel shortening also involves the non-realization of an element. A case at hand is Maltese where vowel shortening counterfeeds rounding harmony that is only triggered by short vowels (Ettlinger 2008). This pattern also falls out from the intuition (13): The constraint demanding that short round vowels spread their [+round] feature is an I-constraint that is hence not violated if an underlyingly long round vowel is shortened on the surface.

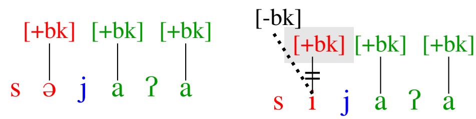
This general logic that non-realization of elements is not sufficient to create the context necessary for another operation can also be extended to feature changing operations since those involve non-realization of underlying features in Containment. A relevant case cited in the literature is counterfeeding in Mafa where vowel harmony for [±back] is not triggered by vowels that are only caused to be front by an adjacent glide: /sə-j-aʔe/ –> [sijaʔa], *[sijeʔe] 'drink it!' (Ettlinger 2008: 9). This falls out in 2LC if the constraint triggering vowel harmony is sensitive to I-structure and hence penalizes any pair of vowels that are not associated to the same [±back] feature. Since an underlyingly [-back] vowel will always keep this value in the I-structure the constraint is not violated even if a fronted vowel cooccurs with a non-front vowel, sketched in (14). In (14a), two vowels with different underlying [±back] features would violate the harmony-triggering constraint and harmony applies. In (14b), however, the disharmony only arises in the P-structure via raising caused by an adjacent glide. Though the epenthetic [-back] feature is different from the [+back] of the following vowel, the first vowel still has its non-realized [+back] in the I-structure and hence no violation of the harmony-triggering constraint occours.

(14) Vowel harmony counterfed by vowel raising: Mafa

a. Underlyingly different backness features: Vowel harmony



b. Underlyingly identical backness features: No vowel harmony



The additional non-realized features in the I-structure hence help to satisfy the constraint in Mafa. Interestingly, the context for a process can also be absent in the I-structure since too many features are there. This can be the case for parasitic harmony processes. An example is the famous counterfeeding in Yawelmani Yokuts where parasitic rounding vowel harmony which only applies between vowels of the same height is not triggered by vowels that are lowered since they are long: /cuːm-al/ –> [coːmal] *[coːmol] 'might destroy' (Kenstowicz & Kisseberth 1979: 90). This falls out in 2LC if the relevant I-constraint demands rounding harmony only for vowels that are associated to the same height features – an additional non-realized feature hence already makes a vowel too different in the I-structure.

As was already shown in the account for Lomongo in (12), the generalization that the context for a process is given in the P-structure but not in the I-structure can also follow if a higher ranked I-constraint blocks the result of a certain process. Another example at hand is the 2LC account of counterfeeding in Shimakonde where a root-controlled vowel harmony process is triggered by mid vowels. If such a mid vowel results from coalescence of a low and a high vowel, however, no vowel harmony surfaces (/va-nda-ím-an-a/ –> [vandeémaána], *[vandeémeéna][1] 'they will deny each other' (Ettlinger 2008: 116)). This follows if root-controlled vowel harmony is restricted by a high-ranked constraint penalizing any [+high] vowel that shares its height features in the I-structure. Since a mid vowel that results from coalescence still bears its [+high] feature in the I-structure, vowel harmony is blocked in such contexts.

Following the terminology of McCarthy (1999), all of the examples discussed above are instances of counterfeeding on environment where the element changed by one process is part of the context for the other process that does not apply. The counterpart are counterfeeding on environment cases where the element changed by one process is also expected to be changed by the other. Counterfeeding on focus cases that result in chain shiftings can follow from exactly the logic in (13) as well. A famous example can be found in Western Basque where mid vowels are raised to high but low vowels are only raised to mid (Hualde 2012). In 2LC, this fell-swoop raising is blocked by a high-ranked constraint against vowels that are both [+low] and [+high] – exactly the configuration that arises in the I-structure if a low vowel is raised to high (see Trommer (2011) or Popp (2018) for the general analysis of chain shifts along these lines in Containment Theory).

[1] As common for Bantu vowel harmony, the process never affects prefixes or final vowels.

2.3. Counterbleeding in Two-Level-Containment

In this subsection, we turn to the 2LC account of counterbleeding, starting with the famous Tiberian Hebrew example from (3). Recall that a rule-based account would assume that /ə/-epenthesis precedes /ʔ/-deletion and that this second process can destroy the context for the first process on the surface. The 2LC account is based on reversing the logic of the counterfeeding account presented above: The context for a process is not given in the P-structure but it is still present in the I-structure since deletion is not true deletion in containment, summarized in (15).

(15) Counterbleeding in 2LC
The context for a process is not present in P but it is present in I.

The relevant constraints for an account of Tiberian Hebrew are given in (16). The constraint (16a) triggers /ə/-epenthesis to break up a final consonant cluster and the constraint (16b) triggers final /ʔ/-deletion. Crucially now, only the latter is a P-constraint, the former is only sensitive to I-structure.

(16) a. *CC]: Assign * for every sequence of two adjacent consonants at the right word edge in I.
b. <u>*ʔ]</u>: Assign * for every [ʔ] at the right word edge in P.

Tableau (17) optimizes the transparent context of /ə/-epenthesis where two consonants are underlyingly adjacent. The absence of any repair process (17a) hence trivially results in a violation of *CC]. Interestingly, non-realization of one of the consonants (17b) does not avoid this violation simply because this consonant and hence the cluster is still present in the I-structure. Only epenthesis (17c) that destroys the adjacency of the two consonants can successfully repair the consonant cluster in the I-structure. Consequently, epenthesis becomes optimal although DEP dominates MAX.

(17) Epenthesis

melk	*CC]	<u>*ʔ]</u>	DEPS	MAXS
a. melk	*!			
b. mel k	*!			*
☞ c. meləx			*	

The ranking argument for MAXS and DEPS becomes apparent in the transparent context of /ʔ/-deletion, shown in (18). In contrast to (17), both non-realization (18b) and epenthesis (18c) can resolve the problem of a final /ʔ/ that is excluded by high-ranked *ʔ] (18a). Since DEPS is ranked over MAXS, candidate (18b) becomes optimal.

(18) ʔ-Deletion

qaraʔ	*CC]	*ʔ]	DEPS	MAXS
a. qaraʔ		*!		
☞ b. qara ʔ				*
c. qaraʔə			*!	

Tableau (19) adds the opaque context where a final consonant cluster ending in /ʔ/ is underlyingly present. Faithful realization of this structure induces violations of both *CC] and *ʔ] as in (19a). Epenthesis on its own (19c) avoids a violation of *CC] but still induces a violation of *ʔ]. Only the combination of epenthesis and non-realization of the final /ʔ/ in (19d) avoids both violations and is predicted to be optimal. The crucial transparent competitor is candidate (19b) that only undergoes non-realization of /ʔ/ and hence avoids a violation of P-sensitive */ʔ/. It still induces a violation of *CC], however, since this constraint is formulated for the I-structure. Although there is no phonetically realized consonant cluster, there still is one in the integrated structure and this cluster can only be avoided via epenthesis.

(19) Insertion and deletion

/deʃʔ/	*CC]	*ʔ]	DEPS	MAXS
a. deʃʔ	*!	*!		
b. deʃ ʔ	*!			*
c. deʃəʔ		*!	*	
☞ d. deʃə ʔ			*	*

Counterbleeding in Tiberian Hebrew hence follows since a 'deleted' element remains in the I-structure and can still trigger processes if the relevant constraints are I-constraints.

This account can be extended to other pervasive counterbleeding examples: In West Greenlandic, for example, overapplication of vowel pharyngalization after the triggering /q/ was deleted pre-consonantally (e.g. /taliq-t/ –> [tali̥t], *[talit] (Ettlinger 2008: 47)) follows if the constraint triggering pharyngalization is an I-constraint and still ‘sees’ the triggering consonant. A similar case of assimilation that is counterbled by consonant deletion is also cited for Ojibwa (Kaye 1974, McCarthy 1999).

Again, this logic also extends to feature changing operations since those involve non-realization of underlying features in Containment Theory. An example can be found in Polish where consonant devoicing counterbleeds vowel raising which is only triggered before voiced consonants (e.g. /ʒob/ –> [ʒup], *[ʒop] ‘crib’ (Kenstowicz & Kisseberth 1979: 73)). In 2LC, devoicing involves the non-realization of an underlying [+vcd] feature that still remains in the structure. If the constraint demanding high vowels before [+vcd] consonants is sensitive to I-structure, this counterbleeding readily follows. Similarly, spirantization affects only voiced stops in Low German but is counterbled by final consonant devoicing (e.g. /taːg/ –> [taːχ], *[taːk] ‘days’ (Bakovic 2011: 59)). If the constraint demanding a [-cont] feature on any consonant that is [+vcd] is sensitive to I-structure, this overapplication is again predicted: The context for the process simply remains in the I-structure though it is destroyed in the P-structure.

3. 2LC as a restrictive theory

In the preceding section, it was shown that 2LC provides a representational solution to counterbleeding and counterbleeding cases which are notoriously challenging in correspondence-theoretic OT. 2LC’s account relies on the fact that the I-structure can contain non-realized elements which make the I-structure different from the P-structure. This difference implies that the context for a process may not be given in I although it is present in P (=counterfeeding) or that the context for a process is given in I although it is not present in P (=counterbleeding). The main argument for 2LC and against alternative accounts of opacity should be its restrictiveness: It only predicts certain attested opacity patterns but systematically excludes other imaginable but unattested patterns.

As we will discuss in this subsection, there are three restrictions on possible counterfeeding and counterbleeding patterns in 2LC that are predicted to exist in an alternative account based on ordered rules.

Firstly, 2LC systematically excludes patterns where epenthesis alone counterfeeds or counterbleeds another process, simply because the relevant parts of the I-structure and the P-structure are identical in such a case. Example (20) illustrates this restriction with a concrete example of counterfeeding epenthesis. In this made-up language, nasalization of vowels preceded by a nasal consonant is counterfed by nasal epenthesis that applies to break up otherwise adjacent vowel clusters. On the surface, nasalization hence underapplies in [baninã] that surfaces instead of transparent *[banĩnã].

(20) Counterfeeding in Dayak': Rule-based account

	/naŋa/	/ba-ina/
1. V-Nasalization	nãŋã	bainã
2. Epenthesis	–	baninã

That this pattern is impossible to predict in 2LC is shown in tableau (22). The constraint (21a) triggers progressive vowel nasalization and (21b) triggers vowel epenthesis (all alternative repairs are excluded for ease of exposition). The former is necessarily a P-constraint since non-realization of [-nas] on the vowel would not help to avoid a violation of this constraints if it were evaluated on the I-structure. Constraint (21b) is also a P-constraint though it in fact does not matter whether it is an I- or a P-constraint since both versions are equally satisfied by epenthesis as a repair.

(21) a. <u>*NV</u>: Assign a violation mark for every [-nas] vowel that is directly preceded by a [+nas] segment.
b. <u>*VV]</u>: Assign a violation mark for every pair of adjacent vowels.

The relevant counterfeeding context (22) shows how these constraints mispredict the transparent application of nasalization. Epenthesis of a nasal creates the adjacency between a nasal consonant and a non-nasal vowel penalized by (21a). Crucially, it creates this adjacency in both the P- and the I-structure, there is hence no version of the constraint (21a) in 2LC that would avoid this misprediction.

(22) Dayak' is impossible in 2LC

ba-ina	*NV	*VV	DEPS	MAX[NAS]
a. baina	*!	*!		
b. bainã		*!		*
☛ c. baninã	*!			*
☞ d. banĩnã				**

An absolutely similar restriction holds for counterbleeding interactions. As was shown in subsection 2.3, these follow in 2LC since the context for a process can (still) be given in the I-structure although it is already destroyed in the P-structure. This again restricts the processes that can counterbleed other processes to deletion that leaves certain elements non-realized. Epenthesis that counterbleeds another process is systematically impossible in 2LC.

This is illustrated with a concrete example in (23). In this made-up language Ojibwa', place assimilation between adjacent consonants is counterbled by /ə/-epenthesis to break up final consonant clusters.

(23) Counterbleeding in Ojibwa': Rule-based account

	/takossin-ka/	/takossin-k/
1. Place assimilation	takossiŋka	takossiŋk
2. Epenthesis	–	takossiŋək

That 2LC is again unable to predict this pattern is shown in tableau (25) where two consonants with different place features are at the right word edge in the input. The transparent candidate (25c) that only inserts an epenthetic vowel successfully avoids violations of both the constraint against consonants with different place features (24a) and the one against a final consonant cluster (24b). Opaque overapplication of place assimilation in (25d) is hence harmonically bounded.

(24) a. $*C_{\alpha}C_{\beta}$: Assign a violation mark for every pair of segments associated with an identical place feature.

b. $*CC]_{\sigma}$: Assign a violation mark for every consonant at the right word edge that is directly adjacent to a preceding consonant.

(25) Ojibwa’ is impossible in 2LC

takossin-k	$*C_\alpha C_\beta$	$*CC]_\sigma$	DEPS	MAX[PL]
a. takossink	*!	*!		
b. takossiŋk		*!		*
☞ c. takossinək			*	
☛ d. takossiŋək			*	*!

The mispredictions illustrated in (22) and (25) are systematic in 2LC and follow from the restrictiveness of the Cloning Hypothesis. Epenthesis destroys an underlying adjacency relation in both the P- and the I-structure and the only constraints that could refer to pre-epenthesis contexts are M-constraints that only refer to coloured material.

The discussion of whether epenthesis can counterbleed other processes has been present since the beginning of the opacity discussion (cf., for example, Kenstowicz & Kisseberth (1971), Kiparsky (1973), Bakovic (2007)) and it is interesting that this restriction arises (again) in 2LC.

A second opaque pattern that is systematically impossible in 2LC but can be predicted by ordered rules is one where a process applies if and only if its context is given in the underlying form and a second process both counterbleeds and counterfeeds this first process. A famous example for this comes from Yawelmani Yokuts where parasitic roundness harmony is taken to be both counterfed and counterbled by lowering of long vowels as in (26).

(26) Yawelmani Yokuts (Kenstowicz & Kisseberth 1979: 90+92)

	Counterbleeding	**Counterfeeding**
	/c’ujuː-hin/	/c’uːm-al/
1. V-Harmony (if same height)	c’ujuːhun	–
2. Lowering ($Vː_{[+high]} \rightarrow Vː_{[-high]}$)	c’ujoːhun	c’oːmal

2LC can either successfully predict the counterfeeding or the counterbleeding relation but not the simultaneity of both. This would only be possible in a system where the constraint triggering parasitic vowel harmony is sensitive only to the M-structure – something explicitly excluded by the Cloning Hypothesis.

The final restriction of 2LC that we want to mention is the exclusion of fed counterfeeding where one deletion process feeds another one which in turn counterfeeds the first. A repeatedly cited example is Lardil where final vowel deletion feeds deletion of final apical consonants. Crucially, this consonant deletion does not feed another application of vowel deletion although it can create the surface context for final vowel deletion.

(27) Fed counterfeeding in Lardil (Hale 1973)

	/wangalk/	/jilijili/	/dibirdibi/
1. V-deletion V–>ø /__#	–	jilijil	dibirdib
2. C-deletion $C_{[-apic]}$–>ø /__#	wangal	–	dibirdi
	‘boomerang’	‘oyster species’	‘rock cod’

2LC cannot predict such a pattern simply because the two constraints triggering the deletion must be P-constraints. This is necessary since no I-constraint can ever result in deletion within 2LC. And as soon as the context for the second deletion process is hence created on the surface, it is predicted to apply (iteratively).

4. The empirical reality of counterfeeding and counterbleeding

In this section we will test the three restrictions of 2LC discussed in the last section 3 against the empirical reality.

We start with the restriction that epenthesis can never counterfeed or counterbleed another process. To get a representative overview over attested patterns, we looked at all examples of counterfeeding and counterbleeding patterns discussed in three central theoretical contributions to the opacity discussion: The proposal of Sympathy Theory in McCarthy (1999) (=M99), the detailed typology of opaque interactions in Bakovic (2007) (=B07) and Bakovic (2011) (=B11), and the argument for diagonal correspondence-theory in Ettlinger (2008). All of these cases are summarized in (28) with an implied rule-based account where process 1 is counterfed or counterbled by process 2. The patterns are distinguished into ‘on environment’ (=E) and ‘on focus’ (=F) cases.

(28) Counterfeeding and counterbleeding: Examples

		Process 1	Process 2	
Counterfeeding				
E	Lomongo	Gliding	C-Deletion	B11
	Sea Dayak	V-Nasalization	C-Deletion	M99,E08
	English	Flapping	C-Deletion	M99
	Maltese	V-Harmony	V-Shortening	E08
	Mafa	V-Harmony	V-Fronting	E08
	Bedouin Arabic	V-Raising	Glide Vocalization	M99, B07
	Yawelmani Yokuts	V-Harmony	V-Lowering	M99, E08
	Kalong	V-Harmony	V-Tensing	E08
	Shimakonde	V-Coalescence	V-Harmony	E08
	Shimakonde	V-Reduction	V-Coalescence	E08
	Icelandic	V-Rounding	V-Epenthesis	E08
F	Western Basque	V-Raising (to high)	V-Raising (to mid)	B11
	Bedouin Arabic	V-Deletion	V-Raising	B07
	Nuu-Chah-Nulth	C-Labialization	C-Delabialization	M99
	Shimakonde	V-Reduction	V-Coalescence	E08
	Mafa	V-Harmony	V-Epenthesis	E08
	Agulis Armenian	V-Harmony	V-Epenthesis	E08
Counterbleeding				
E	Tiberian Hebrew	V-Epenthesis	C-Deletion	M99
	West Greenlandic	V-Pharyngalization	C-Deletion	E08
	Ojibwa	C-Assimilation	C-Deletion	M99
	Shimakonde	V-Harmony	V-Reduction	E08
	Polish	V-Raising	C-Devoicing	B11
F	Yawelmani Yokuts	V-Harmony	V-Lowering	E08
	Yawelmani Yokuts	V-Lowering	V-Shortening	M99, B07
	Low German	C-Spirantization	C-Devoicing	B11

This overview shows that out of these 25 patterns, only three involve an obvious epenthesis process[2] which counterbleeds another process.

The first case is Icelandic where vowel epenthesis before /r/ in coda clusters

[2]Other cases might involve epenthesis depending on the specific interpretation of the relevant processes. In Kalong (Hyman 2002), for example, only vowels in certain stems are undergoers of tensing in open syllables. If those are taken to be underspecified, tensing is hence an epenthesis process that doesn't overwrite an underlying value. However, a reanalysis without a proper epenthesis process is easily possible.

seemingly counterfeeds glide deletion to avoid coda clusters with rising sonority, shown in (29).

(29) Counterfeeding in Icelandic (Karvonen & Sherman 1997: 7)

	/mɨðj-r/
1. Glide deletion	mɨðr
2. Epenthesis	mɨðʏr
	'middle' (nom.sg.fem)

However, it has been convincingly argued in Riggs (2008) that this in fact involves a transparent interaction with */ji/ banning glides before high vowels as the responsible constraint that triggers glide deletion in epenthesis contexts.

The other two examples of Mafa and Argulis Armenian are quite similar and involve epenthetic vowels that don't undergo vowel harmony. In Agulis Armenian, it is quite telling that the non-undergoer epenthetic /ə/ is in fact the only /ə/ of the language – these vowels don't exist underlyingly (Vaux 1998). That they resist vowel harmony can hence follow from a special (underspecified) featural representation of these vowels; an analysis that can easily be extended to Mafa as well.

All other 22 counterbleeding and counterfeeding patterns are consistent with the restriction that epenthesis can never counterbleed or counterfeed another process. The 2LC account for many of them was in fact discussed above in sections 2.2 and 2.3.

For the other two restrictions of 2LC – the impossibility of simultaneous counterfeeding and counterbleeding and fed counterfeeding – the apparent counterexamples were already discussed above, namely Yawelmani Yokuts and Lardil. Although both patterns are repeatedly discussed in the theoretical literature, their validity as empirical arguments is potentially questionable.

For Lardil, it has been argued convincingly that the final vowel deletion is only found in the nominative (cf.Hale (1973), McCarthy & Prince (1993), Horwood (2001), Bye (2006) and Round (2011); but seeStaroverov (2015) for counterarguments against this claim). It is hence not a regular phonological process but an instance of non-concatenative morphology (see Trommer & Zimmermann (2014) for an account of this morphological vowel deletion within containment).

And the extensively discussed opacity pattern in Yawelmani Yokuts (for example, Archangeli (1984), Cole & Kisseberth (1995) or Krämer (2003) among many) is not entirely based on actually attested data, as is emphasized in Kenstowicz & Kisseberth (1979), the source usually cited for opaque interactions in Yawelmani Yokuts.[3]

The empirical reality of attested counterfeeding and counterbleeding cases hence leaves us rather optimistic that 2LC makes the correct predictions about possible and impossible patterns. The apparent counterexamples can either be reanalysed in 2LC without too much a price to pay or are empirically quite questionable.

It is also apparent, however, that such an argument requires more future research, both in terms of arguing for the alternative reanalysis implied for Mafa and Argulis Armenian and also in terms of checking 2LC's predictions against a larger typology of putative cases of counterfeeding and counterbleeding.

5. Summary

In this paper, we investigated the predictions made by 2LC, a restricted version of Containment-based OT, for instances of counterfeeding and counterbleeding. We concluded that the theory systematically excludes certain opaque interactions: Instances where epenthesis counterbleeds or counterfeeds another process, simultaneous counterfeeding and counterbleeding, and fed counterfeeding by deletion. The empirical evidence seems to support these restrictions.

It is clear that this is only a first step for a convincing argument for 2LC based on opacity. For one, the theoretical account needs to be extended to other types of opacity (see, for example, the concise overview and typology in Bakovic (2011)). On the other hand, the restrictions discussed in this paper need to be tested against a more complete typology of empirical evidence and hence include other (putative) cases of counterfeeding and counterbleeding.

[3] 'The data discussed here are taken from Stanley Newman's (1944) description. [. . .] It should be pointed out that not all of the forms cited in this section, nor in the previous generative analyses of Yawelmani, are actually attested in Newman's grammar, the only published source on the language.' (Kenstowicz & Kisseberth 1979: 78).

References

Archangeli, Diana. 1984. *Underspecification in Yawelmani phonology and morphology*: MIT dissertation.

Bakovic, Eric. 2007. A revised typology of opaque generalizations. *Phonology* 24. 217–259.

Bakovic, Eric. 2011. Opacity and ordering. In John Goldsmith, Jason Riggle & Alan Yu (eds.), *The Handbook of Phonological Theory (2nd ed)*, 40–67. Malden, MA: Wiley Blackwell.

Bye, Patrik. 2006. Subtraction, optimization, and the combinatorial lexicon. Ms., University of Tromsø, CASTL.

Cole, Jennifer & Charles Kisseberth. 1995. Restricting multi-level constraint evaluation: Opaque rule interaction in Yawelmani vowel harmony. Ms., University of Illinois, available as ROA 98.

Ettlinger, Marc. 2008. *Input-driven opacity*: UC Berkeley dissertation.

Hale, Ken. 1973. Deep-surface canonical disparities in relation to analysis and change: an Australian example. In T. Sebeok (ed.), *Current Trends in Linguistics, vol XI*, 401–458. The Hague: Mouton de Gruyter.

Horwood, Graham. 2001. Antifaithfulness and subtractive morphology. Ms., Rutgers University, available as ROA 466-0901.

Hualde, Jose. 2012. *Basque phonology*. London: Taylor and Francis.

Hyman, Larry M. 2002. "Abstract" vowel harmony in Kalong: A system-driven account. Ms., University of California Berkeley, available at https://linguistics.berkeley.edu/∼hyman/Hyman_Kalong_VH_Paper.pdf.

Karvonen, Daniel & Adam Sherman. 1997. Opacity in Icelandic revisited: A sympathy account. In M. Katayama D. Karvonen & R. Walker (eds.), *Phonology at Santa Cruz 5*, 37–48.

Kaye, Jonathan. 1974. Opacity and recoverability in phonology. *Canadian Journal of Linguistics* 19(134-149).

Kenstowicz, Michael & Charles Kisseberth. 1971. Unmarked bleeding orders. *Studies in the Linguistic Sciences* 1. 8–28.

Kenstowicz, Michael & Charles Kisseberth. 1979. *Generative phonology: description and theory*. New York: Academic Press.

Kiparsky, Paul. 1973. Abstractness, opacity, and global rules. In Osamu Fujimura (ed.), *Three dimensions of linguistic theory*, 1–135. Tokyo: TEC.

Krämer, Martin. 2003. *Vowel harmony and Correspondence Theory*. Berlin/New York: Mouton de Gruyter.

McCarthy, John. 1981. A prosodic theory of nonconcatenative morphology. *Linguistic Inquiry* 12(3). 373–418.

McCarthy, John. 1996. Remarks on phonological opacity in Optimality Theory. In Jacqueline Lecarme, Jean Lowenstamm & Ur Shlonsky (eds.), *Studies in Afroasiatic Grammar*, 213–243. The Hague: Holland Academic Graphics.

McCarthy, John. 1999. Sympathy and phonological opacity. *Phonology* 16. 331–399.

McCarthy, John & Alan Prince. 1993. Prosodic morphology. Constraint interaction and satisfaction. Available as ROA 485-1201.

McCarthy, John & Alan Prince. 1995. Faithfulness and reduplicative identity. In Jill Beckman, Laura Dickey & Susanne Urbanczyk (eds.), *University of Massachusetts Occasional Papers in Linguistics*, 249–384. Amherst, MA: GLSA.

Nespor, Marina & Irene Vogel. 1986. *Prosodic phonology*. Dordrecht: Foris Publicatios.

van Oostendorp, Marc. 2003. Comparative markedness and containment. *Theoretical Linguistics* 29. 65–75.

van Oostendorp, Marc. 2007. Derived environment effects and consistency of exponence. In Sylvia Blaho, Patrik Bye & Martin Krämer (eds.), *Freedom of analysis?*, 123–148. Berlin: Mouton.

van Oostendorp, Marc. 2008. Incomplete devoicing in formal phonology. *Lingua* 118. 1362–1374.

Popp, Marie-Luise. 2018. Why mid vowels are not always mid vowels. Poster at the 49th Annual meeting of the North-East Linguistic Society (NELS49), Cornell University.

Prince, Alan & Paul Smolensky. 1993. Optimality theory: Constraint interaction in Generative Grammar. Technical reports of the Rutgers University Center of Cognitive Science.

Revithiadou, Anthi. 2007. Colored turbid accents and containment: A case study from lexical stress. In Sylvia Blaho, Patrick Bye & Martin Krämer (eds.), *Freedom of analysis?*, 149–174. Berlin, New York: Mouton de Gruyter.

Riggs, Daylen. 2008. Opacity in Icelandic: transparency and OT with candidate chains. NELS 39.

Round, Erich. 2011. Word final phonology in Lardil: Implications of an expanded data set. *Australian Journal of Linguistics* 31. 327–350.

Staroverov, Peter. 2015. Opacity in Lardil: Stratal vs. serial derivations in OT. In A. Assmann, S. Bank, D. Georgi, T. Klein, P. Weisser & E. Zimmermann (eds.), *Topics at Infl*, vol. 92, 33–64. Institut für Linguistik: Universität Leipzig.

Trommer, Jochen. 2011. Phonological aspects of Western Nilotic mutation morphology. Habilitation, Leipzig University.

Trommer, Jochen. 2014. Moraic prefixes and suffixes in Anywa. *Lingua* 140. 1–34.

Trommer, Jochen & Eva Zimmermann. 2014. Generalised mora affixation and quantity-manipulating morphology. *Phonology* 31. 463–510.

Vaux, Bert. 1998. *The phonology of Armenian*. Oxford: Clarendon Press.

Zimmermann, Eva. 2017. *Morphological length and prosodically defective morphemes*. Oxford: Oxford University Press.