# Opaque Allomorphy in OT

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## 1. Statement of the Problem

Much research in Optimality Theory (OT) (Prince & Smolensky 1993) accounts for allomorphy in terms of the well-formedness of the output. Allomorph distribution has been shown to be determined by phonological factors, such as *stress* (Antilla 1997, Drachman et. al 1995, Kager 1996, Mester 1994), *syllable structure* (Bonet 2004, Hargus & Tuttle 1997, Łubowicz et. al. to appear, Mascaró 1996, McCarthy & Prince 1993, Prince & Smolensky 1993, Rubach & Booij 2001, Tranel 1996, 1998), and *phonotactics* (Antilla 2002, Bermúdez-Otero forthcoming, Oostendorp 1998, Yip 2004).[1]

Allomorphy that cannot be explained by the properties of the output, which I will call **opaque allomorphy**, seemingly presents a problem to this line of research. This paper proposes a solution to opaque allomorphy in this research program in terms of preserving contrast. For related approaches, see Gafos & Ralli (2002), Kenstowicz (2005), Kurisu (1998), McCarthy (2005), Steriade (2000), and Urbanczyk (1999), among others.

In Polish, there is a process of Coronal Palatalization by which alveolars and dentals (t d n s z) turn into prepalatals (ć dź ń ś ź) before front vowels (Rubach 1984). The following are examples of palatalization before the locative singular suffix [-e] in masculine and neuter nouns. (I do not mark final devoicing.)

(1) Coronal Palatalization: /t d n s z/ → [ć dź ń ś ź]/_e

| | | nominative sg. | locative sg. | gloss |
|---|---|---|---|---|
| t → ć | : | lis[t] | o liś[ć] + e | 'letter' |
| d → dź | : | obia[d] | o obie[dź] + e | 'dinner' |
| n → ń | : | ok[n] + o | o ok[ń] + e | 'window' |
| s → ś | : | bruda[s] | o bruda[ś] + e | 'dirty man' |
| z → ź | : | łobu[z] | o łobu[ź] + e | 'troublemaker' |

Interestingly, underlying prepalatals take the back high vowel [–u] suffix in the locative and not the front mid vowel [–e] suffix.

(2) Original prepalatals

| | | nominative sg. | locative sg. | gloss |
|---|---|---|---|---|
| ć | : | liś[ć] | o liś[ć] + u | 'leaf' |
| dź | : | narzę[dź] + e | o narzę[dź] + u | 'tool' |
| ń | : | ko[ń] | o ko[ń] + u | 'horse' |
| ś | : | łoso[ś] | o łoso[ś] + u | 'salmon' |
| ź | : | pa[ź] | o pa[ź] + u | 'type of butterfly' |

This is an example of opaque allomorphy. There are two allomorphs for the locative singular suffix, [-e] and [-u], but from the surface form alone, the selected allomorph cannot be determined. I observe that the choice of the locative allomorph depends on whether the prepalatal in stem-final position is

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[1] For non-OT accounts, see Carstairs-McCarthy (1988), Hudson (1974), and Siegel (1974). For a more complete list of references, see McCarthy (2004).

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underlying or derived. Derived prepalatals, as in (1), take the [-e] ending, while original prepalatals, as in (2), take the [-u] ending.[2]

The main question is why original and derived prepalatals take different suffixes in the locative. In an output-oriented approach to phonology, such as Optimality Theory (Prince & Smolensky 1993), there should be no difference between underlying and derived prepalatals in their choice of the allomorph. Since derived and underlying prepalatals are articulated in the output in the same way (Wierzchowska 1971), they should select the same suffix in the locative.

The key proposal is that the different allomorphs of the locative suffix preserve a contrast that would be otherwise neutralized on the surface. Allomorph distribution preserves the original contrast between dentals/alveolars vs. prepalatals in stem-final position: /list/ vs. /liść/ map onto [liść + e] vs. [liść + u]. If both forms took the same suffix [-e], the contrast between them would be neutralized on the surface due to palatalization; /list/ vs. /liść/ would both map onto [liść + e].

The analysis will be couched within the framework of Contrast Preservation Theory or PC theory (Łubowicz 2003, 2004), which is extended to the area of allomorphy. The next section describes the framework.

## 2. The Framework: Contrast Preservation Theory

Contrast plays an essential role in a number of phonological and morphological processes. Some of the early works on contrast include Gussmann (1976), Hualdé (1990), Kaye (1974), Kisseberth (1976), Martinet (1952), Trubetzkoy (1971), among others. There is a great deal of work on the role of contrast in OT. Contrast has been used to account for phonological mappings (Łubowicz 2003, 2004, Tessier 2004), segmental inventories (Flemming 1995, 1996, 2004, Padgett 1997, 2001), historical change (Ito & Mester 2004, to appear, Padgett 2003, Padgett & Zygis 2003), feature co-occurrence restrictions (Cote 2000), morphological processes (Crosswhite 1997/1999, Horwood 2001, Kurisu 1998, Steriade 2000), tonal and accentual phenomena (Alderete 2001), and stress-epenthesis interaction (Łubowicz 2003). In the rest of this section, I describe the elements of the framework.

### *2.1 The Candidate*

In PC theory, a candidate is a set of input-output mappings, called a scenario (Łubowicz 2003, cf. Flemming 1995, 1996, 2004, Padgett 1997, 2001, 2003, Tessier 2004). The key idea is that phonological mappings are not evaluated in isolation but in the context of other mappings in the same system. This is different from standard Optimality Theory (Prince & Smolensky 1993), where mappings are evaluated in isolation. Similar ideas are present in the models of output-output faithfulness (Benua 1997) and in the allomorphic model of Burzio (1998).

Below is the actual scenario in Polish. Forms that contrast in the quality of the stem final consonant, li[st] vs. li[ść], take different suffixes in the locative, [-e] vs. [-u], respectively.

(3) The actual scenario (cf. (1) and (2))

| Input | | Output |
|---|---|---|
| li**st**, {+e, +u} | ⟶ | liść + **e** |
| li**ść**, {+e, +u} | ⟶ | liść + **u** |

In case of affix allomorphy, scenario inputs consist of a set of stems and allomorphs. The allomorphs are language-particular. In Polish, it is a set of two vowels {+e, +u}. Since the alternation is unpredictable, allomorphs must be stored in the lexicon as a set.

The input also contains stems to which allomorphs attach. I propose that input strings to which allomorphs attach are generated by the function GEN, similar to GEN in Correspondence Theory (McCarthy & Prince 1995). The forms generated by GEN consist of any combination of phonological

[2] There are two other mappings with coronal palatalization: r → ž (rowe[r] ~ o rowe[ž] + e), and w → l (ko[w] + o ~ o ko[l] + e). In both cases, the locative suffix is [-e], whereas the same segments present underlyingly take [-u].

properties P which are essentially any properties governed by standard faithfulness constraints (Prince & Smolensky 1993). This is shown below.

(4) The inputs of the scenario
Gen (list, {+e, +u}) = list, {+e, +u}; liść, {+e, +u}; teść, {+e, +u} etc.

In PC theory, the outputs of the scenario are a subset of the input.

In effect, scenarios represent various mapping coexistence patterns. The scenario is a candidate, and thus, the actual scenario is compared to other scenarios in the same candidate set.

(5) Scenarios in a candidate set (For other scenarios, see Section 4)

| Scenario | Actual | Contrast-neutralizing |
|---|---|---|
| Output | [liść + e] [liść + u] | [liść + e] |
| Input | /list, {+e, +u}/ /liść, {+e, +u}/ | /list, {+e, +u}/ /liść, {+e, +u}/ |

Scenarios are submitted for evaluation to EVAL. The optimal scenario is chosen by the constraints on contrast interacting with each other and with conflicting markedness constraints. There are also constraints on recoverability (see Section 4).

### *2.2 Constraints on Contrast*

In PC theory, contrast exists as an imperative in the phonological system. It is formulated as a family of rankable and violable constraints on contrasts, called PC constraints.[3] The constraints on contrast are defined in (6). The definition of contrast in a phonological property P is given in (7).

(6) PC(P)
For each pair of inputs contrasting in P that map onto the same output in a scenario, assign a violation mark. Formally, assign one mark for every pair of inputs, $in_a$ and $in_b$, if $in_a$ has P and $in_b$ lacks P, $in_a \rightarrow out_k$, and $in_b \rightarrow out_k$.
*"If inputs are distinct in P, they need to remain distinct in the output (not necessarily in P)."*

(7) Contrast in P
A pair of forms, $in_a$ and $in_b$, contrast in P, when corresponding segments in those forms, $seg_a$ and $seg_b$, are such that $seg_a$ has P and $seg_b$ lacks P (same for outputs).

PC constraints are like faithfulness constraints in that they evaluate two levels of representation, inputs and corresponding outputs, but they are different in that they look at pairs of inputs and outputs and not at an individual input-output mapping.

Unlike standard faithfulness, PC constraints allow a given underlying contrast to be realized as a different surface contrast. In Polish locative, the contrast in the quality of the stem-final consonant is transformed into the surface contrast in the choice of the allomorph.

## 3. The Analysis

### *3.1 Core Argument*

Coronal Palatalization, illustrated in (1), turns anterior consonants such as dentals and alveolars /s z t d n/ into prepalatals [ś ź ć dź ń] before front vocoids [i], [e], and [j].

(8) Coronal Palatalization (see Rubach 1984, 2003, Ćavar 2004)
[+anterior, +coronal] → prepalatal / _____ [-cons, -back]

[3] This proposal is different from Alderete (2001) and Horwood (2001) who define contrast as anti-faithfulness.

As a result of palatalization, a contrast is neutralized between underlying and derived prepalatals. I will refer to it as the height contrast.[4]

To account for palatalization, the markedness constraint PAL outranks the constraint on preserving contrast between underlying and derived prepalatals, called PC(high). The constraints and their ranking are defined below.

(9) PAL
No anterior coronal followed by a front vowel.

(10) PC(high)
Preserve contrast in height.

(11) Palatalization ranking
PAL >> PC(high)

(12) Palatalization neutralizes the height contrast

| | Scenarios | PAL | PC(high) |
|---|---|---|---|
| A. Contrast-preserving | /pas + e/ → pas + e<br>/paś + e/ → paś + e | *! | |
| B. Contrast-neutralizing ☞ | /pas + e/ → paś + e<br>/paś + e/ → paś + e | | * |

The scenario which fails to palatalize, scenario A, is eliminated. (The forms are hypothetical and are meant to illustrate the consequences of palatalization in the phonological system.)

Crucially, in the locative allomorphy, the contrast between derived and original prepalatals, the height contrast, is preserved on the surface despite palatalization and realized by different suffixes. Derived prepalatals take the [-e] allomorph while underlying prepalatals take the [-u] allomorph. Thus, the contrast in height is preserved.

(13) Allomorphy preserves the contrast in height

| | Scenarios | PAL | PC(high) |
|---|---|---|---|
| A. Contrast-neutralizing | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + e | | *! |
| B. Contrast-preserving ☞ (=Actual) | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + u | | |
| C. Contrast-preserving | /list, {+e, +u}/ → list + e<br>/liść, {+e, +u}/ → liść + e | *! | |

Scenario B wins. It palatalizes but also preserves the contrast in height. Scenario C fails to palatalize and scenario A neutralizes the contrast in height.

In summary, though palatalization can neutralize the height contrast, the locative allomorphy preserves the height contrast, despite palatalization. In effect, allomorphy keeps apart forms that the regular phonology would otherwise neutralize.[5]

### *3.2 Allomorph Distribution*

The allomorphs in Polish are in near complementary distribution. The front vowel allomorph is selected for front consonants and the back allomorph is selected for back consonants. The front vowel allomorph [-e] is also found after labials and labio-dentals {p, b, m, w, f, v}. The back vowel

[4] Rubach (1984) describes prepalatals as [+high, -back].

[5] Since there are underlying prepalatals, the constraint on preserving the height contrast PC(high) outranks the constraint against prepalatals *[+high, -back]; PC(high) >> *[+high, -back].

allomorph [-u] is after post-alveolars {š, ž, č, dž}, the palatal {j}, velars {k, g, x}, alveolar affricates {c, dz}, and the lateral {l}.[6]

(14) Front and back stems

a. Front consonants

| | | nominative sg. | locative sg. | gloss |
|---|---|---|---|---|
| p → p'j | : | chło[p] | o chło[p'] + je | 'peasant' |
| b → b'j | : | ara[b] | o ara[b'] + je | 'Arab' |
| m → m'j | : | do[m] | o do[m'] + je | 'house' |
| f → f'j | : | gra[f] | o gra[f'] + je | 'graph' |
| v → v'j | : | ró[v] | o ro[v'] + je | 'ditch' |

b. Back consonants

| | | nominative sg. | locative sg. | gloss |
|---|---|---|---|---|
| š | : | ko[š] | o ko[š] + u | 'basket' |
| ž | : | tale[ž] | o tale[ž] + u | 'plate' |
| č | : | królewi[č] | o królewi[č] + u | 'prince' |
| dž | : | bry[dž] | o bry[dž] + u | 'bridge' |
| j | : | kra[j] | o kra[j] + u | 'country' |
| k | : | so[k] | o so[k] + u | 'juice' |
| g | : | ró[g] | o ro[g] + u | 'corner' |
| x | : | stra[x] | o stra[x] + u | 'fear' |
| c | : | ko[c] | o ko[c] + u | 'blanket' |
| dz | : | wi[dz] | o wi[dz] + u | 'viewer' |
| l | : | nauczycie[l] | o nauczycie[l] + u | 'teacher' |

The same distribution is true of borrowings.

(15) Borrowings

| | | nominative sg. | locative sg. | gloss |
|---|---|---|---|---|
| ć | : | gadże[t] | o gadże[ć] + e | 'gadget' |
| dź | : | Harwar[d] | o Harwar[dź] + e | 'Harvard' |
| ś | : | autobu[s] | o autobu[ś] + e | 'bus' |
| ź | : | trape[z] | o trape[ź] + e | 'trapèze' (French) |
| ń | : | badminto[n] | o badminto[ń] + e | 'badminton' (English) |

| | | nominative sg. | locative sg. | |
|---|---|---|---|---|
| š | : | zam[š] | o zam[š] + u | 'Sämisch' (German) |
| ž | : | gara[ž] | o gara[ž] + u | 'garage' (French) |
| dž | : | bry[dž] | o bry[dž] + u | 'bridge' (English) |
| k | : | Nowy Jor[k] | o Nowym Jor[k] + u | 'New York' |
| l | : | alkoho[l] | o alkoho[l] + u | 'Alkohol' (German) |

To account for complementary distribution, I will assume that [u] is preferred over [e] (*e >> *u) but not after front consonants (*Front/u >> *e).[7]

(16) *Front/u
No back vowels after front consonants.

(17) Allomorph distribution
*Front/u >> *e >> *u

[6] In Polish, alveolar affricates pattern together with post-alveolars.

[7] *Front/u is a member of the family of no linkage constraints proposed in Ito, Mester & Padgett (1995). *Front/u is not active in other contexts in Polish. In terms of constraints, PC(vowel) >> *Front/u.

In effect, back consonants select the back allomorph (see (18)) while front consonants select the front allomorph (see (19)).

(18) Back consonants select [-u]

| /talež, {+u, +e}/ | *Front/u | *e | *u |
|---|---|---|---|
| ☞ a. talež + u | | | * |
| b. talež + e | | *! | |

(19) Front consonants select [-e]

| /graf, {+u, +e}/ | *Front/u | *e | *u |
|---|---|---|---|
| a. graf + u | *! | | * |
| ☞ b. graf' + je | | * | |

*3.3 The Role for Contrast*

Given the palatalization facts and the articulation of prepalatals, I assume that prepalatals followed by [-e] are unmarked. Thus, the allomorph [-u] after original prepalatals is unexpected. This is shown below. Both sets of prepalatals should select [-e].[8]

(20) Derived prepalatals

| /list, {+u, +e}/ | *Front/u | *e | *u |
|---|---|---|---|
| a. list + u | *! | | * |
| ☞ b. liść + e | | * | |

(21) Underlying prepalatals: wrong result

| /liść, {+u, +e}/ | *Front/u | *e | *u |
|---|---|---|---|
| ☜ a. liść + u | *! | | * |
| b. liść + e | | * | |

To ensure that derived and original prepalatals select different allomorphs, I propose that the constraint on contrast compels the marked allomorph [-u] (PC(high) >> *Front/u). In summary, palatalization takes place but allomorphy preserves the contrast in height despite palatalization. Contrast preservation and the need to palatalize compel the marked allomorph after underlying prepalatals. The ranking and the summary tableau are given below.

(22) The role for contrast
PAL >> PC(high) >> *Front/u

The following tableau compares three scenarios: a contrast-neutralizing scenario A, the actual scenario B, and a contrast-preserving scenario C.

(23) Summary tableau

| | Scenarios | PAL | PC(high) | *Front/u |
|---|---|---|---|---|
| A. Contrast-neutralizing | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + e | | *! | |
| B. Contrast-preserving<br>☞ (=Actual) | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + u | | | * |
| C. Contrast-preserving | /list, {+e, +u}/ → list + e<br>/liść, {+e, +u}/ → liść + e | *! | | |

Scenario B wins since it palatalizes and preserves the contrast in height. Scenario A fails since it neutralizes the contrast in height, and scenario C fails since it does not palatalize.

## 4. Predictions

*4.1 Other Scenarios*

In PC theory, a candidate is a scenario. A scenario represents various mapping coexistence patterns. Considering the two inputs and the set of allomorphs {+e,+u}, there are 16 logically possible scenarios to consider. Out of those, only 6 scenarios satisfy PAL and PC(high). These are given below. Among them is the actual scenario.

[8] Prepalatals count as front consonants.

(24) Scenarios that satisfy PAL and PC(high)

| | | | |
|---|---|---|---|
| 1. Actual | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + u | 4. | /list, {+e, +u}/ → liść + u<br>/liść, {+e, +u}/ → liść + e |
| 2. | /list, {+e, +u}/ → list + u<br>/liść, {+e, +u}/ → liść + e | 5. | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → list + u |
| 3. | /list, {+e, +u}/ → list + u<br>/liść, {+e, +u}/ → liść + u | 6. | /list, {+e, +u}/ → liść + u<br>/liść, {+e, +u}/ → list + u |

Scenarios 2, 3, 5 and 6 are ruled out by markedness and will not be further discussed here.[9]

Scenario 4, the so-called permuted scenario, has the same set of outputs as the actual scenario but the outputs are permuted. Thus, there is a tie in terms of constraints between the actual scenario and the permuted scenario, as shown below.

(25) A tie between scenarios

| | Scenarios | PAL | PC(high) | *Front/u |
|---|---|---|---|---|
| A. Actual | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + u | | | * |
| B. Permuted | /list, {+e, +u}/ → liść + u<br>/liść, {+e, +u}/ → liść + e | | | * |

To break the tie, I propose a constraint on the recoverability of input contrasts from the way contrasts are represented in the output (see (26)). In Polish, this constraint demands that the higher the input stem-final consonant, the higher the suffix (see (27)).

(26) RECOVER(P)

Let $in_a$ and $in_b$ contrast in P, let $out_a$ and $out_b$ contrast in P', where $in_a \Re out_a$ and $in_b \Re out_b$,
If $in_a$ has P and $in_b$ lacks P, then $out_a$ has P' and $out_b$ lacks P', and vice-versa.
*"The input contrast in P needs to be preserved in the output in the same direction."*

(27) RECOVER (high)

"The input contrast in height needs to be preserved in the output in the same direction."

The following tableau illustrates the role of recoverability.

(28) The role of RECOVER

| | Scenarios | PAL | PC(high) | *Front/u | RECOVER(high) |
|---|---|---|---|---|---|
| A. Actual<br>☞ | /list, {+e, +u}/ → liść + e<br>/liść, {+e, +u}/ → liść + u | | | * | |
| B. Permuted | /list, {+e, +u}/ → liść + u<br>/liść, {+e, +u}/ → liść + e | | | * | *! |

Candidate (b) loses since in this scenario the height contrast is permuted.

### *4.2 Implications*

In PC theory, contrast in addition to markedness determines allomorph distribution. Thus, PC theory predicts the kinds of allomorphy that are not admitted to other approaches. To begin with, PC theory can compel allomorphy in cases where allomorphy is unexpected based on well-formedness of the output (as in markedness-only approaches) or based on the properties of the input (as in the subcategorization approach). Second, PC theory can block allomorphy in cases where allomorphy is expected based on the well-formedness of the output (as in markedness-only approaches) or based on the properties of the input (as in the subcategorization approach).

[9] The failed scenarios contain more marked outputs (*Alveolar/u >> *Prepalatal/u).

Finally, PC theory gives an account of allomorphy within a parallel model of OT. No special mechanism is required to account for opaque allomorphy since in this approach contrast is an inherent property of the grammar.

## 5. Conclusion

This paper has accounted for Polish allomorphy in the locative of masculine and neuter nouns. It has been shown that locative allomorph distribution is opaque and can be accounted for in terms of preserving contrast. The key idea is that the different allomorphs of the locative suffix keep apart forms that the regular phonology would otherwise neutralize. A formal approach to opaque allomorphy has been developed within PC theory (Łubowicz 2003). Under this proposal, allomorph distribution follows from the principle of contrast and markedness.

## References

*Abbreviations:*
CLS = (Proceedings of the) Chicago Linguistics Society
NLLT = Natural Language and Linguistic Theory
ROA = Rutgers Optimality Archive (http://ruccs.rutgers.edu/roa.html)
WCCFL = (Proceedings of the) West Coast Conference on Formal Linguistics


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