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TOMASZ ŁUSZCZEK
University of Warsaw
t.luszczek@uw.edu.pl
ORCID: 0000-0002-3283-0960

POLISH NASAL ASSIMILATION: DIRECTIONALITY AND OPACITY

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Abstract

This paper investigates Polish Nasal Assimilation from the perspective of Optimality Theory (OT), as documented by words such as [sɛmp] 'vulture' and [bɔŋk] 'bumblebee'. It is argued that, contrary to standard assumptions, the directionality of assimilation is not determined by positional faithfulness constraints, but rather is controlled by general faithfulness constraints that require identity to place nodes and are crucially unidirectional. This new analysis of Polish is then tested against the data exhibiting interaction of Nasal Assimilation with Coronal Palatalization and with Yer Deletion. The former interaction is transparent and thus analyzable within standard OT, whereas the latter interaction is opaque and demonstrates that standard OT fails to deliver the correct results. The final section offers a reanalysis of the opaque data in terms of a version of OT that admits derivational levels.

1. Introduction

This paper investigates Polish Nasal Assimilation from the perspective of OT, with a special focus on the issue of directionality as well as on the interaction of Nasal Assimilation with other processes of Polish. There are four points of interest. First, the regressive direction of Nasal Assimilation is determined by unidirectional Input-to-Output (I→O) faithfulness constraints that require identity to place nodes: Ident-Dorsal(I→O), Ident-Coronal(I→O), and Ident-Labial(I→O). Second, only /n/, but not /m/ and /ɲ/, undergoes Nasal Assimilation, which is why words such as [gu*m*ka] 'rubber' (dimin.) and [ba*ɲ*ka] 'bubble' (dimin.) contain unassimilated

nasals. The lack of assimilation in such words receives a systematic explanation in the analysis relying on unidirectional IDENT constraints. Third, Nasal Assimilation interacts transparently with Coronal Palatalization, *t d* → *t͡ɕ d͡ʑ* / __ *i, ɛ*, but opaquely with Yer Deletion, *E* → Ø. Fourth, the opaque interaction poses difficulty for standard OT but is readily analyzed in derivational OT.

This paper is organized as follows. Section 1 introduces background information. Section 2 lays out the data and establishes basic generalizations regarding Nasal Assimilation. Section 3 focuses on the problem of directionality. Section 4 examines the issue of opacity. Section 5 concludes with a summary.

2. Data and basic generalizations

This section provides a descriptive background of the fragment of Polish phonology that is relevant to this paper and introduces the data as well as the basic generalizations pertaining to Nasal Assimilation.

2.1. Background

Polish has a rich system of consonants. Relevant for this paper are the classes of stops, nasals, and affricates. Their surface inventory is given in (1).

(1) Polish stops, nasals and affricates: Phonetic inventory

	LABIAL			CORONAL										DORSAL		
	p	b	m	t	d	n	t͡s	d͡z	t͡ʂ	d͡ʐ	t͡ɕ	d͡ʑ	ɲ	k	g	ŋ
[±obstr]	+	+	–	+	+	–	+	+	+	+	+	+	–	+	+	–
[±cont]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
[±nasal]	–	–	+	–	–	+	–	–	–	–	–	–	+	–	–	+
[±anter]				+	+	+	+	+	–	–	–	–	–			
[±strid]				–	–	–	+	+	+	+	+	+	–			
[±back]	+	+	+	+	+	+	+	+	+	+	–	–	–	+	+	+
[±voice]	–	+	+	–	+	+	–	+	–	+	–	+	+	–	+	+

I assume the standard Halle-Sagey feature geometry (Sagey 1986; Halle 1992), in which the major articulators are LABIAL, CORONAL, and DORSAL. The feature [±anterior] is a dependent of the CORONAL node and hence is distinctive for coronals but not for labials and dorsals. The same logic applies to [±strident] because, as argued by Rubach (1994), this feature is subsumed under CORONAL,

so it makes distinctions in the class of coronals only. I also follow Rubach (1994) in assuming that affricates are strident stops. Such treatment of affricates predicts that they pattern with stops, a prediction that is borne out by the Nasal Assimilation data introduced in the next subsection.

In contrast to its rich inventory of consonants, Polish has a relatively simple system of vowels including [i ɨ u ɛ ɔ a]. All of these vowels occur phonetically and are also posited as underlying segments.[1] While these vowels are self-explanatory, there are two other types of vowels that require explanation: *yers* and nasal vowels.

Like any Slavic language, Polish contains vowels called *yers*, whose defining property is that they alternate with zero, as shown by [ɔsɛt] 'thistle' (nom.sg.) – [ɔst-u] (gen.sg.) (Gussmann 1980; Rubach 1984). I follow Rubach (1986), Kenstowicz and Rubach (1987), and Rubach (2016) in assuming that yers are moraless melodic segments that are transcribed as /E/.[2] An underlying yer either makes it to the surface representation as a full non-yer vowel via Yer Vocalization, $E \longrightarrow \varepsilon$, or is deleted via Yer Deletion, $E \longrightarrow \emptyset$. This complex phonology of yers is not relevant to this paper. All that we need to know is that yers are underlying segments that delete if a vocalic suffix is added to the stem, as in [ɔsɛt] 'thistle' (nom.sg.) – [ɔst-u] (gen.sg.): /ɔsEt-u/ ⟶ [ɔstu]. Schematically:

(2) Yer Deletion: E ⟶ Ø / before a vocalic suffix

According to Rubach (2016), yers that have not been deleted vocalize context-freely and are turned into a full vowel [ɛ].

(3) Yer Vocalization: E ⟶ ɛ

The second issue in Polish phonology that is relevant to this paper is the understanding of the so-called "nasal vowels", written *ą* and *ę*. They used to be nasal historically but are not any longer.[3] The descriptive generalization is that *ą* and *ę* occur in two contexts: word-finally and before consonants. Since the goal of this paper is to investigate Nasal Assimilation, nasal vowels are discussed only inasmuch as they are relevant to the rule of Nasal Assimilation. This means that the context of interest is the one before stops and affricates, as illustrated in the following subsection.

2.2. Nasal Assimilation

Polish nasals agree in place of articulation with the following stop or affricate.

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1 The status of /ɨ/ as an underlying segment is a perennial problem of Polish phonology; see Rydzewski (2017) for discussion.

2 For alternative interpretations of yers, see, for example, Szpyra (1992) and Rowicka (1999).

3 The literature on these vowels is voluminous, encompassing traditional descriptions, such as Benni (1964 [1915]), Wierzchowska (1971), and Biedrzycki (1974), among others, as well as more theoretically oriented studies, including Lightner (1963), Gussmann (1980, 2007), Rubach (1984, 2008), Czaykowska-Higgins (1988, 1992), and Bethin (1992), among others.

(4) Nasal Assimilation in Polish

a. Before stops

i. Labials: [p, b]

[sɛmp] 'vulture'	[tɛmp-ɨ] 'blunt'
[dɔmp] 'oak'[4]	[trɔmb-a] 'trumpet'

ii. Coronals: [t, d]

[kɔnt] 'corner'	[ʐɔnd-ɨ] 'government' (nom.pl.)
[pɛnt] 'speed'	[prɔnd-ɨ] 'current' (nom.pl.)

iii. Velars: [k, g]

[bɔŋk] 'bumblebee'	[mɔŋk-a] 'flour'
[sɛŋk] 'knag'	[fstɛŋg-a] 'ribbon'

b. Before affricates

i. Anterior coronals: [t͡s, d͡z, t͡ʂ]

[tɨɕɔnt͡s] 'thousand'	[nɛnd͡z-a] 'destitution'
[tɛnʈ͡ʂ-a] 'rainbow'	[bɔnʈ͡ʂ-ɛk] 'bumblebee' (dimin.)

ii. Posterior coronals (also called prepalatals): [t͡ɕ, d͡ʑ]

[kɔɲt͡ɕ-ik] 'corner' (dimin.)
[trɔɲd͡ʑ-ik] 'acne'

The data in (4), which, by the way, are easily expandable, document that the nasal assimilates the place features of the following stop (4a), as in [sɛmp] 'vulture', or affricate (4b), as in [kɔɲt͡ɕ-ik] 'corner' (dimin.). In other words, in a cluster of a nasal plus a stop/affricate, the stop or the affricate governs the place of articulation of the nasal. This observation is further supported by the occurrence of the alternations in (5).

(5) Alternations[5]

a. [ŋ] – [n]

nom.sg.	*dat./loc.sg.*	*gloss*
[mɔŋk-a]	[mɔnt͡s-ɛ]	'flour'
[kɕɛŋg-a]	[kɕɛnd͡z-ɛ]	'book' (augm.)
[fstɛŋg-a]	[fstɛnd͡z-ɛ]	'ribbon'

b. [n] – [ɲ]

nom.sg.	*dimin.*	*gloss*
[kɔnt]	[kɔɲt͡ɕ-ik]	'corner'
[prɛnt]	[prɛɲt͡ɕ-ik]	'wire'
[ʐɔnt]	[ʐɔɲd͡ʑ-ik]	'government'

The fully predictable surface forms of the nasals in (4) and (5) as well as the alternations in (5) raise the question of the underlying representations (URs) of the nasal

[4] Polish has Final Devoicing.

[5] In the process of loanword adaptation, some speakers distinguish between the stressed position and the unstressed position, where Nasal Assimilation operates more readily in the former than in the latter. These speakers tend to have [ŋ], for example, in *bank* 'bank', where the syllable with the nasal is stressed, but [n] in *bankowość* 'banking', where the syllable with the nasal is unstressed. Thanks to a reviewer for drawing my attention to this issue.

vowels *ę* and *ą* in the context before a stop or an affricate.[6] The standard analysis is to postulate that these vowels are encoded in the UR as sequences of an oral vowel followed by the dental nasal /n/, so *ą* comes from /ɔn/ and *ę* comes from /ɛn/ (Lightner 1963; Gussmann 1980; Rubach 1984, 1986). I concur with this traditional line of research and posit /ɛn/ and /ɔn/ in (4) and (5), so, for example, *sęp* 'vulture' is represented as /sɛnp/ while *bąk* 'bumblebee' is represented as /bɔnk/.

Postulating /Vn/, where 'V' stands for a mid oral vowel, begs the question of why the dental nasal /n/ should be preferred to the remaining nasals, that is, /m/, /ɲ/, and /ŋ/. Of these nasals only [m n ɲ] are contrastive, as documented by words such as *to*[m] 'book', *to*[n] 'tone', and *to*[ɲ] 'depths'. The velar [ŋ] is not contrastive and hence is treated as an allophone, so the choice must be made between /n/, /m/, and /ɲ/.

There are three arguments that speak in favour of /Vn/ rather than /Vm/ or /Vɲ/ as the UR. The first argument comes from alternations: [n] alternates with [ŋ] in (5a) and with [ɲ] in (5b). These alternations show that postulating /m/ in (5) would lead to unwarranted abstractness because [m] does not occur in any of the data.

Second, to say that Polish nasal-stop/affricate clusters agree in place is actually an oversimplification because /m/ and /ɲ/ do not assimilate in such clusters. Consider the following data, where the alternating [-k-]/[-t͡ɕ-] is a diminutive suffix, the non-alternating [-t͡ɕ-] is an agentive suffix, while [-a] and [-ɛ] are inflectional endings.

(6) No Nasal Assimilation with /m/ and /ɲ/

a. /m/			b. /ɲ/		
nom.sg.	*dat./loc. sg.*	*gloss*	*nom.sg.*	*dat./loc. sg.*	*gloss*
[gum-k-a]	[gum-t͡ɕ-ɛ]	'rubber'	[baɲ-k-a]	[baɲ-t͡ɕ-ɛ]	'bubble'
[bram-k-a]	[bram-t͡ɕ-ɛ]	'goal'	[ɲaɲ-k-a]	[ɲaɲ-t͡ɕ-ɛ]	'nanny'
nom.sg.			*gen.sg.*		
[kwam-t͡ɕ-a]		'liar'	[kɔɲt͡ɕ-a]		'end'
[pɔgrɔm-t͡ɕ-a]		'conqueror'	[ʂaɲt͡ɕ-a]		'fortification'
[kɔmtur]		'commander'			
[mgw-a]		'fog'			

The unassimilated clusters in (6) document that Nasal Assimilation targets /n/ but not /m/ and /ɲ/.

Third, it is generally believed that dental coronals represent the unmarked place of articulation, which means that [n] but not [m], [ɲ], or [ŋ] is universally the default nasal (Paradis, Prunet 1991). This generalization provides independent motivation for underlying /n/.

To conclude, nasals before obstruent noncontinuants are encoded underlyingly as a sequence of an oral vowel plus a dental nasal, for example, *sęp* /sɛnp/ 'vulture' and *bąk* /bɔnk/ 'bumblebee'. The homorganic clusters in the surface representation, [sɛmp] and [bɔŋk], are due to Nasal Assimilation, which is stated semi-formally as follows.

[6] The nasals in (4) and (5) are written as *ę* and *ą*, for example, *sęp* [sɛmp] 'vulture' and *bąk* [bɔŋk] 'bumblebee'.

(7) Nasal Assimilation:
n → [αPlace] / __ [αPlace, +obstr, –cont]

Rule (7) explicitly states that, first, /n/ is the only nasal subject to assimilation and, second, that it is the nasal rather than the following stop or affricate that undergoes assimilation. In other words, the regressive direction of assimilation in Polish, [αPlace] [βPlace] → [βPlace] [βPlace], as opposed to the unattested progressive direction, [αPlace] [βPlace] → [αPlace] [αPlace], is directly written into the the structural description of rule (7). The next section introduces Optimality Theory (OT) and shows that such explicit encoding of directionality of assimilation is not possible in this framework.

3. Directionality

This section constructs an OT analysis of the data presented above, with a focus on the directionality of Nasal Assimilation. Subsection 3.1 lays out a basic constraint-based account and reviews previous approaches to directionality. Subsection 3.2 proposes a new analysis of this issue, and subsection 3.3 evaluates the proposal against data that exhibit interaction between Nasal Assimilation and Palatalization.

3.1. Basic patterns and previous solutions

Nasal Assimilation is stated as a markedness constraint in (8a), which is in conflict with the faithfulness constraint in (8b).

(8) a. Nasal-Assimilation (NA): Assign a violation mark for every nasal that does not agree in PLACE with the following stop.[7]

b. Ident-Place: PLACE on the input segment and its output correspondent must be identical.

These constraints are in conflict because NA triggers changes in the PLACE node, while Ident-Place prohibits them. Nasal Assimilation arises when NA dominates Ident-Place, as shown in tableau (9), which evaluates /kɔnt/ → [kɔnt] 'corner'. The right-pointing finger marks the optimal candidate.

(9) Basic pattern: NA >> Ident-Place

	/kɔnt/	NA	Ident-Pl
☞	a. kɔnt		
	b. kɔmp		*!*
	c. kɔnp	*!	*

[7] Lombardi (1999) introduced the family of agreement constraints in OT.

Since the input /kɔnt/ and the attested output [kɔnt] are identical in shape, any deviation from the input results in a fatal violation, that is why the winner is the faithful candidate (9a), [kɔnt], the correct result.

The mapping /nt/ → [nt] in (9) does not bear on the issue of directionality: the output is identical under both regressive and progressive assimilation. However, other homorganic clusters, such as [ŋk], as in /mɔnk-a/ → [mɔŋ.ka] 'flour', make it possible to detect the direction of assimilation. Dots mark syllable boundaries and the left-pointing finger marks the incorrect winner.

(10) Unresolved directionality in Nasal Assimilation (failed evaluation)

	/mɔnk-a/	NA	Ident-Pl
	a. mɔn.ka	*!	
☜	b. mɔŋ.ka		*
☜	c. mɔn.ta		*

This time, the fully faithful candidate, *[mɔn.ka], fatally violates NA because its nasal-stop cluster is not homorganic. The remaining two candidates exhibit regressive /nk/ → [ŋk] (10b) and progressive /nk/ → [nt] (10c) assimilation that both satisfy NA and incur the same Ident-Place violation, resulting in what seems to be a tie. However, the tie is only apparent, and the problem is compounded by the unmarked status of coronals relative to labials and dorsals. OT expresses these markedness relations with the universal ranking *Lab/Dor ('don't be LABIAL' / 'don't be DORSAL') >> *Coron ('don't be CORONAL'), which favours [nt] over [ŋk] since [nt] is coronal while [ŋk] is dorsal.[8] Consequntly the tie in (10) is resolved in favour of the undesired *[nt] cluster, as shown in tableau (11). The sad face icon identifies the desired winner.

(11) Markedness favours progressive assimilation (failed evaluation)

	/mɔnk-a/	NA	Ident-Pl	*Lab/Dor	*Coron
	a. mɔn.ka	*!		**	*
☹	b. mɔŋ.ka		*	**!	
☜	c. mɔn.ta		*	*	*

The [ŋk] cluster in the intended winner violates *Lab/Dor, while the [nt] cluster in the intended loser does not, since [nt] is coronal rather than labial or dorsal. As a result, *Lab/Dor prefers *[mɔn.ta] (11c), the incorrect result.[9]

Because the nasal-stop cluster in [mɔŋ.ka] 'flour' is heterosyllabic and the onset [k] must be faithfully preserved, past research (Beckman 1997; Casali 1997) has argued

[8] These constraints and their ranking were proposed by Prince and Smolensky (2004).

[9] Two additional comments are in order regarding the violations in (11). First, all candidates violate *Lab/Dor once owing to the initial labial [m] in each candidate. Second, [ŋk] (11b) violates *Lab/Dor once rather than twice because these segments share a single DORSAL node as a result of spreading. Similarly, [nt] (11c) incurs one rather than two violations of *Coron because both [n] and [t] hang off a single CORONAL node.

that the solution is to appeal to positional faithfulness. In fact, settling the problem of directionality is a leading argument for positional faithfulness constraints. Thus, it appears that the following constraint is called for.

(12) IDENT-PLACE$_{(onset)}$: PLACE on the input segment and its output correspondent in the onset must be identical.

IDENT-PLACE$_{(onset)}$ extends its protection to /k/ in /mɔnk-a/ 'flour' only if ranked above the generic IDENT-PLACE, as illustrated in (13).

(13) Positional faithfulness

	/mɔnk-a/	NA	IDENT-PL$_{(onset)}$	IDENT-PL	*LAB/DOR	*CORON
	a. mɔn.ka	*!			**	*
☞	b. mɔŋ.ka			*	**	
	c. mɔn.ta		*!	*	*	*

The analysis works: the undesired candidate *[mɔn.ta] (13c) is effectively blocked by IDENT-PLACE$_{(onset)}$, so the grammar correctly selects the regressive assimilation candidate [mɔŋ.ka] (13b). However, the success of this analysis is short-lived.

The analysis in (13) could work if the nasal-stop clusters were always heterosyllabic, but Polish exhibits Nasal Assimilation in tautosyllabic clusters on a massive scale, for example, [sɛŋk] 'knag' (4). Such words cannot be handled by IDENT-PLACE$_{(onset)}$, as shown in (14). Candidates with unassimilated clusters are ignored as inherently suboptimal.

(14) Failure of positional faithfulness (failed evaluation)

	/sɛnk/	NA	IDENT-PL$_{(onset)}$	IDENT-PL	*LAB/DOR	*CORON
☹	a. sɛŋk			*	*!	*
☜	b. sɛnt			*		**

Both candidates have a nasal-stop cluster in the coda, so onset faithfulness is inert and the problem of directionality remains unresolved. Paradoxically, the failure of positional faithfulness is magnified by /mɔnk-a/ → [mɔŋ.ka] 'flour' and other disyllabic words that motivated the positional faithfulness analysis in the first place. These words have no vowel ending in the gen.pl., so their gen.pl. forms surface with a nasal-stop cluster in the coda, for example, *mąk* [mɔŋk], the gen.pl. of *mąka* [mɔŋ.ka]. Thus, positional faithfulness works for the nom.sg. [mɔŋ.ka] but not for the gen.pl. [mɔŋk]. To conclude, the directionality of Polish Nasal Assimilation is not governed by onset faithfulness.

Rubach (2008) observes that the directionality of Nasal Assimilation in Polish does not follow from onset faithfulness. To solve this problem, he proposes IDENT-PLACE$_{(Stop)}$, a constraint that mandates the retention of PLACE from the input on a stop consonant in the output. This constraint penalizes the undesired candidate

*[mɔn.ta] from /mɔnk-a/ 'flour' because the dorsal place of articulation on the stop has been changed to coronal, *k* → *t*.

The analysis in terms of IDENT-PLACE$_{(Stop)}$ works but comes at a cost. Specifically, there are three issues associated with IDENT-PLACE$_{(Stop)}$. First, it is not clear whether the relevance of this constraint goes beyond the analysis of Nasal Assimilation, so its empirical motivation is weak. Second, IDENT-PLACE$_{(Stop)}$ opens the way to a whole new family of IDENT constraints, that of IDENT-PLACE(class), where "class" denotes any conventional class of segments, such as stops, fricatives, coronals, coronal continuants, and so forth. Consequently, CON is expanded by a considerable number of constraints whose adequacy is unclear. Third, IDENT-PLACE$_{(Stop)}$ is in fact IDENT-PLACE$_{([-son, -cont])}$ because stops as such have no formal status in feature geometry (Clements 1985; Sagey 1986; Halle 1992, among others). Allowing IDENT constraints to make reference to combinations of features begs the question of what the scope and the limit of this type of referencing are. For example, if IDENT-PLACE$_{([-son, -cont])}$ is a licit constraint, nothing stands in the way of proposing an IDENT-PLACE constraint that is relativized to absurd feature combinations such as [+high, +nasal, -ATR].

To conclude, an analysis of Polish Nasal Assimilation in terms of IDENT-PLACE$_{(Onset)}$ is descriptively inadequate, while a reanalysis in terms of IDENT-PLACE$_{(Stop)}$ is descriptively adequate but leads to undesirable theoretical consequences. Therefore, both of these embodiments of positional faithfulness are rejected, leaving the issue of directionality unresolved. The next subsection addresses this by offering a novel analysis of Polish Nasal Assimilation that derives directionality from standard OT place-node constraints: IDENT-DORSAL, IDENT-CORONAL, and IDENT-LABIAL.

3.2. Proposal

It is standardly assumed that IDENT-PLACE is a generic constraint that is broken down into three constraints.

(15) IDENT-PL
- a. IDENT-LAB: The node LABIAL on the input segment and its correspondent in the output must be identical.
- b. IDENT-COR: The node CORONAL on the input segment and its correspondent in the output must be identical.
- c. IDENT-DOR: The node DORSAL on the input segment and its correspondent in the output must be identical.

As shown below, this individualization is crucial for analyzing Nasal Assimilation.

Returning to our data, the changes /n/ → [ŋ], /sɛnk/ → [sɛŋk] 'knag', and [n] → [m], /sɛnp/ → [sɛmp] 'vulture', induced by NA violate IDENT-CORONAL because the input /n/ is coronal and the outputs [ŋ]/[m] are not. Therefore, assimilation is obtained if NA outranks IDENT-CORONAL.

(16) Basic pattern: NA >> IDENT-CORONAL

	/sɛnk/	NA	IDENT-COR
	a. sɛnk	*!	
☞	b. sɛŋk		*

The next step is to address directionality, which appears to be controlled by IDENT-DORSAL and IDENT-LABIAL. Specifically, the ranking IDENT-DORSAL >> IDENT-CORONAL appears to derive regressive assimilation before dorsals (17i) while the ranking IDENT-LABIAL >> IDENT-CORONAL appears to derive regressive assimilation before labials (17ii).

(17) Regressive assimilation as faithfulness to place nodes (failed evaluation)

(i) Before dorsals: IDENT-DOR >> IDENT-COR

	/sɛnk/	NA	IDENT-DOR	IDENT-COR	*LAB/DOR	*CORON
	a. sɛnk	*!			*	**
☹	b. sɛŋk		*	*	*!	*
☞	c. sɛnt		*	*		**

(ii) Before labials: IDENT-LAB >> IDENT- COR

	/sɛnp/	NA	IDENT-LAB	IDENT-COR	*LAB/DOR	*CORON
	a. sɛnp	*!			*	**
☹	b. sɛmp		*	*	*!	*
☞	c. sɛnt		*	*		**

The analysis fails because both /sɛnk/ 'knag' and /sɛnp/ 'vulture' are mapped onto the candidate with the undesired progressive assimilation, *[sɛnt]. Appealing to onset faithfulness is ineffective: positional variants of IDENT-DORSAL and IDENT-LABIAL that target onsets, like the generic IDENT-PLACE$_{(onset)}$ introduced in (12), are inert when the stop occurs in the coda. As a result, they cannot block the incorrect /nk/ → [nt] and /np/ → [nt] mappings in words such as /sɛnk/ → [sɛŋk] and /sɛnp/ → [sɛmp].

The analysis falls into place if IDENT constraints are unidirectional, as proposed by Pater (1999) and further argued for by Struijke (2000) and Rubach (2008), rather than bidirectional (McCarthy, Prince 1995). A bidirectional constraint matches inputs with outputs and outputs with inputs simultaneously, while a unidirectional constraint is either an Input → Output (I→O) constraint or an Output → Input (O→I) constraint. The correct analysis of Nasal Assimilation requires the Input → Output constraints given in (18).

(18) Unidirectional Ident constraints

a. Ident-Labial(I→O): The node LABIAL on the input segment must be preserved in its output correspondent.

b. Ident-Coronal(I→O): The node CORONAL on the input segment must be preserved in its output correspondent.

c. Ident-Dorsal(I→O): The node DORSAL on the input segment must be preserved in its output correspondent.

These constraints demand that input place nodes be *preserved* in the output, which means that they are unidirectional Input → Output constraints, so they match inputs with outputs but crucially not outputs with inputs. This ensures the correct analysis of Nasal Assimilation, as shown in (19), which revisits /mɔnk-a/ → [mɔŋka] 'flour' (nom.sg.) and /mɔnk/ → [mɔŋk] 'flour' (gen.pl.).

(19) Faithfulness to place nodes and unidirectional constraints[10]

(i) Heterosyllabic [ŋ.k]

/mɔnk-a/	NA	Ident-Dor	Ident-Cor
a. mɔn.ka	*!		
☞ b. mɔŋ.ka			*
c. mɔn.ta		*!	

(ii) Tautosyllabic [ŋk]

/mɔnk/	NA	Ident-Dor	Ident-Cor
a. mɔnk	*!		
☞ b. mɔŋk			*
c. mɔnt		*!	

The unidirectional Ident-Dorsal(I→O) is violated when an input dorsal segment surfaces as non-dorsal in the output, as in *k* → *t*, because the dorsality of the input segment (here /k/) is not preserved in the corresponding output segment (here [t]). In contrast, this constraint is not violated when an input non-dorsal segment surfaces as dorsal, for example, *n* → *ŋ*. Consequently, the candidates with /nk/ → [nt] in (19) are rejected and those with /nk/ → [ŋk], whether heterosyllabic (19a) or tautosyllabic (19b), are selected as optimal, yielding the correct outcome. This analysis extends straightforwardly to labial inputs, such as /trɔnb-a/ → [trɔm.ba] 'trumpet' (nom.sg.) and /trɔnb/ → [trɔmp] 'trumpet' (gen.pl.), but the relevant constraint is Ident-Labial rather than Ident-Dorsal.

The analysis in terms of unidirectional Ident constraints extends naturally to nasal-stop/affricate clusters that do not undergo Nasal Assimilation. As documented in (6), Polish /m/ and /ɲ/ remain unassimilated before stops/affricates, as in [gu*m*ka]

[10] In what follows I will omit the I → O specification because all the faithfulness constraints in the remainder of this paper are Input → Output constraints.

'rubber' (dimin.) and [baɲka] 'bubble' (dimin.). To block the assimilation of /m/ and obtain [gumka] rather than the unattested *[guŋka], Ident-Labial must outrank NA. Likewise, to block progressive assimilation, *mk* ⟶ *mp*, and thus avoid *[gumpa], NA must also be outranked by Ident-Dorsal.

A similar solution is available for words with unassimilated *n*-stop clusters, such as [baŋka] 'bubble' (dimin.), except that the constraint that blocks the undesired candidate with assimilation, *[baŋka], is Ident[-anterior].

The constraints and their ranking are summarized in (20).

(20) Polish Nasal Assimilation

Ident-Labial, Ident-Dorsal, Ident[-anter] ≫ NA ≫ Ident-Coronal, *Lab/Dor ≫ *Coron

To conclude, the directionality of Polish Nasal Assimilation is governed by unidirectional Ident constraints targeting the place nodes LABIAL, CORONAL, and DORSAL. An analysis using these constraints is both descriptively adequate for the data examined and methodologically straightforward, as Ident-Labial, Ident-Dorsal, and Ident-Coronal are standard OT constraints grounded in feature geometry. In contrast, an account in terms of Ident-Place$_{(Onset)}$ fails descriptively, while one in terms of Ident-Place$_{(Stop)}$ succeeds descriptively but raises theoretical concerns.[11]

3.3. Transparent interaction: Palatalization

The analysis in terms of place node constraints appears to run into trouble with data that exhibit an alternating nasal-stop/affricate cluster: [nt] – [ɲt͡ɕ].

(21) Alternation between [nt] – [ɲt͡ɕ].

a. nom.sg.	*b. diminutive*	*gloss*
[kɔnt]	[kɔɲt͡ɕ-ik]	'corner'
[kant]	[kaɲt͡ɕ-ik]	'edge'
[bunt]	[buɲt͡ɕ-ik]	'rebellion'
[grunt]	[gruɲt͡ɕ-ik]	'land'
[prɛnt]	[prɛɲt͡ɕ-ik]	'rod'

The forms in both columns conform to Nasal Assimilation because they exhibit homorganic NC clusters: [nt] in (21a) and [ɲt͡ɕ] in (21b). While the current constraint ranking readily generates the faithful mappings in (21a), such as /kɔnt/ ⟶ [kɔnt] 'corner', an analysis of the diminutives in (21b), such as [kɔɲt͡ɕ-ik] 'corner' (dimin.), presents an issue, as illustrated in tableau (22).[12]

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[11] Rydzewski (2023) uses Ident-Labial, Ident-Dorsal, and Ident-Coronal in an analysis of Nasal Assimilation in English, but his analysis is different from the analysis of Polish in this paper because he uses these constraints on a par with positional faithfulness rather than instead of it.

[12] There is no doubt that /t/ rather than /t͡ɕ/ underlies the [t] – [t͡ɕ] alternation in (21). The reason is that /t/ ⟶ [t͡ɕ] in words like [kɔɲt͡ɕ-ik] 'corner' (dimin.) is easily derived by Palatalization

(22) /kɔnt-ik/ → [kɔɲt͡ɕik] (failed evaluation)

	/kɔnt-ik/	Ident-Dor	NA	Ident-Cor
☜	a. kɔntik			
☜	b. kɔɲt͡ɕik			
	c. kɔnt͡ɕik		*!	

Candidates (22a) and (22b) tie, so the evaluation is inconclusive.[13] The problem is that Ident-Coronal is equally satisfied by both the desired prepalatal cluster [ɲt͡ɕ] (22b) and the undesired dental cluster [nt] (22a), since both match the input /nt/ in coronality. This raises the question of why /nt/ surfaces as [ɲt͡ɕ] rather than remain [nt]. The answer lies in the interaction between Nasal Assimilation and Palatalization.

The alternation between [t] – [t͡ɕ] is governed by Coronal Palatalization, which, roughly, changes dentals into prepalatals before front vowels in derived environments.[14]

(23) Coronal Palatalization (Cor-Pal): t d → t͡ɕ d͡ʑ / __ i ɛ

Derivationally, Cor-Pal triggers /t/ → [t͡ɕ] in /kɔnt-ik/ → [kɔɲt͡ɕik] 'corner' (dimin.), and the output of this change, [t͡ɕ], provides the place of articulation for the preceding nasal: we witness a transparent, feeding interaction (Kiparsky 1968) between Cor-Pal and Nasal Assimilation. This interaction is readily built into the current OT analysis. To illustrate that, we first need to restate rule (23) in terms of OT constraints.

(24) Constraints to derive Cor-Pal (Rubach 2000, 2003)[15]

a. Palatalization-*i* (Pal-*i*): Assign a '*' for every consonant and a following high vowel that do not agree in backness.

b. Ident-C$_{([+back])}$: The value [+back] of the input consonant must be preserved on a correspondent of that consonant in the output.

c. Posteriority (Poster): Assign a '*' for every anterior coronal that is [-back].

d. Ident[+anter]: The value [+anter] of the input segment must be preserved on a correspondent of that segment in the output.

(discussed below), while the alternative, /t͡ɕ/ → [t] in words such as [kɔnt] 'corner', is untenable because Polish has many words with word-final [-t͡ɕ], for example, [ʑɛɲt͡ɕ] 'son-in-law'.

[13] [kɔɲt͡ɕik] (22b) is actually worse than [kɔntik] (22a) because the mapping /nt/ → [ɲt͡ɕ] in the former candidate violates a number of faithfulness constraints not shown in (22) but discussed below, such as Ident[+anter].

[14] The following discussion of Coronal Palatalization abstracts away from the numerous (well-studied) complications that this process entails and instead is limited to the two inputs relevant from the perspective of Nasal Assimilation, that is, the dental stops /t/ and /d/. For more comprehensive studies of Coronal Palatalization, see, for example, Gussmann (1980) and Rubach (1984, 2003).

[15] The constraint called Stridency (affrication), not listed here, makes sure that Palatalization produces prepalatal affricates and not prepalatal stops, so *t* → *t͡ɕ* and not *t* → *t*^{j}*$_{[prepalatal]}$*. See Rubach (2003) for an analysis.

An analysis of Cor-Pal using these constraints is adduced in tableau (25), which evaluates /drut-ik/ → [druf͡ɕik] 'wire' (dimin.).

(25) Cor-Pal in OT

	/drut-ik/	Pal-*i*	Poster	Ident[+anter]	Ident-C$_{([+back])}$
	a. ti	*!			
	b. tʲi		*!		*
☞	c. f͡ɕi			*	*

Pal-*i* requires that sequences of a consonant plus a high vowel must agree in backness, which means that they both must be either [-back] or [+back]. Since [i] is [-back] and [t] must also be, Pal-*i* is fatally violated in (25a). In contrast, both [tʲ] and [f͡ɕ] satisfy Pal-*i*, but Poster bans anterior coronals palatalized in a surface manner, such as [tʲ], leaving [f͡ɕ] as the only viable candidate. Since /t/ → [f͡ɕ] is the desired outcome, the analysis is correct.

The feeding between Cor-Pal and Nasal Assimilation is modelled in (26). I ignore the undominated Ident-Dorsal, which is vacuously satisfied in (26) because neither member of the input cluster /nt/ is dorsal.

(26) Feeding between Cor-Pal and Nasal Assimilation: /kɔnt-ik/ → [kɔɲf͡ɕik]

	/nt-i/	Pal-*i*	Poster	NA	Ident-Cor	Ident[+anter]	Ident-C$_{([+back])}$
	a. nti	*!					
	b. ntʲi		*!	*			*
	c. nf͡ɕi			*!		*	*
☞	d. ɲf͡ɕi					**	**

Candidates (26a) and (26b) are eliminated by Pal-*i* and Poster, respectively, because they do not contain [f͡ɕ]. The optimal output form is selected by NA, which prefers [ɲf͡ɕi] to [nf͡ɕi] since only the former cluster is homorganic. Consequently, [kɔɲf͡ɕik] (26d) emerges as the winner, yielding the correct result.[16]

To conclude, the regressive direction of Nasal Assimilation before the prepalatal affricates [f͡ɕ] and [d͡ʑ] follows from Coronal Palatalization, *t d* → *f͡ɕ d͡ʑ*. Cor-Pal introduces the prepalatal place, which the nasal then assimilates: *nt* → *nf͡ɕ* → *ɲf͡ɕ*. Since Poster, a segment inventory constraint, enforces the prepalatal place on the affricates and this place is subsequently spread to the nasal, Nasal Assimilation in forms like [kɔɲf͡ɕik] 'corner' (dimin.) is ultimately governed by segment inventory constraints (here by Poster). This is a novel result.[17]

[16] Let me add that candidate (26b), [ntʲi], violates NA because [n] and [tʲ] disagree in PLACE: [n] is only coronal while [tʲ] is both coronal and dorsal. The reason is that the palatalization effect exhibited by [tʲ] is technically a combination of two features, [-back] and [+high], which are subsumed under the DORSAL node.

[17] Polish has instances of [ɲf͡ɕ] in which the [f͡ɕ] is not derived by Palatalization because there is no palatalizing vowel to speak of, as documented by, for example, [zɛɲf͡ɕ] 'son-in-law' and

4. Opaque interaction: Yer Deletion

This section investigates systematic violations of Nasal Assimilation in [nk] clusters. These violations cannot be explained by standard OT, but are shown to be handled straightforwardly in a version of OT that admits derivational steps.

Polish has a number of words with an unassimilated [nk] cluster, some of which are listed in (27).

(27) No Nasal Assimilation in /n/

[ra*n*-k-a]	'wound' (dimin.)
[ʨ͡ʨa*n*-k-a]	'wall' (dimin.)
[pʲja*n*-k-a]	'foam' (dimin.)
[d͡ʒba*n*-k-a]	'jug' (dimin. gen.sg.)
[bara*n*-k-a]	'lamb' (dimin. gen.sg.)

These words exhibit [nk] instead of the expected [ŋk]: we witness exceptions to Nasal Assimilation. These exceptions result from a systematic generalization in Polish concerning yers, that is, vowels that alternate with zero. Consider the following alternations.

(28) The Ø – [ɛ] alternation

[ran-k-a]	(dimin.)	–	[ran-ɛk]	(dimin. gen.pl.)	'wound'
[ʨ͡ʨan-k-a]	(dimin.)	–	[ʨ͡ʨan-ɛk]	(dimin. gen.pl.)	'wall'
[pʲjan-k-a]	(dimin.)	–	[pʲjan-ɛk]	(dimin. gen.pl.)	'foam'
[d͡ʒban-k-a]	(dimin. gen.sg.)	–	[d͡ʒban-ɛk]	(dimin. nom.sg.)	'jug'
[baran-k-a]	(dimin. gen.sg.)	–	[baran-ɛk]	(dimin. nom.sg.)	'lamb'

The data in (28) show that the diminutive suffix assumes two forms: [k] before a suffix and [ɛk] word-finally. The standard generative analysis of the Ø – [ɛ] alternation in this suffix is to posit that its underlying representation is /Ek/, where *E* represents a yer (see section 2). The deletion of underlying yers is carried out by Yer Deletion, which deletes *E* before a vocalic suffix.

The presence of a yer between the nasal and the stop in the underlying representations of the data in (28) blocks Nasal Assimilation in these words, even though the yer does not surface, as shown by /ran-Ek-a/ → [ra*n*ka] 'wound' (dimin.).[18] This yer-induced blocking effect is further supported by comparing forms with an underlying yer, such as /ran-Ek-a/ → [ra*n*ka], to words without an underlying yer, such as /sɛnk/ → [sɛŋk] 'knag': forms with a yer systematically avoid Nasal Assimilation while forms without a yer systematically undergo it.

[rtɛɲʨ͡ʨ] 'mercury'. In these words, the affricate is underlying, /ʨ͡ʨ/, and regressive assimilation is ensured by a high-ranking faithfulness constraint Ident[-anter], which mandates that the value [-anter] of the input segment must be preserved on a correspondent of that segment in the output. Specifically, the ranking NA, Ident[-anter] ≫ Ident-Coronal prefers /nʨ͡ʨ/ → [ɲʨ͡ʨ] to the unattested /nʨ͡ʨ/ → [nt] because the former but not the latter mapping satisfies Ident[-anter].

[18] In a rule-based framework, this blocking is analyzed as an instance of a counterfeeding interaction between Nasal Assimilation and Yer Deletion: the latter counterfeeds the former.

In OT, Yer Deletion results from the interaction of YER-Del with Max-Seg, the latter of which mandates that every segment in the input must have a correspondent in the output. Being the standard "anti-deletion" constraint, Max-Seg conflicts with YER-Del, which enforces *E* ⟶ Ø. Thus, YER-Del must outrank Max-Seg for deletion to occur, as illustrated by the evaluation of /ɔsEt-u/ ⟶ [ɔstu] 'thistle' (gen.sg.).

(29) Yer Deletion in OT

	/ɔsEt-u/	YER-Del	Max-Seg
	a. ɔsEt-u	*!	
☞	b. ɔst-u		*

Since yers are deleted before a vocalic suffix, candidate (29a) with a yer is rejected and its yer-less competitor emerges as the optimal output form, the correct result.

Whereas standard OT handles Yer Deletion and Nasal Assimilation as independent processes, it struggles to explain why an underlying yer blocks assimilation. The problem is illustrated in the following evaluation of /ran-Ek-a/ ⟶ [ranka] 'wound' (dimin.).

(30) Interaction between YER-Del and NA (failed evaluation)

	/ran-Ek-a/	NA	YER-Del	Ident-Cor	Max-Seg
	a. ranEka		*!		
☹	b. ranka	*!			*
☜	c. raŋka			*	*

The constraint ranking favours the transparent candidate (30c), *[raŋka], because the opaque candidate (30b) without assimilation, [ranka], incurs a fatal violation of NA. This outcome is incorrect, so the analysis fails. I conclude that standard OT is unable to provide a workable analysis of the opaque interaction between Yer Deletion and Nasal Assimilation.

As originally observed by Iwan (2015), an OT analysis of Nasal Assimilation can be salvaged by resorting to Derivational/Stratal OT (DOT; Kiparsky 1997; Rubach 1997). DOT is a version of Optimality Theory that admits four derivational levels: (i) the stem level, (ii) the word level, (iii) the clitic level, and (iv) the sentence level. As indicated by their names, these levels or, less technically, derivational steps are defined on morphological domains in a bottom-up fashion, specifically, the stem, the word, the clitic phrase, and the sentence. This stratified architecture of the grammar requires phonological evaluation to proceed as a serial derivation: the optimal output of level 1 is the input to level 2, then, the optimal output of level 2 is the input to level 3 and, finally, the optimal output of level 3 constitutes the input to level 4. The output of level 4 is the final output of the evaluation. Last but not least, while the constraint ranking is fixed at each of the four levels and, by default, stays unchanged, constraints may be reranked between levels to the extent motivated by the data.

DOT analyzes the opaque blocking effect between Yer Deletion and Nasal Assimilation by allocating the latter process to level 1 (i.e. the stem level) and the former process to level 2 (i.e. the word level). Such allocation means that Nasal Assimilation is active at level 1 but inactive at level 2, while, conversely, Yer Deletion is inactive at level 1 but active at level 2. These operations are implemented by reranking the relevant constraints between levels 1 and 2.

(31) Rerankings to derive yer-induced blocking of NA

a. Level 1: MAX-SEG ≫ YER-DEL, so *E* → *Ø* is blocked
   Level 2: YER-DEL ≫ MAX-SEG, so *E* → *Ø*
b. Level 1: NA ≫ IDENT-CORONAL, so *n* → *ŋ*
   Level 2: IDENT-CORONAL ≫ NA, so *n* → *ŋ* is blocked

Yer Deletion is blocked at level 1 due to MAX-SEG ≫ YER-DEL, while Nasal Assimilation is operative due to NA ≫ IDENT-CORONAL. Consequently, words without a yer undergo Nasal Assimilation, whereas those with a yer, such as /ran-Ek-a/ → [ranka] 'wound' (dimin.), do not. This analysis is summarized in (32).

(32) Level 1: Nasal Assimilation but no Yer Deletion[19]

(i) Words without a yer: /sɛnk/ → /sɛŋk/

/sɛnk/	MAX-SEG	YER-DEL	NA	IDENT-COR
a. sɛnk			*!	
☞ b. sɛŋk				*
c. sɛn	*!			

(ii) Words with a yer: /ran-Ek-a/ → /ranEka/ (no change)

/ran-Ek-a/	MAX-SEG	YER-DEL	NA	IDENT-COR
☞ a. ranEka		*		
b. ranka	*!		*	
c. raŋka	*!			*

As expected, assimilation is induced in /nk/ (32i) but not in /nEk/ (32ii) because an undeleted yer in the latter representation interrupts the nasal-stop adjacency. The outputs of level 1 now become the inputs to level 2.

At level 2, Yer Deletion is activated while Nasal Assimilation is deactivated due to the rerankings given in (32). This analysis is illustrated in (33).

[19] The direction of assimilation is governed by IDENT-LABIAL, IDENT-DORSAL ≫ IDENT-CORONAL, but I ignore IDENT-LABIAL and IDENT-DORSAL in order to enhance the clarity of the tableaux.

(33) Level 2: Yer Deletion but no Nasal Assimilation

(i) Words without a yer: /sɛŋk/ → [sɛŋk] (no change)

	/sɛŋk/	YER-Del	Max-Seg	Ident- Cor	NA
☞	a. sɛŋk				
	b. sɛnk				*!

(ii) Words with a yer: /ranEka/ → [ranka]

	/ranEka/	YER-Del	Max-Seg	Ident- Cor	NA
	a. ranEka	*!			
☞	b. ranka		*		*
	c. raŋka		*	*!	

Tableau (33i) shows that it is impossible to undo Nasal Assimilation after it already took place at level 1, so the faithful candidate (a), [sɛŋk], wins the evaluation. Further, tableau (33ii) documents that the adjacency of /n/ and /k/ created by Yer Deletion cannot trigger NA because the assimilatory change *nk* →*ŋk* fatally offends Ident-Cor, which now outranks NA. Consequently, the candidate with Yer Deletion but not Nasal Assimilation, [ranka], emerges as the winner. Both results are correct, so the analysis works.

By disallowing simultaneous application of Nasal Assimilation and Yer Deletion at a single derivational level, the two-step analysis in (32) and (33) formally correlates the lack of *n* → *ŋ* in words such as /ran-Ek-a/ → [ra*n*ka] 'wound' (dimin.) with the presence of an underlying yer between the nasal and the stop. Underapplication of Nasal Assimilation in [ra*n*ka] and other similar words is now understood as being a systematic property of the Polish grammar rather than an accident.

5. Conclusion

This paper has examined Polish Nasal Assimilation within the framework of Optimality Theory, with particular attention to directionality of assimilation and its interaction with other phonological processes. Contrary to previous accounts in terms of positional faithfulness, which are shown here to be flawed, the analysis presented in this paper posits that the regressive direction of Nasal Assimilation is governed by the place-faithfulness constraints Ident-Dorsal, Ident-Coronal, and Ident-Labial. This analysis weakens the evidence for positional faithfulness but, at the same time, corroborates a different theory within the OT framework. Specifically, the analysis works only if the place-faithfulness constraints are unidirectional, which adds to the growing body of evidence that Identity constraints in general are better stated as unidirectional. This evidence comes from the domain of directionality effects in Nasal Assimilation, which is a new result.

Nasal Assimilation interacts transparently with Coronal Palatalization but opaquely with Yer Deletion. Modelling the transparent interaction in OT leads to a non-obvious conclusion: directionality of assimilation can be governed by segment inventory constraints such as Poster. Further, accounting for the opaque interaction is possible if OT is modified to allow constraint reranking between derivational levels, as postulated by Derivational OT.

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