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POSITIONAL FAITHFULNESS AND NASAL ASSIMILATION IN ENGLISH

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Abstract

This article analyzes the process of Nasal Assimilation in English.[1] The approach to Nasal Assimilation in a standard rule-based framework can be conducted in two ways: by assuming an underlying alveolar nasal or by employing underspecification. The article contributes to the ongoing debate regarding underspecification in phonology and focuses on employing underspecified representations in Optimality Theory. First, it is argued that in such words as, for instance, *somber*, Nasal Assimilation is best analyzed in terms of positional faithfulness in the form of prevocalic faithfulness. Second, as the analyses show, positional faithfulness does not provide a workable scenario for all the data, and it is necessary to use underspecification to satisfactorily analyze English words which lack the context for positional faithfulness, for example, *swamp*. Nevertheless, subsequent evaluations demonstrate that in certain phrases, for instance, *sing boys*, employing underspecification is not sufficient either, and level distinction is necessary. Therefore, the article also offers an argument in favour of levels in Optimality Theory.[2]

[1] This paper develops the analysis originally conducted in Rubach (2019) by extending the empirical coverage.

[2] I would like to thank the two anonymous reviewers and the Editor of *SLing* for their discussion and criticism, which have led to considerable improvement of both the content and the presentation of my analysis. However, let me add that the responsibility for this paper is solely mine.

1. Data

English nasals exhibit a well-known behaviour before non-continuant obstruents. Consider the examples in (1), where the relevant word-internal clusters are underlined.

(1) Word-internal clusters

a. [mb]/[mp]	b. [ŋg]/[ŋk]	c. [nd]/[nt]
somber	anger	Andy
rhomboid	hunger	mendacious
amber	linger	condition
pamper	ankle	contact
whimper	sprinkle	tentative
thumper	cantankerous	sentence

As the examples in (1) illustrate, the nasal has exactly the same place of articulation as the following consonant. In a classic rule-based framework, such as SPE (Chomsky and Halle 1968) or Lexical Phonology (Kiparsky 1982, 1985; Booij and Rubach 1987), one possibility when addressing the generalization in (1) is to assume a rule which stipulates that the underlying nasal //n//[3] assimilates to the place of articulation of the following obstruent non-continuant. Evidence in favour of the underlying //n// comes from, for instance, the behaviour of negative prefixes in adjectives, as shown in (2), where the relevant sequence of segments is transcribed.

(2) Negative prefixes
transitive – in+transitive [ɪn+t]
possible – im+possible [ɪm+p]
competent – in+competent [ɪŋ+k]
audible – in+audible [ɪn+ɔ]

As in the previous examples, the nasal and a following obstruent agree in the same place of articulation. The data in (2) also point to the fact that the underlying form of the nasal must be //n//. Specifically, in the word *in+audible* the nasal is followed by a vowel, which lacks a consonantal place of articulation. Given that, before vowels the nasal appears in its "unassimilated" form, which corresponds to its underlying representation, so the nasal is //n//.

Further evidence supporting the underlying //n// may be observed on the basis of fast-speech processes.

(3) Evidence from fast speech

a.	b.	c.
ten cooks [ŋ#k]	team cooking [m#k]	sing Carol [ŋ#k]
ten boys [m#b]	team building [m#b]	sing boys [ŋ#b]
ten dogs [n#d]	team dancing [m#d]	sing twice [ŋ#t]

[3] I use double slashes for underlying representations, single slashes for intermediate representations and square brackets for surface forms.

In fast speech, only the alveolar [n] changes its place of articulation and assumes that of the following consonant, (3a). The place of articulation of the remaining nasals, namely [ŋ] and [m], remains intact, (3b–c). In other words, [ŋ] and [m] remain impervious to the following consonant. The examples in (3a) lend support to the claim that the underlying form of the nasal should be //n//. Since in fast speech the alveolar [n] can change its place of articulation depending on the following obstruent non-continuant, its behaviour mirrors that of the nasal in the negative prefixes. It can be observed that [n] is the only "active" nasal that is susceptible to assimilation in fast speech, which, combined with the analysis of negative prefixes in (2), suggests that the alveolar [n] may constitute an input to a rule that enforces assimilation to the following obstruent non-continuant.

Therefore, the rule that captures the behaviour of the alveolar nasal is given schematically below.

(4) Nasal Assimilation
n → αPlace/_ [αPlace, +obstruent, -continuant]

Another strategy to resolve the issue of Nasal Assimilation in English is underspecification. In this case, instead of the alveolar [n] we may postulate an archiphoneme in the underlying representation, the so-called "placeless" nasal //N//, which will similarly follow the rule given in (4). I repeat the relevant examples below, this time utilizing underspecification underlyingly.

(5) Word-internal clusters with archiphoneme

a. somber //sɑNbər//[4] → [sɑmbər]
b. anger //æNgər// → [æŋgər]
c. Andy //æNdi// → [ændi]

Assimilation employing an underspecified nasal can be illustrated on a feature tree, which is expressed as a spreading of the Place node. Below I assume the Halle-Sagey model of Feature Geometry[5] (Sagey 1986; Halle 1992) for the assimilation of //N// to [ŋ] in *anger*, //æNgər// → [æŋgər].

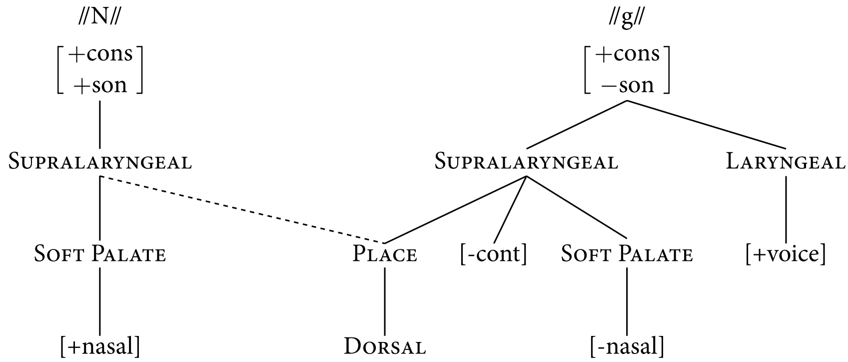
Since //N// lacks its own place of articulation, it will assume whatever place of articulation the following consonant has. Thus, the feature Place of the velar spreads leftwards. In this way, both the nasal and the velar share the same value for Place.[6]

4 In the article, I use General American transcription. Moreover, not to obfuscate the presentation of the data, I abstract away from the process of vowel reduction and include schwa in the underlying representation.

5 The Halle-Sagey model of Feature Geometry is assumed throughout the article.

6 A reviewer asked whether the alveolar nasal in the phrases in (3a) can be underspecified for Place, which then would account for the assimilation in, for example, *ten cooks*. The answer is negative. Since the data in (3) are all phrases, the constituents that enter the phrase level are already fully generated words with fully specified nasals, for example, *ten cooks* at the phrase level is a sequence of /tɛn/ and /kʊks/. Given that, the nasal [n] would have to be underspecified underlyingly, before the phrase level. However, the assumption relaying on an underlying underspecified nasal in *ten* would require an extremely abstract analysis. As opposed to words such as *tent* or *tank*, where the place of articulation of the nasal comes from the following

(6) Nasal Assimilation in Feature Geometry



Both strategies offer equally satisfactory results in rule-based frameworks. Nevertheless, since the advent of Optimality Theory (McCarthy and Prince 1995; Prince and Smolensky 2004), traditional serial approaches to various phonological phenomena have been replaced with parallel evaluations of data. Standard Optimality Theory (henceforth, OT) pivots on the assumption that language-specific rules should be abandoned for the sake of typologically universal constraints. Moreover, another tenet of OT is the prohibition of underspecification. Thus, representations such as those in (5) are not permitted by the OT framework. In the next section I will recast the process of Nasal Assimilation in English in a parallel fashion assuming the underlying //n//, and will show that underspecification is an additional tool that is essential in accounting for all types of English data.

2. Optimality Theory

Assimilation processes in OT are expressed by a family of agreement constraints[7] that require the participating consonants to share a given feature. Relevant for the analysis of English Nasal Assimilation is the constraint stated in (7).

(7) Nasal Assimilation (NA): A nasal and an obstruent non-continuant must agree in Place.

The constraint in (7) is counterbalanced by an antagonistic faithfulness constraint that preserves the place of articulation of the input segment.

(8) Ident(Place): Place of articulation on the input segment must be preserved on a correspondent of that segment in the output.

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obstruent, in *ten* we would need a default rule operating at a word level that assigns a [+coronal] value to the nasal because it appears word-finally. On the other hand, the approach that assumes that the nasal is underlyingly alveolar is less abstract and obviates the need for the aforementioned rule.

[7] The idea of a family of Agree constraints goes back to Lombardi (1999) and Baković (2000).

Since English nasals change their place of articulation, NA must be ranked above IDENT(Place). Consider the evaluation of *somber* below, where the symbol '☜' marks the undesired winner.

(9) //sɑnbər// ⟶ [sɑmbər] (failed evaluation)

	NA	IDENT(Place)
a. sɑnbər	*!	
☜ b. sɑmbər		*
☜ c. sɑndər		*

Candidate (9a) is eliminated due to a fatal offence of the high-ranked NA constraint. However, the evaluation remains unresolved as both candidates (9b) and (9c) tie on the number of violations. The reason behind this is that the current constraint ranking cannot account for the issue of directionality. Specifically, in (9b) the underlying nasal is assimilated to the following stop, and both segments are now bilabial, thus incurring a single violation of IDENT(Place). In (9c), on the other hand, the stop has changed its place of articulation to that of the underlying nasal, rendering both consonants alveolar, an action that is also penalized by IDENT(Place). Nevertheless, in each case the agreement between the nasal and the following stop is satisfied, thus NA is mute on (9b) and (9c). In order to break the deadlock, we must ensure that PLACE of the input stop remains intact. This can be achieved by resorting to positional faithfulness.

Positional faithfulness (Beckman 1997; Casali 1997) entails that the underlying contrasts are asymmetrically preserved only in strong positions, for example, in stressed syllables, initial syllables and onsets, an idea that goes back to Trubetzkoy (1939). In other positions underlying contrast may be lost. In this type of analysis faithfulness constraints are divided into two categories: those that apply context freely and those that are context sensitive. Positional faithfulness arises when a context-sensitive faithfulness constraint outranks a generic markedness constraint, which, in turn, is ranked above a context-free faithfulness constraint: Context-sensitive(FAITH) ≫ Markedness ≫ Context-free(FAITH). The idea is illustrated by voice assimilation in Polish.

Polish obstruent clusters exhibit agreement in the feature [±voice]. The segments must be either voiceless or voiced, as the examples below show.

(10) Polish voice assimilation

a. Voiced clusters	licz+y+ć [tʂɨtɕ] 'to count'	licz+b+a [dʐb] 'number'
	pros+i+ć [ɕitɕ] 'to ask'	proś+b+a [ʑb] 'request'
b. Voiceless clusters[8]	chleb+a [b] 'bread' (gen.sg.)	chleb+k+a [pk] (dim.)
	głow+a [v] 'head'	głów+k+a [fk] (dim.)

To account for the changes in (10), I assume the following constraints:

[8] The examples in (10), apart from *prosić – prośba*, contain an underlying *yer*, a vowel that alternates with zero, for example *chleb+ek* (nom.sg.) – *chleb+k+a* (gen. sg.). However, I omit *yers* in the analysis as they do not contribute to the present discussion. For the most recent and comprehensive account of yers in Polish see Rubach (2017).

(11) Voice Assimilation (VA): Obstruent clusters must agree in the feature [±voice].

IDENT(Voice): The feature [±voice] on the input segment must be preserved on a correspondent of that segment in the output.

IDENT(Voice)$_{\text{ONSET}}$: The feature [±voice] on the input segment must be preserved on an output correspondent of that segment in the onset.

In *licz+b+a* 'number', for example, the input //tʂ// becomes voiced when concatenated with a voiced //b//. In *chlep+k+a* 'bread' (gen. dim.), on the other hand, the underlying //b// loses its [+voice] feature when followed by the voiceless //k//. Since obstruents lose their input values for [±voice], VA must outrank IDENT(Voice). Consider a sample evaluation of *chleb+k+a* below.

(12) *chlebka* //xlɛb+k+a// → [xlɛpka]

	VA	IDENT(Voice)
☜ a. xlɛpka		*
b. xlɛbka	*!	
☜ c. xlɛbga		*

The evaluation is inconclusive as (12a) and (12c) incur the same number of violations. The problem with evaluation (12) is that it is impossible to enforce the direction in which the feature [±voice] should spread. Namely, [-voice] can spread from the underlying //k// to [b], or, *vice versa*, [+voice] can spread from the underlying //b// to [k]. Both changes are equally acceptable under the current constraint hierarchy. To solve the conundrum, we need positional faithfulness.

Since Onset is a privileged position, it may mandate a syllable-initial segment to remain faithful to its underlying feature. Licensing by the Onset is prosody-based as it makes reference to the syllable structure. Given that, the constraint hierarchy in (12) can be expanded by employing IDENT(Voice)$_{\text{ONSET}}$. In order for positional faithfulness to arise, I rank IDENT(Voice)$_{\text{ONSET}}$ above VA. A corrected evaluation of *chleb+k+a* is shown below. Syllable boundaries are separated by dots.

(13) *chlebka* //xlɛb+k+a// → [xlɛpka] (corrected)

	IDENT(Voice)$_{\text{ONSET}}$	VA	IDENT(Voice)
☞ a. xlɛp.ka			*
b. xlɛb.ka		*!	
c. xlɛb.ga	*!		*

The evaluation is correct. Candidate (13c) is eliminated as it offends the undominated IDENT(Voice)$_{\text{ONSET}}$. As a consequence, (13a) wins the evaluation, the correct result.

However, as argued in Rubach and Booij (1990) and Rubach (2008a), there is a variation in the syllabification of the words in (10). A more common syllabification pattern is that where speakers maximize onsets. Namely, words such as *chlebka* tend to be syllabified as [xlɛp.ka] or [xlɛ.pka], with the former syllabification found less frequently. Given this fact, below I repeat the words from (10) adopting onset-maximizing syllabification.

(14) Onset Maximization

licz+y+ć [li.tʂɨtɕ] ‘to count’	licz+b+a [li.dʐba] ‘number’
pros+i+ć [prɔ.ɕitɕ] ‘to ask’	proś+b+a [prɔ.ʑba] ‘request’
chleb+a [xlɛ.ba] ‘bread’ (gen.sg.)	chleb+k+a [xlɛ.pka] (dim.)
głow+a [gwɔ.va] ‘head’	główk+a [gwu.fka] (dim.)

Since in *chlebka* the bilabial and velar obstruents are now in the onset, the question arises as to whether IDENT(Voice)$_{\text{ONSET}}$ can successfully account for the assimilation of voice in [xlɛ.pka]. The analysis is shown in (15), where ‘☹’ stands for the desired winner that loses the evaluation.

(15) *chlebka* //xlɛb+k+a// ⟶ [xlɛpka] (Onset Maximization)

	IDENT(Voice)$_{\text{ONSET}}$	VA	IDENT(Voice)
☹ a. xlɛ.pka	*!		*
☞ b. xlɛ.bka		*!	
c. xlɛ.bga	*!		*

The evaluation, however, is incorrect. IDENT(Voice)$_{\text{ONSET}}$ eliminates candidate (15c) because the both obstruents, [b] and [g], are in the onset. This is not a faithful mapping of the underlying form due to the fact that the velar changed its feature [voice], //k// ⟶ [g], thus conforming with the requirement imposed by VA. In a similar vein, the desired output, candidate (15a), is also eliminated as the bilabial stop //p// emerged voiceless. Nevertheless, since the sequence [pk] now belongs to the onset, any discrepancy in the input string //b+g// constitutes a violation of the high-ranked IDENT(Voice)$_{\text{ONSET}}$ constraint. Thus, onset faithfulness incorrectly predicts that variation in syllabification should coincide with the variation in VA, but it never does, as VA applies every time. Specifically, assuming the variation *chleb.ka*, as in (13), we expect VA to apply as only [k] is in the onset, so its underlying feature [-voice] is preserved, and VA mandates the change in [±voice] on the bilabial consonant, //b// ⟶ [p]. On the other hand, assuming the syllabification *chle.bka* where both obstruents are in the onset, we expect VA not to apply because the faithfulness relations in the onset hold for both obstruents. Therefore, in *chle.bka*, IDENT(Voice)$_{\text{ONSET}}$ overrides the requirement imposed by VA. Nonetheless, this is in fact counterfactual as speakers exhibit reflexes of Voice Assimilation regardless of their preferred syllabification pattern. Therefore, syllabification may be variable but Voice Assimilation does not coincide with this variation.

In order to solve this difficulty, Rubach (2008a) proposes that faithfulness relations should not depend on the occurrence of a segment within the onset. Instead, he argues that Identity requirements should be adhered to before vowels. Thus, the constraint that preserves the feature [voice] prevocalically is stated below.

(16) IDENT(Voice)$_{\text{PREVOC}}$: The feature [±voice] on the input segment must be preserved on an output correspondent of that segment before a vowel.[9]

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9 Although originally Rubach (2008a) uses IDENT(Voice)$_{\text{PRESON}}$, which preserves the feature [voice] before a sonorant, and resorts to Prevocalic Faithfulness to account for Labial

To illustrate the application of IDENT(Voice)$_{PREVOC}$, consider the corrected evaluation of *chlebka* below.

(17) *chlebka* //xlɛb+k+a// ⟶ [xlɛpka] (Onset Maximization; corrected)

	IDENT(Voice)$_{PREVOC}$	VA	IDENT(Voice)
☞ a. xlɛ.pka			*
b. xlɛ.bka		*!	
c. xlɛ.bga	*!		*

The analysis is correct. IDENT(Voice)$_{PREVOC}$ eliminates candidate (17c) as it emerged with a voiced velar obstruent before a vowel. Candidate (17b) is a faithful mapping of the underlying form, however, it loses as it fails to undergo voice assimilation, which is penalized by VA. Given that, (17a) wins.

The application of IDENT(Voice)$_{PREVOC}$ can also extend to syllabification that does not maximize onsets, namely *chleb.ka*. IDENT(Voice)$_{PREVOC}$ will correctly select the attested output, as it will only mandate the preservation of [voice] on a consonant before a vowel. For the sake of completeness, I include the tableau with the syllabification of *chleb.ka* below.

(18) *chlebka* //xlɛb+k+a// ⟶ [xlɛpka] (no Onset Maximization)

	IDENT(Voice)$_{PREVOC}$	VA	IDENT(Voice)
☞ a. xlɛp.ka			*
b. xlɛb.ka		*!	
c. xlɛb.ga	*!		*

Although Prevocalic Faithfulness was originally employed in the analysis of Slavic languages, insights from Polish Voice Assimilation may be logically extended to account for the problematic evaluation of *somber* in (9). Given the tableau in (9), the undesired surface form, (9c), has changed the place of articulation of the consonant, which is exactly in a prevocalic position, //sɑnbər// ⟶ [sɑn.dər]. Therefore, the change //b// ⟶ [d] violates a positional faithfulness constraint that demands the preservation of PLACE before a vowel.

(19) IDENT(Place)$_{PREVOC}$: Place of articulation on the input segment must be preserved on an output correspondent of that segment before a vowel.

For the constraint in (19) to have an effect, we must rank it above the IDENT(Place) constraint. Consider the corrected evaluation of *somber* below. Syllable boundaries are separated by dots.

Depalatalization in Polish in the form of IDENT(C[-back])$_{PREVOC}$, for the purposes of this article I use a modified version of Prevocalic Faithfulness stated in (16), because in the analyzed data the relevant segments occur before vowels.

(20) //sɑnbər// ⟶ [sɑm.bər] (corrected)

	IDENT(Place)$_{\text{PREVOC}}$	NA	IDENT(Place)
a. sɑn.bər		*!	
☞ b. sɑm.bər			*
c. sɑn.dər	*!		*

Candidate (20c) is eliminated as it changed the input //b// to [d], a segment that is before a vowel, which is penalized by IDENT(Place)$_{\text{PREVOC}}$. Consequently, (20b) wins the evaluation, the correct result.

Thus far, the proposed analysis offers a workable scenario of Nasal Assimilation in English. Nevertheless, the current set of data does not exhaust all the possible cases of English Nasal Assimilation. Consider the examples below.

(21)

a. [mp]	b. [ŋk]	c. [nd]/[nt]
stamp	tank	cent
swamp	clank	mend
clamp	spank	lend

As the examples in (21) show, the nasal exhibits the familiar behaviour before a following stop, as both segments must agree in PLACE. Nevertheless, the crucial difference between the examples in (21) and those in (1), e.g. *somber*, is that in (21) the consonant following the nasal is not in the onset. Thus, the onset cannot license the place of articulation of the word-final consonant. This seems problematic because there is no way of preserving the place of articulation on the obstruent, which is crucial in order to force the nasal into agreement in PLACE. Consider the evaluation of *swamp* below.

(22) //swɑnp// ⟶ [swɑmp] (failed evaluation)

	IDENT(Place)$_{\text{PREVOC}}$	NA	IDENT(Place)
a. swɑnp		*!	
☜ b. swɑmp			*
☜ c. swɑnt			*

Candidate (22a) is eliminated due to a fatal offence of NA. However, the evaluation remains unresolved, as (22b) and (22c) each accrue a single violation of IDENT(Place), and thus tie on the number of violations. IDENT(Place)$_{\text{PREVOC}}$ is mute and cannot preserve the input consonant as the relevant stop is not in the prevocalic position.

The analysis that assumes an underlying alveolar //n// does not offer a workable scenario for the data with word-final *nasal+stop* clusters. Hence, a solution should be sought elsewhere. As argued in Rubach (2019), a structure that is predictable from the context, for instance aspiration in English, should not be encoded in the underlying representation. In OT, this observation is expressed as *Contextual Predictability Principle.*

(23) *Contextual Predictability Principle* (Rubach 2019)
Phonological information that is predictable from context is not encoded in the underlying representation.

Given the analysis in (22), the predictable structure is the place of articulation of the surface nasal, which coincides with the place of the following obstruent non-continuant. Therefore, in order to account for the failed evaluation in (22), we may call upon the analysis that employs a different representation of the nasal, where the place of articulation is not specified in the underlying form, namely underspecification (Rubach 2019).[10] Below, I repeat the tableau from (22), although this time instead of the alveolar //n// I adopt the underspecified //N//.

(24) //swɑNp// → [swɑmp] (underspecification)

	IDENT(Place)$_{PREVOC}$	NA	IDENT(Place)
a. swɑNp		*!	
b. swɑnp		*!	
☞ c. swɑmp			
d. swɑnt			*!
e. swɑŋp		*!	

The evaluation is correct. NA successfully eliminates candidates (24a) and (24b) as the agreement in PLACE between the nasal and the following stop is not met. Moreover, no surface form of the nasal that has emerged in the evaluation can violate IDENT(Place). The reason is that //N// is not specified for PLACE in the input string, hence the PLACE of its surface form is irrelevant from the perspective of IDENT(Place), as the constraint looks at the correspondence between the input and the output form. However, such an interpretation of Identity is only possible if we assume unidirectional constraints.[11] In contrast to the analysis presented in this article, Standard OT (McCarthy and Prince 1995) assumes that Identity constraints are bidirectional, which means that correspondent segments in the input and the output have identical values for a given feature (F). The differences are significant. By assuming unidirectionality in (24), IDENT(Place) preserves the input feature PLACE in the output. Since the input nasal //N// is underspecified for PLACE, the constraint is mute on all the candidates, as there is no input value to preserve in the output. Bidirectional IDENT(Place), on the other hand, compares not only Input – Output but also Output – Input relations. In this way, the input value for PLACE must be identical to that in the output. Therefore, to satisfy the bidirectional IDENT(Place) the nasal must

[10] As a reviewer correctly noted, rather than underspecification, Standard OT uses *Richness of the Base* to encode predictable underlying information. With regard to ROTB, any form may constitute an input and the constraint hierarchy should select the attested output. Thus, the ROTB input in (22) may be either //swɑmp//, //swɑnp// or even //swɑŋp//. Although //swɑmp// is essentially the surface form, and its direct mapping will not violate any constraint, assuming //swɑnp// will generate exactly the inconclusive result given in (22). Hence, in the remainder of the article instead of ROTB I assume underspecification. See, for example, Bermúdez-Otero (1999), Vaysman (2002) and Rubach (2019) for a critique of ROTB.

[11] Thanks to a reviewer for bringing this to my attention.

be underspecified in the output as well, otherwise IDENT(Place) will assign violation marks for every nasal that emerges with a different PLACE value than underspecified, as then the input and output segments are not identical. Despite these disparities, the result of the analysis in (24) would be the same with the bidirectional IDENT(Place), the sole difference being that all the candidates, apart from (24a), would receive an additional violation of the IDENT(Place)[12] because they emerged with nasals specified for PLACE. Nevertheless, bidirectional constraints have been heavily criticized in the literature by Pater (1999), Rubach (2003a), Rubach (2008b) and Rubach (2014), who reject them completely.

The analysis with underspecified //N// successfully accounts for those cases of Nasal Assimilation where there is no vowel to preserve the place of articulation of the word-final stop. A further question is whether underspecified nasals are necessary in all instances where word-final nasals are present, in particular, in phrases such as *ten cooks, team cooking* or *sing boys.* Recall that in fast speech only the alveolar [n] changes its place of articulation, *ten cooks* [n#k] ⟶ [ŋ#k], whereas the remaining nasals, [m] and [ŋ], remain unaffected. Moreover, adopting the same constraint hierarchy as in (24) for fast speech processes is insufficient to successfully generate the attested surface forms. While the current constraint hierarchy will correctly account for the assimilation in *ten cooks*, it will incorrectly enforce assimilation in *team cooking* or *sing boys*. The reason is that constraints apply across the board to every input and, in this case, the hierarchy will also demand the input /m/ in *team cooking* to change PLACE to that of the following obstruent, as I show below. Consider the tableaux in (25) and (26), where only the relevant fragments of the words are considered.

(25) *ten cooks* /n#k/ ⟶ [ŋ#k] (correct evaluation)

	IDENT(Place)$_{PREVOC}$	NA	IDENT(Place)
a. n#k		*!	
☞ b. ŋ#k			*
c. n#t	*!		*

The evaluation is correct. IDENT(Place)$_{PREVOC}$ is in full effect and eliminates candidate (25c), which changed its input value for PLACE. Furthermore, the candidate also offends the generic IDENT(Place) constraint. The success is short-lived as the analysis of *team cooking* in (26) shows.

(26) *team cooking* /m#k/ ⟶ [m#k] (failed evaluation)

	IDENT(Place)$_{PREVOC}$	NA	IDENT(Place)
☹ a. m#k		*!	
☜ b. ŋ#k			*
c. m#p	*!		*

12 In this way (20c) would win over (20d) as the former would violate PLACE only once by changing the input nasal, while the latter would incur two violations of PLACE: one for the nasal and the other for the word-final obstruent.

The desired output, (26a), loses due to a fatal offence of the high-ranked NA constraint. What is more, any change in the constraint ranking will not ameliorate the situation. By promoting IDENT(Place) above NA we could eliminate (26b) and (26c), however, such a promotion would in effect block all Nasal Assimilation, not only in (26) but also in (25). Therefore, it is essential that the input features for the dorsal /ŋ/ and the labial /m/ are protected from assimilation, whereas the PLACE of the coronal /n/ is susceptible to the change. This can be achieved by summoning the relevant faithfulness constraints.

In order to protect the input /m/, an Identity constraint may be required that protects the LABIAL features of the nasal.

(27) IDENT-LAB: The feature LABIAL on the input segment must be preserved on a correspondent of that segment in the output.

Similarly, a constraint that protects the input /ŋ/ looks as follows.

(28) IDENT-DOR: The feature DORSAL on the input segment must be preserved on a correspondent of that segment in the output.

It is imperative that (27) and (28) are ranked the highest, as only in this way can the input nasals be removed from the purview of NA. On the other hand, the constraint that preserves the CORONAL features of the nasal must be ranked low, so that the input /n/ may undergo assimilation. This constraint is given below.

(29) IDENT-COR: The feature CORONAL on an input segment must be preserved on the correspondent of that segment in the output.

Summing up, the expanded constraint hierarchy is as follows: IDENT-LAB, IDENT-DOR ≫ IDENT(Place)$_{\text{PREVOC}}$ ≫ NA ≫ IDENT(Place), IDENT-COR. All the constraints are now in place, so the analysis of *team cooking* proceeds as below.

(30) *team cooking* /m#k/ → [m#k] (corrected)

	IDENT-LAB	IDENT-DOR	IDENT-(Place) PREVOC	NA	IDENT-(Place)	IDENT-COR
☞ a. m#k				*		
b. ŋ#k	*!				*	
c. m#p		*!	*		*	
d. m#t				*!	*	

The evaluation is correct. IDENT-LAB eliminates (30b) as the input value for LABIAL has changed to DORSAL. Conversely, IDENT-DOR eliminates (30c) because the input velar /k/ has emerged as a bilabial stop. The attested output form, (30a), wins the evaluation despite incurring a single offence of NA. Nevertheless, the NA constraint is now ranked low so its offence is not fatal.

The analysis of *ten cooks* is now unproblematic. Consider the tableau in (31), where Nasal Assimilation is expected to occur.

(31) *ten cooks* /n#k/ → [ŋ#k] (assimilation)

	IDENT-LAB	IDENT-DOR	IDENT-(Place) PREVOC	NA	IDENT-(Place)	IDENT-COR
☞ a. ŋ#k					*	*
b. n#k				*!		
c. n#t		*!	*		*	
d. n#p		*!	*		**	*

The current constraint hierarchy correctly selects the attested output form, candidate (31a). Since IDENT-COR is one of the lowest-ranked constraints, the change from /n/ to [ŋ] is a minor violation. However, IDENT-DOR penalizes candidate (31c), which changed the place of articulation on the input obstruent from velar to alveolar, /k/ → [t]. This is expected as Identity constraints do not discriminate against the input segments and target both nasals and stops. In the same vein, IDENT(Place) assigns two violation marks to candidate (31d) because both input segments, /n/ and /k/, changed their values for PLACE.

The remaining unresolved issue is the analysis of *sing boys*. As was the case in (30), in *sing boys* the input nasal does not yield to assimilation. The evaluation is given in (32).

(32) *sing boys* /ŋ#b/ → [ŋ#b] (no change)

	IDENT-LAB	IDENT-DOR	IDENT-(Place) PREVOC	NA	IDENT-(Place)	IDENT-COR
☞ a. ŋ#b				*		
b. ŋ#k	*!				*	
c. m#b		*!			*	
d. ŋ#d			*!	*	*	

The evaluation in (32) works. However, the analysis hinges on the assumption that [ŋ] is present in the underlying representation, and such an assumption is controversial, to say the least. The default analysis since *SPE*, assumes that the surface angma comes from an underlying sequence of an underspecified nasal //N// followed by a voiced velar stop, namely //Ng//.[13] Therefore, let us assume the default underlying representation of [ŋ] and submit it for evaluation. Consider the tableau in (33), the IDENT(Place)$_{\text{PREVOC}}$ and IDENT-COR constraints are omitted.

[13] To keep the analysis within manageable bounds, I omit the arguments regarding the status of *angma*. However, for a detailed discussion and analysis, see Kuźmicki (2019).

(33) *sing boys* /Ng#b/ → [ŋ#b] (underspecified nasal)

	Ident-LAB	Ident-DOR	NA	Ident-(Place)
☹ a. ŋ#b			*!	
☞ c. m#b				
d. Ng#b			*!	
e. n#b			*!	
☞ f. ŋg#b				

The evaluation fails to provide a desirable result. Assuming underspecification, candidates (33c) and (33f) emerge with zero violations of the given constraints. The desired winner, (33a), loses as it offends NA. It must be stressed that Ident-DOR is mute on (33a) and cannot override the purview of NA. The reason is that the input //N// is "placeless", thus any place of articulation on the output nasal will satisfy Ident-DOR and Ident-LAB.

In order to solve this problem and eliminate candidate (33f) we may call upon a markedness constraint that bans a sequence of [ŋg] in the codas.

(34) *ŋg)$_\sigma$: Do not be a velar homorganic sequence [ŋg] in the syllable coda. (Kuźmicki 2019)

The constraint in (34) will not allow [ŋg] clusters word-finally at the expense of the voiced velar stop. Conforming with (34) results in the deletion of the obstruent, which violates a generic constraint that militates against such actions.

(35) Max(Seg): Do not delete a segment.

Since the input //g// is deleted, I rank *ŋg)$_\sigma$ above Max(Seg): *ŋg)$_\sigma$ ≫ Max(Seg). Consider the tableau in (36), where I focus only on the relevant candidates and omit the mute constraints.

(36) *sing boys* /Ng#b/ → [ŋ#b]

	*ŋg)$_\sigma$	Max(Seg)	NA
☹ a. ŋ#b		*	*!
☞ b. m#b		*	
c. ŋg#b	*!		

The analysis yields an incorrect result. Although *ŋg)$_\sigma$ correctly eliminates candidate (36c), the desired winner loses as it fatally offends NA. The evaluation is beyond repair and any re-ranking of the constraints will not ameliorate the situation. This is because the undesired winner, (36b), incurs a subset of the violations incurred by (36a).

It seems that Standard Optimality Theory cannot account for three distinct operations simultaneously, namely the assimilation of //N// to /ŋ/, the deletion of the underlying //g//, and the lack of assimilation between [ŋ] and [b]. In order for (36a) to win, a sequence of processes, that is //Ng// → /ŋg/ → /ŋ/, should occur before a fully generated *sing* is concatenated with *boys*. Then, the assimilation between [ŋ] and [b] can be blocked by resorting to the familiar constraint hierarchy in (32). However, to implement sequential alterations between each consecutive form of *sing*, the analysis needs to be divided into three distinct steps, an option offered by Derivational Optimality Theory, as I show in the following section.

3. Derivational Optimality Theory

Derivational Optimality Theory (henceforth, DOT; Kiparsky 1997, 2000; Rubach 1997, 2000a, 2000b, 2003a, 2003b) draws on the principles of Lexical Phonology and enables us to divide the analysis into three distinct levels, which progressively encapsulate larger domains.[14] Thus, Level 1 and Level 2 correspond to the lexical levels in Lexical Phonology, specifically, Level 1 is a stem level and Level 2 is a word level. Level 3, on the other hand, is postlexical and focuses on sentence phonology. Furthermore, the winner of an evaluation at a lower level constitutes the input to the higher level. Therefore, the winner from Level 1 is the input to Level 2, and the winning candidate at Level 2 is the input to Level 3. Each DOT level comprises the same set of constraints but, at the same time, constitutes a mini phonology of its own as the constraints can be re-ranked between levels. However, it must be noted that DOT employs the *principle of minimalism* in an evaluation (Rubach 2000a). This means that the number of levels, as well as the re-ranking of the constraints, should be minimal, and any changes in the constraint ranking should be motivated only by significant analytical evidence.

DOT provides the solution to the conundrum of *sing boys*. Given that the analysis can be divided into derivational steps, the problematic sequence of //Ng// ⟶ /ŋg/ ⟶ /ŋ/ can be easily explained through the serial nature of the framework. The DOT analysis of *sing boys* proceeds as follows.

At Level 1, which is a stem level, the underlying //N// undergoes assimilation to /ŋ/ before the following velar. For the nasal to assimilate, NA and Max(Seg) must be ranked high in order to enforce the change in Place, and to preserve the velar obstruent, respectively. At the same time *ŋg)$_{\sigma}$ is ranked low. Ident-DOR does not play a role at this level and is also low in the hierarchy. Summing up, Level 1 ranking is as follows: NA, Max(Seg) ≫ Ident(Place)$_{\text{PREVOC}}$ ≫ Ident(Place) ≫ *ŋg)$_{\sigma}$, Ident-LAB, Ident-DOR. Level 1 evaluation is shown in (37). Since Level 1 is the stem level, I focus only on the word *sing* as phrases are analyzed at Level 3.

(37) Level 1 evaluation for *sing* //sɪNg// ⟶ /sɪŋg/[15]

	NA	Max(Seg)	*ŋg)$_{\sigma}$	Ident-DOR
☞ a. sɪŋg			*	
b. sɪŋ		*!		
c. sɪm		*!		
e. sɪNg	*!		*	
f. sɪn		*!		

14 Rubach (2011) recognizes an additional, fourth level, which encompasses a clitic phrase. However, the analysis in this article utilizes only three stages of evaluation.

At Level 1, NA eliminates (37e) as there is no agreement in Place between the word-final segments. Max(Seg) eliminates the candidates that deleted the velar stop, an action that is prohibited at this level. Ident-DOR is mute because the input nasal is not specified for Place in the underlying representation, thus any output form satisfies the constraint. The desired winner, (37a), violates *ŋg)$_\sigma$, nevertheless the violation is insignificant as the constraint is ranked low. Given that, (37a) proceeds to Level 2 for further evaluation.

At Level 2 it is imperative to delete the velar obstruent, therefore, *ŋg)$_\sigma$ is promoted to the highest position in the tableau, thus outranking NA and Max(Seg). This is an example of the minimal re-ranking between Level 1 and Level 2. Ident-(Place), which has been mute so far, comes into play at Level 2 to eliminate those candidates that have changed the Place of the input nasal. Pulling all the facts together, Level 2 ranking is as follows: *ŋg)$_\sigma$ ≫ NA, Max(Seg) ≫ Ident(Place)$_{\text{PREVOC}}$ ≫ Ident(Place) ≫ Ident-LAB, Ident-DOR. Consider Level 2 evaluation for *sing*, where mute constraints are omitted.

(38) Level 2 evaluation for *sing* /sɪŋg/ ⟶ /sɪŋ/

	*ŋg)$_\sigma$	NA	Max(Seg)	Ident-DOR
a. sɪŋg	*!			
☞ b. sɪŋ			*	
c. sɪm			*	*!
d. sɪn			*	*!
e. sɪng	*!	*		*

The evaluation is correct. Candidates (38a) and (38e) are eliminated as they emerge with a word-final velar obstruent, thus offending the undominated *ŋg)$_\sigma$ constraint. Max(Seg) penalizes the loss of the input /g/ in (38b), however, the attested surface form still wins the evaluation as it is faithful to the input nasal. Ident-DOR assigns additional violation marks to candidates (38c–e) because the input feature Dorsal on the nasal is lost in the output form.

At Level 3 we are looking at sentence phonology. Thus, the fully generated word *sing* is concatenated with the word *boys*. In order to prevent the assimilation of the input /ŋ/ to /m/, Ident-DOR is now ranked the highest. Moreover, Ident(Place)$_{\text{PREVOC}}$ is again active as it ensures the preservation of the word-initial consonant in *boys*. Level 3 ranking is as follows: Ident-LAB, Ident-DOR ≫ *ŋg)$_\sigma$ ≫ NA, Max(Seg) ≫ Ident(Place)$_{\text{PREVOC}}$ ≫ Ident(Place). The evaluation of *sing boys* is given in (39), with the relevant fragments of both words and the mute constraints omitted.

(39) Level 3 evaluation for *sing boys* /ŋ#b/ ⟶ [ŋ#b] (no change)[16]

	Ident-DOR	NA	Ident(Place)$_{\text{PREVOC}}$	Ident(Place)
☞ a. ŋ#b		*		
b. m#b	*!			*
c. n#b	*!			*
d. n#d	*!		*	**

15 In (37), I omit Ident(Place)$_{\text{PREVOC}}$, Ident(Place) and Ident-LAB as they do not contribute to the evaluation at this level.

The analysis is correct, IDENT-DOR eliminates the candidates that changed the value for PLACE on the output nasal. IDENT(Place)$_{PREVOC}$ assigns a violation mark to (39d) because the candidate changed the place of articulation of the word-initial segment which is before a vowel. As a result, (39a) wins the evaluation with a single violation of NA, which is the desired result.

I conclude that the analysis employing levels in the form of DOT offers a viable solution to the issue of Nasal Assimilation in the phrase *sing boys*, and constitutes an argument for level distinction in OT.

4. Conclusion

The article has shown that an analysis of English Nasal Assimilation in OT requires different strategies in order to account for the whole spectrum of data. Examples which exhibit reflexes of assimilation word-internally, such as *somber*, are best accounted by positional faithfulness in the form of IDENT(Place)$_{PREVOC}$. Nevertheless, positional faithfulness is not sufficient to guarantee a satisfactory account of those cases of Nasal Assimilation which occur at the edge of words, such as, for instance, *swamp*. Words such as *swamp, clank* or *mend* are best analyzed by assuming underspecification of the underlying nasal, a strategy that is not permitted in Standard Optimality Theory, yet seems necessary to generate the attested surface forms of the problematic inputs. Other cases of Nasal Assimilation, for instance *ten cooks*, are easily resolved by expanding the constraint hierarchy with a set of Identity constraints that manipulate faithfulness relations between the input and the output nasals. However, the analysis of *sing boys*, in which the traditional underlying representation of angma, //Ng// is adopted, creates insurmountable difficulties for the parallel nature of the framework. However, the intricate sequence of processes that apply to *sing boys* can be analyzed by adopting level distinction in the form of DOT. Admitting level distinction allows us to divorce the process of Nasal Assimilation of //Ng// to /ŋg/ from the process of word-final consonant deletion, a process which must occur before *sing* is concatenated with *boys* in the sentence phonology, in order to prevent the potential assimilation of /ŋ/ to [m], as the evaluation in (32) demonstrated. However, such an analysis requires a re-ranking of the constraints between the levels, which, nevertheless, is minimal, as the complete summary of the interactions indicates.

(40) Summary of interactions

a. //sɪNg// ⟶ /sɪŋg/
Level 1: NA, MAX(Seg) ≫ IDENT(Place)$_{PREVOC}$ ≫ IDENT(Place) ≫ *ŋg)$_\sigma$, IDENT-LAB, IDENT-DOR

b. /sɪŋg/ ⟶ /sɪŋ/
Level 2: *ŋg)$_\sigma$ ≫ NA, M$_{AX(Seg)}$ ≫ IDENT(Place)$_{PREVOC}$ ≫ IDENT(Place) ≫ IDENT-LAB, IDENT-DOR

[16] This evaluation must be Level 3 as only at this level does the syntax joins words together with phrases and into sentences.

c. /sɪŋ#b/ ⟶ [sɪŋ#b]
Level 3: Ident-LAB, Ident-DOR ≫ *ŋg)$_\sigma$ ≫ NA, Max$_{(Seg)}$ ≫ Ident(Place)$_{PREVOC}$ ≫ Ident(Place)

Derivational Optimality Theory does not encounter any issues in dealing with the sequential changes of Nasal Assimilation, (40a), the loss of the underlying //g//, (40b), and the lack of assimilation between /ŋ/ and /b/, (40c). Therefore, this analysis of English Nasal Assimilation constitutes an argument for level distinction in OT.

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