Tundra Nenets consonant sandhi as coalescence

Peter Staroverov & Darya Kavitskaya
April 2017

Abstract
Consonant cluster simplification in Tundra Nenets coexists with other consonantal alternations, such as fricative strengthening, lenition of stops, and a variety of NC-effects, which all apply within the same phrasal domain. These processes interact with each other, suggesting an opaque ordering within the same post-lexical domain and thus presenting a challenge not only for inherently parallel theories like classical Optimality Theory, but also for the cyclic derivational approaches such as Stratal OT. We analyze all instances of Tundra Nenets cluster simplification as coalescence and show that a variety of apparently opaque alternations accompanying cluster simplification can be seen as transparent on this account. We also argue that strengthening in consonant clusters is caused by an intermediate stage where coda obstruents lose their place and turn into a glottal stop.

1. Introduction
The phonology of Tundra Nenets, a Uralic language spoken in Northern Russia, presents a number of opaque process interactions, which challenge Optimality Theory (OT) (Prince & Smolensky 2004). Tundra Nenets also exhibits a clear division between phonological processes that operate only within words and those that also operate across word boundaries (Janhunen 1986; Salminen 1997; 2012). This, together with additional evidence, suggests that Tundra Nenets phonology is cyclically organized (Chomsky et al. 1956; Kiparsky 1982; 1985; Mohanan 1986; Bermúdez-Otero 2011).

Interestingly, the consonantal alternations of Tundra Nenets present an apparent example where two processes not only interact opaquely but also seem to belong to the same stratum or cycle. We focus in particular on cluster simplification and alternations accompanying it, such as place loss, lenition, and a variety of NC-effects.

A derivational cyclic theory such as Lexical Phonology (Kiparsky 1982; 1985; Mohanan 1986) has no restrictions on interacting processes, and therefore such a theory would apply to Nenets data. However Stratal Optimality Theory (Kiparsky 2000; forthc.; Bermúdez-Otero forthc.) puts forward the hypothesis that no opaque interactions happen within a Stratum, all opaque interactions derive from ranking differences between cycles (Jones 2014; Bermúdez-Otero 2014). On the face of it, this more restrictive assumption of Stratal OT appears to be falsified by the Nenets data.

However, we show that a Stratal OT approach to Tundra Nenets opacity is possible, relying on three key assumptions. First, we assume abstract partially underspecified autosegmental representations. Second, we assume that consonant cluster simplification starts with place loss, based both on the Tundra Nenets data and on cross-linguistic evidence from McCarthy (2008). A final important component of our account is the assumption that apparent opaque deletion mappings can be reanalyzed as coalescence (de Haas 1988; de Lacy 2002; 2006). We define COALESCENCE within the correspondence theory of McCarthy & Prince (1995; 1999) as a mapping where one input segment corresponds to more than one output segment.

In Section 2 we provide some background on Tundra Nenets and on our data sources. Section 3 discusses stratal organization of Tundra Nenets phonology. Section 4 introduces the relevant alternations, and Section 5 outlines the problem. Our analysis is presented in Section 6, followed by a brief consideration of alternatives in Section 7, and a conclusion in Section 8.

2. Background on Tundra Nenets

Tundra Nenets (TN) is a Uralic language spoken in a vast area in Northern Russia (Castrén 1854; Tereshchenko 1947; 1956; Janhunen 1984; 1986; Salminen 1997; 1998a; 2012; Nikolaeva 2014; Tatevosov 2016 a.o.). The most extensive and detailed account of TN cluster simplification and glottal stop is presented by Janhunen (1986) and adopted with some adjustments in later descriptions of TN phonology (Salminen 1997; 1998a; 2012; Nikolaeva 2014). This article explores several problems that TN data present for output-driven phonological theories such as Optimality Theory (Prince & Smolensky 2004), combined with the cyclic view of phonology-morphology interface in Stratal OT (McCarthy & Prince 1993; Kiparsky 2000; forthc.; Bermúdez-Otero forthc.).

We supplement and verify the data from grammatical descriptions (cited above) and dictionaries (Lehtisalo 1956; Tereshchenko 1965; Salminen 1998b) with two corpora of recorded TN speech. The first corpus was collected during fieldwork conducted by the authors in the village of Nelmin Nos in the Nenets district of Russia in 2004, 2005, and 2009. The second corpus consists of texts recorded by Irina Nikolaeva and available online at larkpie.net/siberianlanguages/, together with glosses and translations (see also Nikolaeva 2014). The authors' fieldwork results come from six female speakers ranging in age from forty-four to sixty-five at the time of recording. All speakers were born and raised in the same area (the Nenets district of Russia).

The dialect of Nelmin Nos belongs to the Western TN dialect group and therefore differs from Central-Eastern TN that formed the basis for orthography and can be considered standard. Our consultants (two of whom teach Standard TN at school) are for the most part aware of both Western and Central TN pronunciations, and produce both standard and dialectal forms depending on the social context of conversation. In what follows, we will focus on the Central TN alternations, while also acknowledging the dialectal traits relevant to our investigation.

The consonantal inventory of TN is presented in (1). We use the IPA in our transcription, making it distinct from the existing orthographies.[1]

[1] Our notation differs from the most widely accepted transcription of Salminen (1997, et seq.) in the following ways. We use the IPA [ts] pro 'c' for the dental affricate, [j] pro 'y/ÿ' for the palatal glide, [ʔ] pro 'q/h' for the surface representation of glottal stop, and [C^j] pro 'Cy' for consonant palatalization. Salminen (2012) lists [dz, dz^j] (his j and jy) in the inventory of Western dialects. [dz, dz^j] occur in Nelmin Nos speech only due to denasalization, and we abstract away from this variable dialectal phenomenon here (see note 10).

(1) Tundra Nenets consonantal inventory

	labial	dental	palatal	velar	glottal
stops	p pʲ b bʲ	t tʲ d dʲ		k g	ʔ
nasals	m mʲ	n nʲ		ŋ	
fricatives		s sʲ z zʲ		x	
affricates		ts tsʲ			
liquids		r rʲ l lʲ			
glides	w wʲ		j		

All obstruents are pronounced voiced after nasals in TN. We uniformly transcribe post-nasal obstruents as voiced on the surface, even though this makes the inventory in (1) not phonemic since surface [z zʲ] and [g gʲ] only occur after nasals and do not contrast with [ts tsʲ] and [k kʲ] (respectively) in this environment (Salminen 1997; 2012). In this respect, our surface phonetic transcription is different from the phonemic notations employed by Salminen (1997, 2012) and Janhunen (1986).

The vowel inventory of TN is given in (2) (see Helimski 1984; Janhunen 1993; Salminen 1993a; 1993b for discussion).[2] The symbols [iˑ] and [uˑ] represent high vowels that can be pronounced either long or semi-long, and only occur in the first syllable (Salminen 2012).

(2) Tundra Nenets vowel inventory

i iˑ		u uˑ
e		o
	ʌ	
	a	

The only non-IPA symbol that is used in our transcription is the symbol °, a morphophonemic null vowel resulting from pervasive vowel reduction. According to Salminen (1997; 1998a; 2012), TN stress falls on non-final odd syllables, causing the vowel /ʌ/ to reduce to [°] in unstressed positions (though see Amelina 2011; 2012 for an opposing view). This reduced vowel ° does not have a uniform phonetic instantiation; it may be pronounced as an over-short vowel, a release of a consonant, or it may not be pronounced in some cases. However, it triggers a number of surface alternations, such as postvocalic voicing (pace Kavitskaya & Staroverov 2010) and thus needs to be represented in the transcription.

3. Stratal organization of Tundra Nenets phonology

The existing accounts of TN phonology (Janhunen 1986; Salminen 1997; 2012) suggest a clear divide between lexical and post-lexical alternations. While some processes apply across word boundaries, others are only applicable within words. In this section, we briefly discuss what it means to be a *word* vs. a *phrase* for phonological purposes in TN.

[2] Unlike Salminen (2012), we transcribe the shorter *a*-like vowel as [ʌ] rather than [ə] since this seems to capture the pronunciation more closely. The potential existence of [æˑ] contrasting with [e] in the first syllables (Salminen 1997; 2012) may need further investigation for the studied dialect. None of the examples in this article have this vowel.

TN words are comprised of the stem together with derivational and inflectional suffixes. As is typical for word domains, the stem-suffix combinations are rather restricted for both inflection and derivation. Nouns are inflected for case and number, as well as for number and person of the possessor. In most dialects, the nouns may also be inflected in a *predestinative* paradigm, conveying the beneficiary person and number (Salminen 1997; 1998; 2012; Nikolaeva 2014). The verbal inflectional paradigm is vast, conveying a large number of temporal, aspectual, and modal distinctions (Salminen 1997; 1998; 2012; Nikolaeva 2014). Verbs also take a number of productive derivational suffixes for aspect and argument structure modifications (Nikolaeva 2014; Tatevosov 2016).

Words (as defined above) are the domain of a number of phonological processes. Such alternations occur only at a stem-suffix boundary as TN does not have prefixes. Examples of lexical alternations include lenition of /m/ to [w] between vowels as in /ŋʌm-ʌʔ/→ [ŋʌw°ʔ] 'eat-connegative', and /r r^{j}/ changing to [l l^{j}] after consonants, e.g. /n^{j}um-rʌ/ → [n^{j}uml°] 'your name'.

Most phonological processes that we focus on in this article apply in a domain larger than a word, which we loosely refer to as *phrase*. There are few morphosyntactic restrictions on the members of a phrase. Not only can a noun form a phrase together with its dependents, as in (3)a-b, but the subject noun can also form a phrase together with the predicate VP, as in (3)c. Although further research on TN prosody would be needed to determine the exact kind of prosodic phrases involved, we hypothesize that this is the minor phrase because it is typically composed of only two members.

(3) Phrase-level (post-lexical) alternations[3]

a. /m^{j}ar^{j}ojʌ pʌniʌ-naʔ/	m^{j}ar^{j}oj° bʌniːnaʔ
bald garment-POSS.PL1PL	'our bald garments'
b. /n^{j}e-t xʌnʌ/	n^{j}e kʌn°
woman-GEN.PL sledge	'a women's sledge'
c. /pedara pasʌʔxojʌ/	pedara bas°koj°
forest beautiful	'the forest is beautiful'

Importantly, phrases do not behave like words in a few respects. Words may be combined in phrases rather freely, and there are no known lexical restrictions (unlike with stem-suffix combinations). The meaning of phrases is compositionally derived from the meanings of the parts whereas stem-suffix combinations may be idiomatic, especially for derivational suffixes. Finally, suffixes cannot form standalone words, whereas single words can optionally form standalone phrases. In careful speech style, apparent in the most formal of our elicitations, each word forms a phrase of its own and the phrase-internal processes are blocked between words. This relative freedom of phrasing would

[3] We provide underlying representations on the left and surface pronunciations on the right. Abbreviations used in the examples are as follows: ACC 'accusative'; DAT 'dative'; GEN 'genitive'; GER.MOD 'modal gerund'; LOC 'locative'; NOM 'nominative'; PL 'plural'; POSS 'possessive declension'; SG 'singular'. Possessive declension forms are abbreviated as in PL1SG 'plural possessee, 1st person singular possessor'.

be unexpected if our ‘phrasal phonology’ actually corresponded to the Word Stratum of Stratal OT.

All of this evidence points to the fact that TN phonology is organized in phonological strata with a crucial difference between Word Stratum and Post-lexical (phrasal) stratum. The Word Stratum aligns rather nicely with the notion of *word* in the existing TN descriptions, and the Phrase Stratum seems to correspond roughly to the Minor Phrase level. Although Stem-level processes will not be considered here, there is also evidence for the Stem Stratum, distinct from the Word Stratum. For example, lexical stems cannot begin with a consonant cluster while suffixes sometimes do (Salminen 1997:61).

4. Consonant sandhi and glottal stop alternations

TN voiceless stops /p pʲ t tʲ/ surface as voiced [b bʲ d dʲ] after a vowel, as exemplified in (4). This process can be analyzed as applying to all stops, assuming that all surface instances of [k] derive from an underlying fricative (Janhunen 1986; Salminen 1997, 2012). Voicing applies both within words, as in (4)a, and across word boundaries, as in (4)b. In the latter case, the process is optional: in slow speech, the two words do not form a phrase together, and no voicing applies across a phrasal boundary. As shown in (4)b, phrasal voicing may be triggered both by full vowels and by the reduced vowel [°]. These new data contradict the earlier findings of Kavitskaya & Staroverov (2010).

(4) Postvocalic voicing[4]

a. Word-medially

/ja-ta/ earh-POSS.SG3SG	jada
/xʌrʌ-ta/ knife-POSS.SG3SG	xʌr°da
cf. /jar-ta/ side-POSS.SG3SG	jarta

b. Across word boundaries (in connected speech)

/pedara pasʌʔxojʌ/ forest beautiful	pedara bas°koj° ‘the forest is beautiful’
/mʲarʲojʌ pʌniʌ-naʔ/ bald garment-POSS.PL1PL	mʲarʲoj° bʌniːnaʔ ‘our bald garments’
/nʌʔxʌrʲo taraʌ/ be_ready need.3SG	nʌk°rʲo daraː ‘It is necessary to get ready.’

[4] The voiced stops in this example may undergo further variable lenition, coming close to [β ð] in some pronunciations. In Western TN, /d/ is commonly realized as [ð] in all environments (see also Salminen 2012). In what follows, we will abstract away from these variable lenition processes.

Tundra Nenets exhibits a variety of consonant cluster simplification processes as well as place loss in coda consonants. All of these processes apply to /t d s n ŋ/,[5] although the cluster simplification strategies are different for obstruents and sonorants.

Before we illustrate the processes themselves, we would like to briefly comment on the *class* of consonants undergoing these changes. Obviously, /t d s n ŋ/ is an unnatural class, and the complement set of TN codas is not more natural: /b l m r/. We believe that it may be possible to reduce the class of debuccalizing coda consonants to just coronal obstruents and nasals (i.e. /t d s n/). The existing descriptions (Janhunen 1986; Salminen 1997; 2012) postulate an underlying stem-final /ŋ/ only in nouns, where the most convincing evidence comes from accusative plural forms with [ŋ], e.g. /wiˑŋ/ 'tundra': acc.pl [wiˑŋo] (see example (6) below). However, TN accusative plural is formed by applying a complicated set of stem change rules, pointing to a possibility that all accusative plurals may be suppletive. If suppletion is the correct analysis for accusative plurals, then the set of consonants that undergo phrase-final debuccalization can be reduced to coronal obstruents and nasals. However, spelling out this line of argumentation would require a detailed overview of TN nominal paradigms, and we leave this for future research.

We now turn to a description of TN coda consonant alternations. The coda obstruents /t d s/ surface as a glottal stop prepausally and before sonorants, as in (5)a. The last example in (5)a shows that the same is true in phrase-medial word-final position. On the other hand, coda /t d s/ are lost before obstruents, leaving behind a variety of opaque effects demonstrated in (5)b-c: fricatives undergo hardening after a consonant whereby /x/ changes to [k] and /s sʲ/ to [ts tsʲ] (e.g. /sx/ → [k]), while stops surface intact but fail to undergo postvocalic voicing (e.g. /att/ → [at]). Cluster simplification with concomitant strengthening and voicing inhibition is applicable across word boundaries if the two words form a phrase together (5)c. Finally, some instances of the surface final glottal stop in examples (3)-(4) above cannot be associated with either /t/ or /s/, and we hypothesize an underlying /ʔ/ in such cases, although Janhunen (1986) proposes to derive all such 'ambiguous glottal stops' from /t/.

(5) Coda obstruents /t s/: debuccalization, fricative strengthening, voicing inhibition

a. Obstruents neutralize to [ʔ] prepausally and before sonorants

/mʲat/ tent	mʲaʔ
cf. /mʲat-ʌN/ tent-GEN.SG	mʲad°ʔ
/mʲelʌt/ master	mʲel°ʔ
cf. /mʲelʌt-ʌN/ master-GEN.SG	mʲelʌd°ʔ

[5] It may be possible to derive all instances of surface [d] from underlying /t/ via postvocalic voicing. Anticipating our focus on the OT treatment of these alternations, we include the possibility of underlying /d/ here in accordance with Richness of the Base (Prince and Smolensky 2004).

/maʌs/	maːʔ
place on chest under the outer layer of clothing	
cf. /maʌs-ʌN/	maːs°ʔ
place on chest under the outer layer of clothing-GEN.SG	
/mʲat-rʌ/[6]	mʲaʔl°
tent-POSS.SG2SG	
/to-t[7] warʌ-t[7]/	toʔ war°ʔ
lake-GEN.PL shore-NOM.PL	‘shores of lakes’

b. Word-medial cluster simplification

/mʲat-ta/	mʲata, *mʲada
tent-POSS.3SG	
/jas-xʌna/	jak°na
piece_of_hair-LOC.SG	
/maʌs-xʌna/	maːkʌna
place on chest under the outer layer of clothing-LOC.SG	
/sʌs-sʲʌ/	sʌtsʲ°
be_strong-GER.MOD	

c. Word-boundary clusters (in connected speech)

/nʲe-t xʌnʌ/	nʲe kʌn°
woman-GEN.PL sledge	‘a women’s sledge’
/palʲʌt sʲajʌ/	palʲ° tsʲaj°
thick tea	‘thick tea’

The examples in (5)b-c exhibit at least two opaque interactions. Cluster simplification counterfeeds postvocalic voicing, resulting in a chain shift pattern whereby, for instance, underlying /VtV/ changes to [VdV] but underlying /VstV/ surfaces as [VtV]. On the other hand, cluster simplification counterbleeds consonant strengthening: the first consonant of the sequence does not surface in /nʲet xʌnʌ/ [nʲe kʌn°] ‘a women’s sledge’, and there is apparently no surface reason for the first consonant of the second word to strengthen.

Unlike the pre-consonantal obstruents /t d s/, the debuccalizing nasals /n ŋ/ surface as a glottal stop only phrase-finally, as in (6)a. The nasals are deleted before sonorants, as

[6] This form exhibits a couple additional complications. The SG.2SG possessive marker /rʌ/ (e.g. [xʌrʌ-r°] ‘knife-POSS.SG2SG’) undergoes a word level process whereby /r/ changes to [l] after a consonant (see Section 3). The output for ‘your house’ also exhibits an optional reduced vowel after the glottal stop varying between [mʲaʔl] and [mʲaʔəl]. This variable process is outside the scope of the paper, it could be treated as intrusive vowel formation or as a metathesis process dislocating the final reduced vowel ° (Salminen 1997, 2012).

[7] The evidence that NOM.PL and arguably GEN.PL are underlyingly /t/ comes from a few examples of plural [d] in verbal paradigms (Janhunen 1986: 61). One could also treat these markers as /ʔ/ underlyingly.

exemplified in (6)b-c.[8] Before obstruents, the nasals undergo place assimilation and trigger voicing and strengthening of a following consonant (6)b-c – the cross-linguistically common *NC effects* (Herbert 1986; Steriade 1993; Padgett 1994; Pater 1999; Halpert 2012 a.o.). NC effects and cluster simplification work the same way word-medially, as in (6)b, and at phrase-medial word boundaries, as in (6)c.

(6) Coda nasals: place assimilation, voicing, and fricative strengthening[9]

a. Nasals neutralize to [ʔ] prepausally

/s^{j}iˑn/ s^{j}iˑʔ
lid

cf. /s^{j}iˑn-ta/ s^{j}iˑnda
lid-POSS.SG3SG

/wiˑŋ/ wiˑʔ
tundra

cf. /wiˑŋ-o/ wiˑŋ-o
tundra-ACC.PL

b. Word-medial NC effects and cluster simplification

/wen-rʌ/ wel°
dog-POSS.2SG

/s^{j}alʌn-xʌnta/ s^{j}al°ŋgʌnda
underarm-DAT.POSS.SG3SG

/s^{j}iˑn-ta/ s^{j}iˑnda
lid-POSS.SG3SG

/pen-s^{j}ʌ/ penz$^{j°}$
put-GER.MOD

c. NC cluster simplification across word boundaries (connected speech)

/to-N warʌ/ to war°
lake-GEN.SG shore

/n^{j}e-N xʌnʌ/ n^{j}eŋ gʌn°
woman-GEN.SG sledge

The table in (7) summarizes the alternations of TN coda consonants /t d s n ŋ/.

[8] The behavior of nasals in front of [j] in the studied dialect may require further investigation. According to Salminen (1997; 2012), word-medial nasals /n ŋ/ are preserved in this environment merging as [n]. No data on nasal + [j] sequences at a phrase-medial word boundary are available.

[9] In Western TN dialectal speech, which is the source of our data, the homorganic nasal-stop sequences often undergo *denasalization* (Salminen 1997; 2012), that is, /nd ŋg/ are pronounced [d g], although, as discussed above, most of our consultants are also aware of the Central TN pronunciation such as [nd ŋg], shown in (6).

(7) Summary of TN consonant cluster simplification

C_1	C_2 or #	Output	Processes
/t d s/	/p p^j t t^j/	[p p^j t t^j]	Cluster simplification, no postvocalic voicing
/t d s/	/s s^j x/	[ts ts^j k]	Cluster simplification, strengthening
/t d s/	/m n ŋ l w j/	ʔ + C_2	Debuccalization
/n ŋ/	/m n ŋ l w (j)/	C_2	Cluster simplification
/n ŋ/	/p p^j t t^j x/	ND	Place assimilation, NC-effects
/n ŋ/	/s s^j/	[nz nz^j]	Place assimilation, postnasal voicing
/t d s n ŋ/	#	[ʔ]	Debuccalization

The coda alternations of obstruents and nasals are in many ways parallel to each other. Building on the analysis of Janhunen (1986), we assume that all of the alternations in (5)-(6) start out with place loss or *debuccalization*. Unlike other coda alternations, place loss can be analyzed as confined to words, and hence word level (Janhunen 1986; Salminen 1997; 2012). Thus, all relevant consonant clusters enter the post-lexical level with a placeless consonant as their first member, but this placeless consonant is eliminated by post-lexical processes in most cases, surfacing only phrase-finally and in some medial [ʔ]+sonorant clusters. Thus, somewhat paradoxically, *word*-final place loss shows its effects mostly at the edge of a *phrase*.

Aside of place loss, all other processes applying in TN consonant clusters have to be post-lexical since they apply across phrase-medial word boundaries. Nevertheless, many of these processes interact opaquely, presenting a significant challenge for both Classical OT and Stratal OT. We illustrate this problem in Section 5 and spell out our solution in Section 6.

5. The problem

TN consonant sandhi processes exhibit a number of opaque interactions. In this section, we focus on two interacting processes, which seem to belong to the same stratum: cluster simplification and fricative strengthening. The interaction between these two processes is a potential instance of within-stratum opacity, challenging not only Classical OT, but also Stratal OT. We will illustrate the problem with alternations of obstruents, but similar questions arise with regards to clusters where C_1 is a nasal.

Janhunen (1986) argues that TN coronal obstruents /t d s/ undergo a process of debuccalization to a glottal stop in the coda, as was shown in (5). This glottal stop surfaces unchanged before sonorants and word-finally (as in [m^jaʔl°] ‘your tent’; [m^jaʔ] ‘tent’), but is deleted before obstruents (as in [m^jata] ‘his tent’). The debuccalization is attributed here to the lexical level, building on Janhunen (1986) and Salminen (1997; 2012).

After debuccalization has happened, there are two additional processes, which interact opaquely. These processes are cluster simplification (ʔC_2 → C_2) and fricative strengthening (s s^j x → ts, ts^j, x/C_). A CC sequence, where C_1 is a debuccalizing obstruent (/t, d, s/) and C_2 is a fricative, will thus go through three changes, schematized as follows for /tx/: /tx/ → /ʔx/ →/ʔk/ → [k]. In what follows, we focus on the latter two steps of this derivation.

On the one hand, cluster simplification and fricative strengthening interact opaquely, but on the other hand, all available evidence of stratal affiliation suggests that the two processes apply within the same phrasal domain. The opaque interaction between two post-lexical processes can be illustrated with the phrase /nʲet xʌnʌ/ 'woman-GEN.PL sledge', pronounced [nʲe kʌn°] (5).

The post-lexical derivation of this phrase is given in (8) below. The input in (8) is the output of Word Level, showing the effects of coda debuccalization. We also assume that vowel reduction from /xʌnʌ/ to |xʌn°| has applied lexically, although nothing hinges on this. Observe that the two processes in (8) are in a counterbleeding relation: if cluster simplification applied first, it would have bled fricative strengthening.

(8) Counterbleeding in Tundra Nenets phrasal consonant sandhi

Input	nʲeʔ xʌn°
Strengthening	nʲeʔ kʌn°
Cluster simplification	nʲe kʌn°
Output	nʲe kʌn°
	'women's sledge'

The opaque interaction in (8) not only presents a problem for Classical OT (Prince & Smolensky 2004), but is also problematic for Stratal OT (Kiparsky 2000; forthc.; Bermúdez-Otero forthc.), a theory that accounts successfully for many kinds of opacity. The Stratal OT approach to opacity requires that the two processes belong to different strata. However, neither of these processes can be exclusively lexical, i.e. applying only in the Word Stratum (contra the suggestion by an anonymous reviewer). As discussed in Section 3, TN words are unlike phrases such as (8) in that they involve morphological restrictions on morpheme combinations, they often have a partially idiomatic meaning, and single morphemes (stems or suffixes) cannot form words of their own. The units like 'women's sledge' in (8) are phrases: they can take just about any two words as their components, their meaning is compositional, and phrase formation is optional. In (8), we have a connected speech example, but in slower speech and more formal registers, each word would form a phrase of its own, yielding [nʲeʔ xʌn°].

Thus, both cluster simplification and fricative strengthening have to apply within phrasal phonology. It also does not seem plausible that the two processes have different phrasal domains, or (equivalently) belong to two different post-lexical strata. Such an account predicts an unattested surface phrasing. To illustrate this, let us assume that there are two different phrasal strata, Stratum 1 (S1) and Stratum 2 (S2), where S1 has fricative strengthening but not cluster simplification, while a larger domain at S2 simplifies consonant clusters, but takes the strengthened consonant as given. By assumption, S1 and S2 are nested phrasal prosodic domains. However, phrasing the two words together is optional in TN, and therefore such an account predicts an unattested phrasing where cluster simplification applies but strengthening does not. If two words in (8) were phrased as $[[\text{n}^{\text{j}}\text{eʔ}]_{S1}\ [\text{xʌn°}]_{S1}]_{S2}$ (where brackets indicate domain boundaries), then the boundary between the words would be a legitimate environment for cluster simplification (since this boundary is within the domain S2) but not for strengthening (since this boundary is *not* within S1). This account would therefore predict a semi-casual speech style where /nʲet xʌnʌ/ 'women's sledge' would surface *[nʲe xʌn°], where the glottal stop is deleted, but strengthening does not occur. Such a phrasing is impossible: strengthening and cluster simplification either both apply or both do not apply. Thus, an analysis assuming two phrasal domains would capture the opaque interaction, but it would also predict an unattested phrasing.

We argue that the two processes can be described as one mapping involving coalescence, rather than deletion plus assimilation. We define coalescence as in (9) within the correspondence theory of McCarthy & Prince (1995; 1999), and we symbolize correspondence relations with indices. For example, TN post-lexical phonology involves a mapping /$ʔ_1x_2$/ → [$k_{1,2}$]. Such an analysis treats the seemingly opaque mapping in (8) as transparent, and therefore we can maintain that both processes belong to the same cycle.

(9) Coalescence: a mapping where two input segments correspond to one output segment /s_1s_2/ → [$s_{1,2}$]

A related problem for OT is posed by TN voicing alternations, which essentially involve a chain shift whereby underlying /VʔtV/ maps to [VtV] (as shown in (5)) and underlying /VtV/ maps to [VdV] (as shown in (4)). Relying on the treatment of cluster simplification as coalescence, we propose that this chain shift can be analyzed as an instance of resistance to the application of multiple input-output disparities at the same time, or a *gang effect*. While voicing of input consonants is allowed in TN, changing both [voice] and [constricted glottis] in one mapping is not allowed. In Section 6, we propose to formalize this intuition in terms of constraint conjunction (Smolensky 1993), although a formalization within Harmonic Grammar is also possible.

6. Analysis

The proposed analysis provides a way of maintaining the basic assumptions of Stratal OT. We assume that the grammatical evaluation is entirely parallel at each cycle, but the grammar of TN contains multiple cycles or Strata with potentially different rankings. Specifically, we will appeal to two such strata: *Lexical* and *Post-lexical*. Section 6.1 provides an overview of the proposed analysis. Section 6.2 introduces the constraint set. Sections 6.3 and 6.4 describe the grammar of TN lexical and post-lexical alternations respectively. Section 6.5 summarizes the proposal and explores its implications.

6.1. *Overview*

We analyze the glottal stop in TN as a placeless consonant, treating debuccalization formally as loss of place features. While there is ample precedent for assuming that glottal stop is placeless (Bessell & Czaykowska-Higgins 1992; Bessell 1993; McCarthy 1994; Rose 1996), we do not assume that this specification of laryngeals is universal (see Lombardi 2001; de Lacy 2006; McCarthy 2008).

Our analysis of cluster simplification relies on the idea that reduction of consonant clusters starts out with place loss (McCarthy 2008). However, obstruents and nasals pattern differently with respect to debuccalization: while a placeless obstruent is essentially non-distinct from a glottal stop, a placeless nasal still differs from it in nasality (McCarthy 2008). The loss of place features happens at the lexical level and thus does not lead to complete neutralization of the obstruent-nasal contrast. Aside of place loss, all other relevant processes happen post-lexically.

We propose to treat cluster simplification in TN as coalescence. On our account, a post-lexical mapping like /ʔ$_1$s$_2$/ → [ts$_{1,2}$] involves correspondence between two input segments and one output segment. This analysis avoids postulating intermediate strata (and hence intermediate phrases) that, as we saw in Section 5, do not exist in TN.

While placeless obstruents (i.e. glottal stops) may either survive intact or coalesce with a following consonant post-lexically, the options are different for a placeless nasal coming from the lexical level. A placeless nasal may coalesce with a following segment to yield a prenasal affricate, or else be turned into a glottal stop by losing nasality.

6.2. *Constraints*

This section introduces the OT constraints that are responsible for the alternations in question. We assume that debuccalization is triggered by a constraint from the family of coda conditions (Itô 1986; 1989; McCarthy 2008; Kavitskaya & Staroverov 2010 a.o.), defined in (10).

(10) CODACOND: assign a violation for each coda consonant which is specified for place and not place-linked to a following onset

We further assume that place features are privative, and thus a change from an oral to a laryngeal obstruent violates MAX(place). The exact nature of place features, and the faithfulness constraints protecting these features are subject to a number of opposing views (see Itô et al. 1995; Zoll 1996; Davis & Shin 1999; Lombardi 2001; McCarthy 2008 for some discussion), and thus we admit that the analysis proposed here may not necessarily extend to every language with debuccalization.

Similarly, we do not propose to treat *all* features as privative. In the absence of positive evidence, we will treat other features as equipollent, and hence protected by IDENT constraints (McCarthy & Prince 1995; 1999). The IDENT constraints play a crucial role in our analysis since they dictate which features may or may not be compromised in coalescence.

We propose that all TN phrasal consonant sandhi can be analyzed as resulting from coalescence. Such a mapping is penalized by the constraint UNIFORMITY, abbreviated as UNIF (McCarthy & Prince 1995; 1999). Another relevant faithfulness constraint is the segmental MAX that prohibits deletion of full segments. In places of potential ambiguity with MAX(place), we will refer to this constraint as MAX(seg).

Segmental merger in TN competes with place spreading, which is another way to satisfy CODACOND. We assume that place spreading violates a special faithfulness constraint, namely *SPREAD(place), also known as DEP-association-line (Kirchner 1993). We will abbreviate ‘place’ as ‘pl’ in constraint names.

(11) *SPREAD(pl): assign a violation for each pair of underlying X-slot and place node which are not connected by an association line s.t. their correspondents are connected by an association line.

Our analysis of TN consonant sandhi relies on several markedness constraints. Placeless obstruents and placeless nasals behave differently in TN, and in fact in many languages. While a placeless glottal stop is allowed in TN, and in a variety of languages, the placeless nasals are rare (see Ramsammy 2012 for a possible case). We assume that both placeless nasals and the glottal stop are targeted by specific markedness constraints: *N in (12) and *ʔ in (13). Both of these constraints are similar to HAVEPLACE (McCarthy 2008), a constraint against glottal stops is also proposed by Lombardi (2002), de Lacy (2006), Rubach (2000), and Staroverov (2014), among others.

(12) *N: assign a violation for every [+nasal] consonant lacking place features
(13) *ʔ: assign a violation for every [–nasal] consonant lacking place features

The nasal-consonant sequences in TN exhibit a variety of NC effects such as postnasal voicing and hardening. We will analyze these 'sequences' formally as complex segments (see 6.4.2). NC phonology is governed by two well-documented preferences: postnasal obstruents tend to be voiced and [–continuant] (Clements 1987; Steriade 1993; Padgett 1994; Pater 1996; 1999; Gouskova, et al. 2011; Halpert 2012). We encode these requirements as separate constraints, formulated in (14) and (15). These constraints apply to both sequences of segments and complex segments.

(14) *NT: assign a violation for every [+nasal] root node followed by a [-voice] obstruent root node
(15) *NF: assign a violation for every [+nasal] root node followed by a [+continuant] obstruent root node

Finally, TN has a process of postvocalic voicing that we assume is triggered by the constraint *VT in (16). For the data considered in this article, the process could as well be analyzed as *intervocalic*, although the full treatment of TN morphophonology requires reference to a broader set of environments (Janhunen 1986; Salminen 1997; 2012).

(16) *VT: assign a violation for every voiceless oral stop that is preceded by a vowel

Having introduced the constraints required for our analysis, we now proceed to spell out the details of their ranking.

6.3. *Lexical level*

Word-final consonants lose their place at the lexical level in TN. Crucially, place loss preserves the contrast between final nasals and obstruents. The tableau in (17) illustrates the lexical level ranking with the analysis of obstruent debuccalization in the word /maʌs/ 'place on chest under the outer layer of clothing'. Here and in what follows we abstract away from the alternations involving the TN reduced vowel /ʌ/. Post-vocalically (as in (17)), this vowel coalesces with a preceding vowel to yield a long segment.

(17) Lexical debuccalization of obstruents

	maʌs	CODACOND	MAX(seg)	MAX(pl)	*ʔ	ID(cont)	ID(cg)
☞ a.	maːʔ			1	1	1	1
b.	maːs	W1		L	L	L	L
c.	maː		W1	L	L	L	L

Coda place loss is accounted for by the high ranking of CODACOND. Since glottal stop is the only placeless consonant in TN ([h] is not in the inventory), place loss also implies a change in continuancy and in the feature [constricted glottis] for the underlying word-final /s/. The former change is crucial, since at the post-lexical level the [–continuant] glottal stop will trigger strengthening of a following consonant. Finally, since MAX(seg) dominates MAX(place), the coda condition triggers removal of place rather than segment deletion.

At the lexical level, the fate of word-final nasals is very similar to that of the final obstruents: they lose their place. However, final nasals preserve their nasality, remaining distinct from obstruents. This is illustrated in (18) for a nasal-final word /s^{j}iˑn/ 'lid'.

(18) Lexical debuccalization of nasals

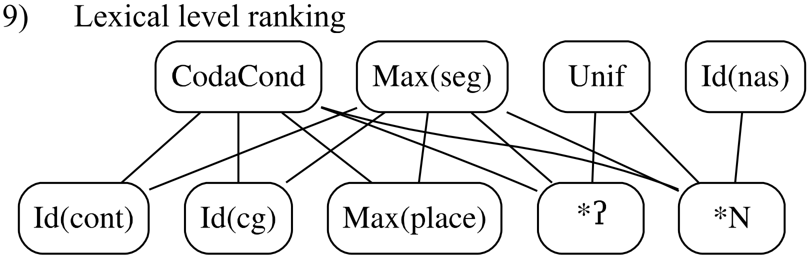
	s^{j}iˑn	CODACOND	IDENT(nas)	MAX(seg)	MAX(pl)	*N
☞ a.	s^{j}iˑN				1	1
b.	s^{j}iˑʔ		W1		1	L
c.	s^{j}iˑn	W1			L	L
d.	s^{j}iˑ			W1	L	L

At the output of the lexical level, /s^{j}iˑn/ shows up as |s^{j}iˑN|, an intermediate form with a final placeless nasal. Here and below we use straight brackets to denote intermediate representations. The final segment has to preserve its nasality due to high ranking of IDENT(nasal) and relatively low ranking of *N.

The account presented so far straightforwardly generalizes to the word-medial environment where coda obstruents and nasals also lose place at the lexical level, thus /m^{j}at-rʌ/ 'tent-POSS.SG2SG' maps to |m^{j}aʔl̥| (5) and /s^{j}iˑn-ta/ 'lid-POSS.SG3SG' to |s^{j}iˑNta| (6). Cluster simplification is not applicable at the lexical level, which follows from the ranking of MAX and UNIFORMITY above *N and *ʔ (18)b.

To summarize, lexical level phonology involves coda place loss. As shown in the lexical level ranking in (19), the markedness constraint CODACOND dominates the relevant faithfulness constraints, whereas the constraints disfavoring placeless consonants are low-ranked. Additionally, CODACOND is responded to via place loss and not deletion, since segmental MAX is high-ranked. The constraints whose ranking cannot be determined based on our data are omitted from this diagram.

(19) Lexical level ranking



As a result of debuccalization, final obstruents turn into a glottal stop while final nasals turn into |N|. At the output of the lexical level, there is still a contrast between the two classes of consonants, which explains why they behave differently in the phrasal phonology.

6.4. *Post-lexical level*

On our analysis, post-lexical level is the locus of a complex interaction between consonant cluster simplification via coalescence and a variety of consonant sandhi. In what follows we will first analyze fricative strengthening (6.4.1), then turn to NC effects (6.4.2), and finally to the lack of postvocalic voicing in cluster simplification (6.4.3).

6.4.1. *Coalescence and fricative strengthening after obstruents*

An important difference between lexical and post-lexical levels of the phonology of TN concerns their tolerance to placeless consonants. While placeless nasals and obstruents are freely allowed lexically, they are only tolerated in a restricted set of environments post-lexically. We assume that the constraints against placeless consonants (*N, *ʔ) are high-ranked post-lexically, triggering cluster simplification. In this section, we present an account of fricative strengthening after obstruents.

Descriptively, coda glottal stop (which is the output of lexical level) merges with following continuants to yield stops and affricates: |ʔ + x| → [k] and |ʔ + s, s^j| → [ts, ts^j], as was illustrated in (5). On our coalescence analysis, two input segments, e.g. |ʔ$_1$x$_2$|, correspond to one output segment [k$_{1,2}$], which preserves some properties of the first segment (continuancy) and some properties of the second one (place). The analysis of this process as a single parallel mapping avoids the unattested domains problem outlined in Section 5.

The details of the coalescence analysis are spelled out in (20) for the phrase |n^{j}eʔ xʌn°| [n^{j}e kʌn°] 'women's sledge'. Here we analyze the consonant sandhi in connected speech, and hence it is assumed that the two words are phrased together (if they were not, the output would be [n^{j}eʔ xʌn°]). Indices show crucial instances of input-output correspondence.

(20) Post-lexical glottal + obstruent coalescence in connected speech

n^{j}eʔ$_1$ x$_2$ʌn°	MAX	*SPREAD(pl)	*ʔ	ID(cont)	ID(cg)	UNIF
☞ a. n^{j}e k$_{1,2}$ʌn°				1	1	1
b. n^{j}eʔ$_1$ x$_2$ʌn°			W1	L	L	L
c. n^{j}e x$_2$ʌn°	W1			L	L	L
d. n^{j}ek$_1$ x$_2$ʌn°		W1		L	1	L

The pre-consonantal glottal stop in (20) cannot be preserved due to a high ranking of *ʔ that rules out the candidate (20)b. The glottal also cannot be deleted because of segmental MAX, ruling out (20)c. Finally, as the candidate (20)d shows, the glottal stop also cannot be avoided by spreading place from a following consonant, since *SPREAD(pl) dominates UNIFORMITY. In the winning coalescence candidate (20)a, the glottal stop is avoided, but no deletion has applied.

Fricative strengthening in TN applies even to input clusters like /s+s/ and /x+s/, where no stop consonant is present underlyingly. We explain this by assuming a two-step derivation, where the first consonant of the cluster first changes to a glottal *stop* as a by-product of lexical-level debuccalization (since TN has no [h], see 6.3). The lexical-level glottal stop then triggers strengthening post-lexically. Schematically, the derivation looks like this: /s+s/ (Input) → |ʔ + s| (Lexical output) → [ts] (Post-lexical output).[10] An alternative, suggested to us by a reviewer, would be to assume that a feature [-continuant] or a full stop, perhaps a [t], is inserted in these mappings. However, such an analysis would have to appeal to an otherwise unmotivated epenthesis process whereas our analysis builds on component processes, each of which is independently motivated in other environments.

The outcomes of post-lexical coalescence differ, depending on the place of consonants involved. Thus |ʔ + s| yields an affricate [ts], but |ʔ + x| yields a stop [k]. This pattern is accounted for by the sheer existence of the constraint IDENT(continuant). When glottal stop coalesces with a dorsal fricative (20), both input continuancy values cannot be preserved since TN does not have a dorsal affricate *[kx]. On the other hand, when laryngeal stops coalesce with coronal fricatives, both continuancy values can be preserved, and thus |ʔ + s| yields [ts], obeying IDENT(cont), e.g. |pal^{j}ʌʔ s^{j}ajʌ| [pal$^{j°}$ ts^{j}aj°] 'thick tea' (5). The analysis of coalescence in this case is essentially identical to (20).

The ranking *ʔ >> UNIFORMITY only becomes active post-lexically, and it limits the range of contexts where glottal stops may occur. Simply put, all environments where a surface glottal stop shows up are cases of impossible coalescence. Glottal stop surfaces only in front of sonorants and vowels or before a pause.[11] The key observation is that continuancy can be compromised in coalescence, in order to avoid surface laryngeals, whereas the feature [sonorant] cannot. This is illustrated in (21) with the analysis of a glottal + sonorant cluster where coalescence does not apply: |m^{j}aʔl°| 'your tent' surfaces as [m^{j}aʔl°] (the input |l| is derived from /r/ at the word level) .

(21) Post-lexical coalescence cannot merge a sonorant consonant with a non-sonorant

	m^{j}aʔ$_1$l$_2$°	ID(son)	*SPREAD(pl)	*ʔ	ID(cont)	ID(cg)	UNIF
☞ a.	m^{j}aʔ$_1$l$_2$°			1			
b.	m^{j}al$_{1,2}$°	W1		L	W1	W1	W1
c.	m^{j}at$_1$l$_2$°		W1	L			

If a sequence like |ʔl| were to undergo coalescence, as in (21)b, the result would inevitably violate IDENT(sonorant) since the two input consonants cannot simultaneously match the output. Ranking IDENT(sonorant) over *ʔ rules out coalescence in these cases. Glottal stops also cannot be avoided via long-distance coalescence (for example, coalescing with an obstruent across a vowel), but it is not clear if long-distance coalescence is attested at all (see Struijke 2000; McCarthy 2007 for some discussion). Finally, (21)c demonstrates that the glottal stop cannot be avoided via place spreading due to a relatively high ranking of *SPREAD(pl).

[10] TN fricatives also strengthen after coda consonants that do not debuccalize, namely /b l m r/. However, word-final /b l m r/ surface followed by a glottal stop (the *added glottal stop* of Janhunen (1986)). We would like to suggest that the cause of strengthening after /b l m r/ is related to the reason why a glottal stop always follows these consonants word-finally. This can be captured by assuming a floating feature [–continuant] after these segments.

[11] The glottal in TN may occur *after* vowels or after the non-glottalizing consonants /b l m r/. Although we do not attempt a full analysis of the alternations of these consonants, it can be assumed that no coalescence is possible here for the sake of the same constraint that makes it impossible for these consonants to debuccalize in the first place.

The coalescence analysis has two important advantages over an assimilation + deletion account. First, this account allows us to reconcile TN opaque interactions with the independent evidence for stratal affiliation of phonological processes: all opacity is accounted for by ranking differences between strata. Second, the stratal account allows us to pinpoint the underlying cause of consonant strengthening: in sequences like /s+s/ and /s+x/, the first consonant changes to a stop at the lexical level, triggering subsequent strengthening of a following consonant. The interaction between place loss and fricative strengthening is opaque on our analysis, since, if coalescence applied simultaneously with place loss, there would be no need for strengthening in /s+s/ and /s+x/.

6.4.2. *Word-medial NC-effects*

When placeless nasals are followed by another consonant at the post-lexical level, they either coalesce with a following sonorant or assimilate in place triggering a variety of NC effects. These processes are summarized in (22), with examples repeated from (6).

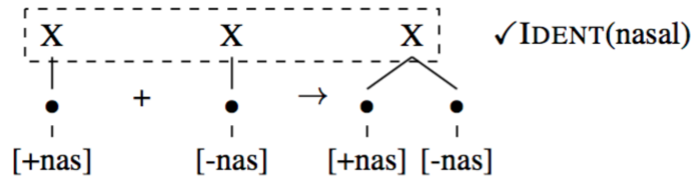
(22) The fate of placeless nasal: a summary

Context	Process	Example
N + |m mʲ n nʲ ŋ l lʲ w|[12]	coalescence	|weNl°| [wel°] ‘your dog’
N + |p pʲ t tʲ s sʲ|	voicing	|sʲi·Nta| [sʲi·nda] ‘his lid’ |peNsʲ°| [penzʲ°] ‘to put’
N + |x|	strengthening, voicing	|sʲalʌNxʌNta| [sʲal°ŋgʌnda] ‘underarm-DAT.POSS.SG3SG’

We assume that homorganic nasal + obstruent clusters in TN form complex segments, following ample precedent in the phonological analysis of such sequences (Hirst 1985; Herbert 1986; Clements 1987; Clements & Hume 1995; Duanmu 2009; Halpert 2012; Shih & Inkelas 2014). From now on, we will write these sequences accordingly as monosegmental, e.g. [^{n}d], although this representation does not imply a change in our evaluation of the actual phonetic substance. We adopt the feature-based model of nasal contour segments spelled out in Clements (1987) and Clements & Hume (1995) (C&H), although other approaches to contour segments would work as well (in particular, Steriade 1993; Halpert 2012; Shih & Inkelas 2014). In all of these models, a single unit at some level (the level of timing, or *X-slots* for C&H) dominates multiple units at a lower level (*root nodes* of C&H). For instance, the segment [^{n}d] involves one X-slot dominating two root nodes which differ in the features [nasal] and [sonorant]. A coalescence mapping like $|N_1t_2| \rightarrow [{}^{n}d_{1,2}]$ thus amounts to merging two input X-slots into a single complex X-slot in the output, as schematized in (23) (with only the feature [nasal] shown).

[12] /r/ changes to |l| after consonants, and the behavior of /N+j/ requires further investigation. See Section 3 for some discussion.

(23) Schematic representation of prenasal segment formation and faithfulness



We further assume that the IDENT constraints are evaluated on X-Slots (cf. Shih & Inkelas 2014 on correspondence between subsegmental nodes). Since a complex segment has all features of its parts, IDENT(nasal) is satisfied in (23). Finally, although the existence of features [nasal] and [sonorant] is crucial to our theory, our account will work regardless of the details of feature geometry.

Coalescence of nasals is parallel to coalescence of obstruents. The various results of nasal-obstruent coalescence are derived by the interaction of two pressures: the well-formedness constraints on prenasal obstruents (*NT, *NF), and the featural faithfulness constraints. To set the scene, we begin our discussion of nasal+consonant coalescence by considering the only environment where coalescence does not happen: phrase-finally after a vowel. In this context, the placeless nasal turns into a glottal stop. The analysis of the phrase-final behavior of |s^jiˑN| → [s^jiˑʔ] 'lid' is given in (24), where the right phrase boundary is signified by a square bracket. We assume that the nasal cannot surface due to a high ranking of *N (24)b. The nasal also cannot regain its place via insertion of some feature, since CODACOND has to be obeyed (24)c.

(24) Post-lexical denasalization at a phrase boundary

	s^jiˑ$_1$N$_2$]	*N	CODA COND	MAX	ID(cons)	ID(son)	*ʔ	ID(nas)	ID(cg)	UNIF
☞ a.	s^jiˑ$_1$ʔ$_2$]					1	1	1	1	
b.	s^jiˑ$_1$N$_2$]	W1				L	L	L	L	
c.	s^jiˑ$_1$n$_2$]		W1			L	L	L	L	
d.	s^jiˑ$_1$]			W1		L	L	L	L	
e.	s^jiˑ$_{1,2}$]				W1	L	L	1	L	W1

The candidate (24)d deletes the final consonant altogether, incurring a fatal violation of MAX. Particularly interesting is the candidate (24)e, which employs coalescence of a vowel + nasal, instead of deletion. Coalescence of a vowel and a consonant is never possible in TN, and we attribute this to the constraint IDENT(consonantal).[13] The final consonant of the winner in (24)a changes its values for the features [nasal], [sonorant], and [constricted glottis] to become a glottal stop. The ranking illustrated in (24) also predicts no change to the final glottal stops that come from an obstruent, as in [m^jaʔ] 'tent'.

[13] The account of nasal+glide sequences is a bit more involved. More data is needed on /N+j/ sequences, and coalescence applies in /Nw/. This indicates that TN /w/ is a consonantal rather than a vocalic glide (Hume 1995; Levi 2004; 2008; Nevins & Chitoran 2008; Padgett 2008). Indeed, [w] never alternates with vowels and it occurs palatalized.

Although coalescence of a vowel and a consonant is not allowed, two consonants can merge, provided that they share the value of the feature [sonorant]. In this vacuous coalescence, a nasal essentially dissolves within the next sonorant. For instance, |weNl°| 'your dog' surfaces as [wel°] (6). This mapping is analyzed in (25) where CodaCond is omitted since it is satisfied by all candidates.

(25) Post-lexical coalescence of a nasal + sonorant

	weN$_1$l$_2$°	*N	Id(son)	*Spread(pl)	Id(nas)	Id(lat)	*ʔ	Unif
☞ a.	wel$_{1,2}$°				1	1		1
b.	weN$_1$l$_2$°	W1			L	L		L
c.	weʔ$_1$l$_2$°		W1		1	L	W1	L
d.	wen$_1$l$_2$°			W1	L	L		1
e.	we^{n}d$_{1,2}$°		W1		L	1		1

The underlying nasal leaves no surface trace in this case since all candidates preserving nasality fail. The placeless nasal cannot stay intact due to *N (25)b. Ident(sonorant) prevents the intermediate |N| from changing to a glottal stop (25)c: in this case, unlike in (24), there is an alternative candidate preserving the feature [sonorant]. The placeless nasal also cannot regain its place via spreading due to *Spread(pl) (25)d. Finally, the nasal cannot produce a complex segment [^{n}d] since this would involve a change in the feature [sonorant]: both merging consonants are sonorants, whereas the resulting complex segment is partially [–sonorant].

In the case of (25), we have no independent evidence that the process involved is coalescence rather than deletion. However, the analysis in Section 6.4.1, as well as the following examples in this section, suggest that deletion is dispreferred to coalescence by the ranking of Max over Uniformity (see (20)).

When a placeless nasal merges with a following voiceless stop, the result is a complex segment such as [^{n}d] in |s^{j}i·Nta| → [s^{j}i·^{n}da] 'his lid' (26). The change in voicing is mandated by the high-ranked constrain *NT, whereas keeping both segments without forming a complex segment is prohibited (again) by *Spread(pl). Note that the winner (26)a satisfies *Spread(pl): even though spreading has occurred, there was no spreading of [Place]. The tableaux in (26)-(28) omit other ranking arguments, which are identical to those in (25).

(26) Post-lexical NT coalescence with voicing

	s^{j}i·N$_1$t$_2$a	*NT	*Spread(pl)	Id(voi)	Unif
☞ a.	s^{j}i·^{n}d$_{1,2}$a			1	1
b.	s^{j}i·^{n}t$_{1,2}$a	W1		L	1
c.	s^{j}i·n$_1$d$_2$a		W1	1	L

The reader will recall that in Western dialects, the complex segments like [^{n}d] may variably denasalize simply to [d] (although our Western TN consultants are quite aware of the standardized Central pronunciation). Thus, although we concentrate on Central TN here, we note that optional denasalization could be captured as an effect of an articulatory timing pattern where the oral part of [^{n}d] overlaps the nasal part to a large enough extent.

We would suggest that even in Western TN, these sounds are phonologically complex segments where nasality is simply masked by gestural overlap (see Fourakis & Port (1986); Halpert (2012), and Steriade (1993) for similar proposals).

Interestingly, the merger of |N + s| does not produce the same result as the |N + t| merger. The outcome with strident fricatives is voicing without strengthening, that is, a prenasal affricate [^{n}z] rather than [^{n}d]. The actual pronunciation of [^{n}z] sometimes includes an 'intrusive' stop portion, i.e. [^{n}z] ~ [^{n}dz], but there is no contrast between the two pronunciations, and in fact such a contrast may be universally impossible (Clements 1987; Steriade 1993). We thus transcribe nasal affricates with a strident release as [nz] (as was done in sections 1-6.4.2) or [^{n}z] (this section), but our transcription should not be taken too literally. (27) shows our analysis of |peNs^{j}°| → [pe^{n}z^{j}°] 'put'. A crucial role is played by the constraint IDENT(strident).

(27) Post-lexical coalescence preserves stridency

	peN$_1$s$^{j}_{2}$°	ID(strid)	*NF	ID(voi)	UNIF
☞	a. pe^{n}z$^{j}_{1,2}$°		1	1	1
	b. pe^{n}d$^{j}_{1,2}$°	W1	L	L	1

The winner in (27) violates the constraint against prenasal segments with a continuant release. However, this violation cannot be avoided since changing the release would imply a change in stridency.

Finally, let us turn to a case where post-nasal continuants undergo both hardening and voicing, such as |n^{j}eN$_1$ x$_2$ʌn°| → [n^{j}e^{ŋ}g$_{1,2}$ʌn°] 'a woman's sledge'. The analysis of this mapping is given in (28). The winning candidate satisfies both IDENT(nasal) and IDENT(sonorant) since it preserves input specifications of both /N/ and /x/ on two distinct positions under the same X-Slot. The [+continuant] value of /x/ is not preserved (28)b, since this fricative is not strident and the preservation of stridency is not at stake as it was in (27). The fate of (28)c-d is parallel to (26)b-c.

(28) Post-lexical coalescence with hardening and voicing

	n^{j}eN$_1$ x$_2$ʌn°	*NF	*NT	*SPREAD(pl)	ID(cont)	ID(voi)	UNIF
☞	a. n^{j}e^{ŋ}g$_{1,2}$ʌn°				1	1	1
	b. n^{j}e^{ŋ}ɣ$_{1,2}$ʌn°	W1			L	1	1
	c. n^{j}e^{ŋ}k$_{1,2}$ʌn°		W1		1	L	1
	d. n^{j}eŋ$_1$g$_2$ʌn°			W1	1	1	L

In sum, this tableau shows that *NT and *NF dominate IDENT(voice) and IDENT(continuant) respectively, in TN.

We have shown that the coalescence analysis of TN cluster simplification can be straightforwardly extended to nasal + obstruent sequences. Our analysis assumes that the placeless nasal coalesces with a following obstruent to yield a single complex segment, and correctly predicts a variety of attested NC effects such as post-nasal voicing and post-nasal hardening, as well as non-application of these processes in specific environments.

6.4.3. *Post-vocalic obstruent voicing and non-voicing*

The last part of the complex picture of TN consonant sandhi concerns the laryngeal features of obstruents. Thus, /t/ is voiced after vowels, but only if it was not preceded by a consonant underlyingly. For example, /ja-ta/ ‘his earth’ surfaces as [jada] while /m^{j}at-ta/ ‘his tent’ is [m^{j}ata], and not *[m^{j}ada]. Just like the counterbleeding pattern considered in Section 6.4.1, these alternations present a challenge for parallel OT since there is no surface-apparent reason for why /t/ would not voice in ‘his tent’. Furthermore, the problem cannot be addressed by assigning postvocalic voicing to the lexical level, since the process operates at phrase-medial word boundaries.

We propose to treat the lack of voicing after underlying consonants as a gang effect. While a single output segment may be unfaithful in voicing, the coalescence of $|ʔ_1+t_2|$ is more complex. If the two consonants $|ʔ_1+t_2|$ were to change to a surface $[d_{1,2}]$ after a vowel, this would involve a change not only in [voice], but also in [constricted glottis]. The reason for the lack of voicing in $|ʔ_1+t_2|$ sequences is that both of these features cannot be changed at the same time. We formalize this intuition using a conjoined constraint IDENT(voice)&IDENT(constricted glottis). This constraint is violated if a single output segment changes both laryngeal features of its input correspondent(s). The same intuition can also be formalized within Harmonic Grammar, which may have some advantages over constraint conjunction (Pater 2009).

We illustrate our solution with the analysis of the two mappings involving laryngeal feature mismatch and/or coalescence. The tableau (29) shows our analysis of postvocalic voicing, which results from the ranking *VT >> IDENT(voice).

(29) Post-vocalic voicing

	jata	*VT	ID(voi)
☞ a.	jada		1
b.	jata	W1	

In (30), we show that a surface postvocalic [t] may escape voicing, if it also corresponds to a segment in lexical level output, which had a [constricted glottis] specification. Thus, the output of lexical level |m^{j}aʔta| ‘his house’ maps to [m^{j}ata] rather than *[m^{j}ada] post-lexically.

(30) No post-vocalic voicing for underlying consonant sequences

	m^{j}aʔ$_1$t$_2$a	ID(voi)&ID(cg)	*ʔ	*VT	ID(voi)	ID(cg)	UNIF
☞ a.	m^{j}at$_{1,2}$a			1		1	1
b.	m^{j}ad$_{1,2}$a	W1		L	W1	1	L
c.	m^{j}aʔ$_1$t$_2$a		W1	L		L	L

The winning candidate merges the two consonants, resulting in a violation of UNIFORMITY and IDENT(cg). The candidate (30)b shows intervocalic voicing, but it violates both IDENT(voice) and IDENT(cg) and thereby incurs a violation of a high-ranked conjoined constraint. The proposed analysis thus crucially relies on an intermediate derivational step (lexical level) where coda obstruents are glottal stops in TN. Finally, the winning candidate violates *VT, but this violation cannot inhibit cluster simplification, since *ʔ dominates *VT (30)c.

Although the TN data show the need for cumulative constraint interaction (a gang effect), we think it may be premature to claim that all such effects should be allowed. In TN, it is the *related* featural changes that gang up, not some random changes. An intuitive observation that gang effects are limited to sets of related processes has also been made in other accounts of cumulative interactions (Itô & Mester 2003; Pater 2009).

6.5. *Summary of the analysis*

This section gives a final overview of the main properties of our analysis, focusing on several key issues such as the role of derivations, abstract representations, the cycle, and many-to-one input-output mappings.

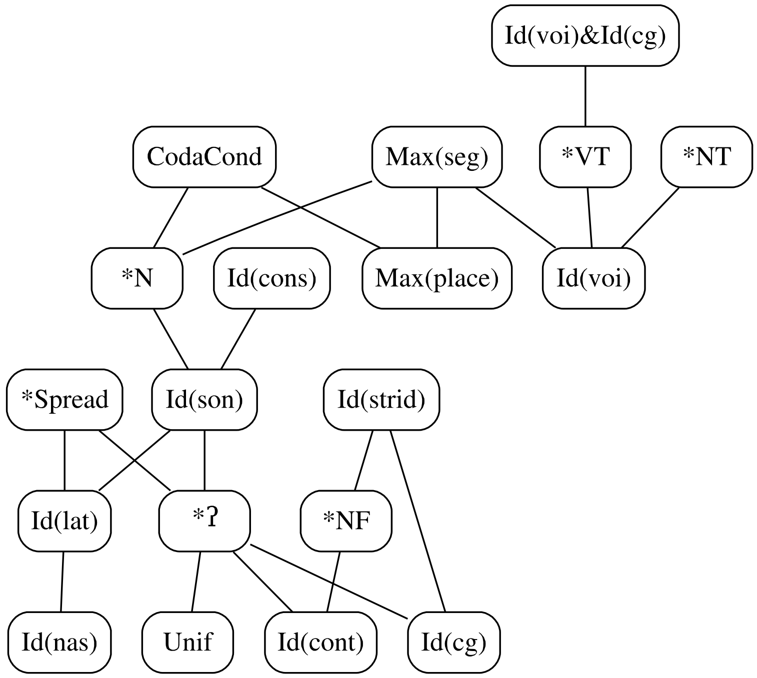
Building on the analysis by Janhunen (1986) and Salminen (1997; 2012), we argued for a derivational history of cluster simplification, which is similar to that proposed by McCarthy (2008), but is implemented in Stratal OT (Kiparsky 2000; forthc.; Bermúdez-Otero forthc.). All relevant coda consonants lose their place at the lexical level. Place loss also triggers additional adjustments in the features [continuant] and [constricted glottis] for obstruents, so that they turn into a glottal stop. These accidental consequences of lexical place loss have important repercussions in the post-lexical phonology: the [–continuant] value of the glottal triggers strengthening whereas its [constricted glottis] feature inhibits postvocalic voicing.

Apart from the cyclic derivational architecture of Stratal OT, our analysis also relies on abstract autosegmental representations. This is particularly apparent in our treatment of nasal + consonant clusters. Here we assume that lexical debuccalization creates placeless nasals, similar to the proposals in McCarthy (2008) and Ramsammy (2012). At the post-lexical level, the placeless nasals may regain their place, as a result of a general consonant merger process. Thus the derivations proposed here resemble Duke-of-York derivations (Pullum 1976; McCarthy 2003; Rubach 2003). Bermúdez-Otero (2001) proposes a similar analysis of Catalan laryngeal feature alternations.

We have proposed a unified account of TN phrasal consonant sandhi, where all consonant clusters undergo coalescence, and the result of this coalescence depends on the features of the component consonants and on the ranking of relevant IDENT-feature constraints. The post-lexical rankings are summarized in (31), where lexical level rankings have been preserved to the extent possible. Post-lexical level involves reranking of the constraint *ʔ above UNIFORMITY and *N above UNIFORMITY and IDENT(nasal).

The trigger of coalescence in our view is the relatively high ranking of the constraints against placeless consonants: *N and *ʔ (cf. HAVEPLACE which has the same effect in McCarthy (2008)). Coalescence is preferred to other repairs since UNIFORMITY is outranked by other faithfulness constraints such as MAX(seg) and *SPREAD(pl). The relative ranking of IDENT constraints plays a crucial role in predicting the result of coalescence. For instance, preservation of the feature [sonorant] prohibits coalescence in obstruent + sonorant sequences.

(31) Ranking summary: post-lexical level



We treat homorganic nasal + obstruent 'sequences' as complex segments similar to affricates. The placeless nasal |N| *can* coalesce with a following obstruent, because the resulting complex X-slot preserves both input values of the feature [sonorant] on two distinct root nodes (Clements 1987; Clements & Hume 1995). The formation of prenasal affricates in TN is accompanied by voicing due to *NT and hardening due to *NF. The distribution of voicing and hardening is regulated by the ranking of IDENT constraints that in general serve to restrict the output of coalescence on our account. For example, the sequence |Nx| undergoes both voicing and hardening to surface as [$^{\text{ŋ}}$g], violating the low-ranked IDENT(continuant) and IDENT(voice). On the other hand, |Ns| shows voicing but not hardening, surfacing as [^{n}z/^{n}dz], and not *[^{n}d]. This difference is due to the fact that /s/ is underlyingly specified for the feature [+strident], and IDENT(strident) is ranked higher than *NF.

The key assumption of our analysis is that a set of processes, which may look like assimilation and deletion, should in fact be analyzed as a single mapping involving coalescence. Thus, we recast a seemingly opaque mapping as transparent solving a major challenge to Stratal OT, identified in Section 5. Since we assume a single transparent mapping, postulating multiple phrasal domains becomes unnecessary.

Surface codas in TN arise in the environments where coalescence is impossible. Word-medially, a placeless obstruent cannot coalesce with a following sonorant since such a mapping would violate IDENT(sonorant). The phrase-final placeless consonants could only coalesce with a vowel, but consonant-vowel coalescence is not allowed in TN, since it violates IDENT(consonantal).

The number of surface glottal stops is a famous controversy of TN phonology and orthography (Tereshchenko 1956; Janhunen 1986). We have argued that TN has only one glottal stop on the surface, but the distinction between placeless nasals and placeless obstruents is maintained in the output of the lexical level, parallel to the distinct morphophonemes postulated by Tereshchenko (1956), Janhunen (1986), and Salminen (1997 et seq.), among others.

Finally, we have argued that the patterns of postvocalic voicing in TN can be analyzed as a gang effect. The lack of postvocalic voicing in surface obstruents resulting from underlying sequences is due to a cumulative constraint interaction, whereby the change in *both* [constricted glottis] and [voice] is not allowed.

7. Alternatives: a comment on Harmonic Serialism

TN consonant sandhi exhibit a number of transparent and opaque process interactions and proposed a treatment of these interactions within Stratal OT. In this section, we briefly mention a few challenges that TN consonant sandhi present for a potential account within opacity-augmented versions of Harmonic Serialism (McCarthy 2007; Wolf 2008; Kavitskaya & Staroverov 2010; Jarosz 2014).

Coalescence presents a logical challenge for gradual frameworks like Harmonic Serialism. Indeed, merging several segments typically also involves some featural changes, and therefore it is not clear whether the merger can happen in one step (cf. Gietz et al. 2015). McCarthy (2007) proposes that within Harmonic Serialism coalescence should be reduced to multiple steps involving other processes (e.g. assimilation and deletion in the analysis of TN discussed in Section 5). It remains to be seen whether such a reductionist account is possible for TN consonant sandhi.

Underlying fricative sequences undergo strengthening in TN (e.g. /s + s/ → [ts]), and the surface context of the alternation does little to explain how two continuants ultimately produce a non-continuant. Our account of this alternation relies on grammar differences between derivational levels. At the lexical level, the first consonant of the cluster changes to a glottal stop [ʔ], which then causes strengthening. It is not entirely obvious to us how this explanation could be recast within Harmonic Serialism, where all derivational steps obey the same ranking.

To summarize these arguments, we think that there is a number of challenges that TN consonant sandhi would present for a possible analysis within Harmonic Serialism. We therefore expect that working out a serialist analysis could help to further the debate between Harmonic Serialism and Stratal OT.

8. Conclusion

TN presents a set of consonant sandhi alternations, which combine apparent opaque ordering relations such as counterbleeding within a single phrasal domain of application. These properties make the TN alternations an interesting test ground for Stratal OT, and for the theories of phonological derivations in general. In this paper, we have proposed that TN consonant cluster simplification can be thought of as coalescence. This analysis unifies all consonant cluster effects, such as post-obstruent strengthening and NC-effects, as consequences of the same process. Our approach provides a way of reanalyzing what otherwise looks like a counterbleeding interaction within an entirely parallel grammar of a single stratum (see also Baković 2007; 2013; Tesar 2008; 2013 on reanalyzing opaque interactions). Despite our analysis of cluster simplification as coalescence, we argue that TN data have to be analyzed within a derivational phonological framework, since strengthening in consonant clusters is caused by an intermediate stage, where coda obstruents neutralize to glottal stops. This intermediate glottal stop stage also accounts for postvocalic voicing inhibition in cluster simplification. Our analysis makes use of underspefication for place, thus corroborating the previous findings of McCarthy (2008) and Ramsammy (2012). Finally, our analysis of TN voicing alternations yields further empirical support to the existence of cumulative phonological effects (Legendre et al. 2006; Pater 2009).

Acknowledgements
We are very grateful to our Tundra Nenets consultants for sharing their language with us. We thank the audiences at GLOW 38, at AMP 2015, at Leipzig University, Wayne State University, and Swarthmore College for their invaluable feedback. This paper also owes a lot to the comments by Eva Zimmermann, Joanna Zaleska, Jochen Trommer, Nathan Sanders, Harry van der Hulst, and two anonymous reviewers. All errors and imprecisions are our own. The first author's work on this paper was supported in part by Leipzig University and German Research Foundation (DFG Research Training Group GRK 2011).

References

Amelina, Maria K. 2011. Akcentnye kharakteristiki neproizvodnykh imen v tundrovom narechii neneckogo jazyka, Chast' 1. Jaml'skij i kaninskij dialekty. *Ural-Altaic Studies*(5). 7–38.

Amelina, Maria K. 2012. Akcentnye kharakteristiki neproizvodnykh imen v tundrovom narechii neneckogo jazyka, Chast' 2. Gydanskij dialekt. *Ural-Altaic Studies*(6). 7–54.

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

Baković, Eric. 2013. *Blocking and Complementarity in Phonological Theory*. London: Equinox.

Bermúdez-Otero, Ricardo. forthc. *Stratal Optimality Theory*. Oxford: OUP.

Bermúdez-Otero, Ricardo. 2001. Voicing and continuancy in Catalan: a nonvacuous Duke-of-York gambit and a Richness-of-the-Base paradox. Ms, University of Manchester.

Bermúdez-Otero, Ricardo. 2011. Cyclicity. In Marc Van Oostendorp, Elizabeth Hume & Keren Rice (eds.), *The Blackwell Companion to Phonology*, vol. 4, 2019–2048. Malden, MA: Blackwell.

Bermúdez-Otero, Ricardo. 2014. Stratal Phonology: arguments for cyclic containment, morphological implications. Ms, University of Manchester.

Bessell, Nicola. 1993. *Towards a phonetic and phonological typology of post-velar articulation*. PhD dissertation, University of British Columbia.

Bessell, Nicola & Ewa Czaykowska-Higgins. 1992. Interior Salish evidence for placeless laryngeals. *NELS 22 Proceedings*, 35–49. Amherst, Mass: GLSA.

Castrén, Matias. 1854. *Grammatik der samojedischen Sprachen*. (Nordische Reisen Und Forschungen, Herausgegeben von A. Schiefner 5). St. Petersburg.

Chomsky, Noam, Morris Halle & Fred Lukoff. 1956. On accent and juncture in English. In Morris Halle, Horace G Lunt, Hugh McLean & Cornelis H van Schooneveld (eds.), *For Roman Jakobson: Essays on the occasion of his sixtieth birthday*, 65–80. The Hague: Mouton.

Clements, George N. 1987. Phonological feature representation and the description of intrusive stops. *Parasession on autosegmental and metrical phonology*. Chicago: Chicago Linguistic Society.

Clements, George N. & Elizabeth Hume. 1995. The internal organization of speech sounds. In John Goldsmith (ed.), *Handbook of Phonological Theory*, 245–306. Oxford: Blackwell.

Davis, Stuart & Seung-Hoon Shin. 1999. The Syllable Contact Constraint in Korean: An Optimality-Theoretic Analysis. *Journal of East Asian Linguistics* 8(4). 285–312.

de Haas, Wim. 1988. *A Formal Theory of Vowel Coalescence: a case study of Ancient Greek*. Dordrecht: Foris.

de Lacy, Paul. 2002. *The Formal Expression of Markedness*. PhD dissertation, Umass Amherst.

de Lacy, Paul. 2006. *Markedness: Reduction and Preservation in Phonology*. Cambridge: CUP.

Duanmu, San. 2009. *Syllable structure. The limits of variation*. Oxford: OUP.

Fourakis, Marios & Robert Port. 1986. Stop epenthesis in English. *Journal of Phonetics* 14. 197–221.

Gietz, Frederick, Peter Jurgec & Maida Percival. 2015. Linguistic shift work: not so strange after all (shifting in Harmonic Serialism). Paper presented at NELS 46.

Gouskova, Maria, Elizabeth Zsiga & One Tlale Boyer. 2011. Grounded constraints and the consonants of Setswana. *Lingua* 121(15). 2120–2152.

Halpert, Claire. 2012. Overlap-driven consequences of nasal place assimilation. In Philip Hoole, Lasse Bombien, Marianne Poulpier, Christine Mooshammer & Barbara Kühnert (eds.), *Consonant clusters and structural complexity*, 345–368. Berlin, New York: De Gruyter.

Helimski, Eugene A. 1984. Phonological and morphonological properties of quantity in Samoyed. In Péter Hajdú & László Honti (eds.), *Studien zur phonologischen Beschreibung uralischer Sprachen*, 13–17. Budapest: Akadémiai Kiadó.

Herbert, Robert K. 1986. *Language Universals, Markedness Theory, and Natural Phonetic Processes*. Walter de Gruyter.

Hirst, Daniel. 1985. Linearisation and the single segment hypothesis. In Jacqueline Guéron, Hans Obenauer & Jean-Yves Pollock (eds.), *Grammatical Representation*, 87–99. Dordrecht: Foris.

Hume, Elizabeth. 1995. Representing the duality of glides. In George Tsoulas & Lea Nash (eds.), *Actes du congrès: Langues et grammaire. Paris: Université, Paris VIII*.

Itô, Junko. 1986. *Syllable theory in prosodic phonology*. PhD dissertation, Umass Amherst.

Itô, Junko. 1989. A prosodic theory of epenthesis. *NLLT* 7(2). 217–259.

Itô, Junko & Armin Mester. 2003. On the sources of opacity in OT: coda processes in German. In Caroline Féry & Ruben van de Vijver (eds.), *The Syllable in Optimality Theory*, 271–303. Cambridge: CUP.

Itô, Junko, Armin Mester & Jaye Padgett. 1995. Licensing and Underspecification in Optimality Theory. *Linguistic Inquiry* 26(4). 571–613.

Janhunen, Juha. 1984. Problems of Nenets phonology. In Péter Hajdú & László Honti (eds.), *Studien zur phonologischen Beschreibung uralischer Sprachen*, 19–28. (Bibliotheca Uralica 7). Budapest: Akadémiai Kiadó.

Janhunen, Juha. 1986. *Glottal stop in Nenets*. (Mémoires de La Société Finno-Ougrienne 196). Helsinki.

Janhunen, Juha. 1993. Options for Tundra Nenets vowel analysis. In Marianne Bakró-Nagy & Enikő Szíj (eds.), *Hajdú Péter 70 Éves*, 143–147. Budapest: Nyelvtudományi Intézet.

Jarosz, Gaja. 2014. Serial markedness reduction. *Proceedings of AMP 1*. LSA.

Jones, Patrick Jackson. 2014. Tonal interaction in Kinande: cyclicity, opacity, and morphosyntactic structure. Massachusetts Institute of Technology Thesis.

Kavitskaya, Darya & Peter Staroverov. 2010. When an interaction is both opaque and transparent: the paradox of fed counterfeeding. *Phonology* 27. 255–288.

Kiparsky, Paul. forthc. *Paradigm Effects and Opacity*. Stanford: CSLI Publications.

Kiparsky, Paul. 1982. Lexical Phonology and Morphology. In Yang In-Seok (ed.), *Linguistics in the Morning Calm*. Seoul.

Kiparsky, Paul. 1985. Some consequences of Lexical Phonology. *Phonology Yearbook 2*. 85–138.

Kiparsky, Paul. 2000. Opacity and cyclicity. *The Linguistic Review* 17(2–4). 351–366.

Kirchner, Robert. 1993. Turkish vowel harmony and disharmony: an Optimality Theoretic account. Ms, University of Alberta. ROA-4.

Legendre, Géraldine, Antonella Sorace & Paul Smolensky. 2006. The Optimality Theory-Harmonic Grammar connection. In Paul Smolensky & Géraldine Legendre (eds.), *The harmonic mind: From neural computation to optimality theoretic grammar*, vol. 2, 339–402. Cambridge, Mass: MIT Press.

Lehtisalo, Toivo. 1956. *Juraksamojedisches Wörterbuch*. Lexica Societatis Fenno-Ugricae 13. Helsinki.

Levi, Susannah V. 2004. *The representation of underlying glides: a cross-linguistic study*. PhD Dissertation, University of Washington.

Levi, Susannah V. 2008. Phonemic vs. derived glides. *Lingua* 118(12). 1956–1978.

Lombardi, Linda. 2001. Why place and voice are different: constraint interactions and feature faithfulness in Optimality Theory. In L. Lombardi (ed.), *Segmental phonology in Optimality Theory: constraints and representations*, 13–45. Cambridge: CUP.

Lombardi, Linda. 2002. Coronal epenthesis and markedness. *Phonology* 19(2). 219–251.

McCarthy, John J. 1994. The phonetics and phonology of Semitic pharyngeals. In Patricia Keating (ed.), *Papers in Laboratory Phonology III: Phonological Structure and Phonetic Form*, 191–233. Cambridge: CUP.

McCarthy, John J. 2003. Sympathy, cumulativity, and the Duke-of-York gambit. In Caroline Féry & Ruben van de Vijver (eds.), *The Syllable in Optimality Theory*, 23–77. Cambridge: CUP.

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

McCarthy, John J. 2008. The gradual path to cluster simplification. *Phonology* 25(2). 271–319.

McCarthy, John J. & Alan Prince. 1993. Prosodic morphology: constraint interaction and satisfaction. Ms, UMass Amherst and Rutgers University.
McCarthy, John J. & Alan Prince. 1995. Faithfulness and Reduplicative Identity. Ms, UMass Amherst and Rutgers University.
McCarthy, John J. & Alan Prince. 1999. Faithfulness and identity in Prosodic Morphology. In René Kager, Harry van der Hulst & Wim Zonneveld (eds.), *Prosody-morphology interface*. Cambridge: CUP.
Mohanan, Karuvannur. 1986. *The Theory of Lexical Phonology*. Dordrecht: Reidel.
Nevins, Andrew & Ioana Chitoran. 2008. Phonological representations and the variable patterning of glides. *Lingua* 118. 1979–1997.
Nikolaeva, Irina. 2014. *A Grammar of Tundra Nenets*. Berlin, Boston: De Gruyter Mouton.
Padgett, Jaye. 1994. Stricture and nasal place assimilation. *Natural Language & Linguistic Theory* 12(3). 465–513.
Padgett, Jaye. 2008. Glides, vowels, and features. *Lingua* 118. 1937–1955.
Pater, Joe. 1996. *NC. In Jill Beckman (ed.), *Proceedings of NELS 26*, 227–239. Amherst, Mass: GLSA.
Pater, Joe. 1999. Austronesian Nasal Substitution and Other NC Effects. In René Kager, Harry van der Hulst & Wim Zonneveld (eds.), *The Prosody Morphology Interface*, 310–343. Cambridge: CUP.
Pater, Joe. 2009. Weighted Constraints in Generative Linguistics. *Cognitive Science* 33(6). 999–1035.
Prince, Alan & Paul Smolensky. 2004. *Optimality Theory. Constraint Interaction in Generative Grammar*. Malden, Mass: Blackwell.
Pullum, Geoffrey K. 1976. The Duke of York gambit. *Journal of Linguistics* 12(1). 83–102.
Ramsammy, Michael. 2012. *The realisation of coda nasals in Spanish*. PhD Dissertation, University of Manchester.
Rose, Sharon. 1996. Variable laryngeals and vowel lowering. *Phonology* 13(1). 73–117.
Rubach, Jerzy. 2000. Glide and Glottal Stop Insertion in Slavic Languages: A DOT Analysis. *Linguistic Inquiry* 31(2). 271–317.
Rubach, Jerzy. 2003. Duke-of-York Derivations in Polish. *Linguistic Inquiry* 34(4). 601–629.
Salminen, Tapani. 1993a. A phonemization of Tundra Nenets long vowels. In Marianne Bakró-Nagy & Eniko Szíj (eds.), *Hajdú Péter 70 Éves*, 347–352. (Linguistica, Series A, Studia et Dissertationes 15). Budapest: MTA Nyelvtudományi Intézet.
Salminen, Tapani. 1993b. On identifying basic vowel distinctions in Tundra Nenets. *Finnisch-Ugrische Forschungen* 51. 177–187.
Salminen, Tapani. 1997. *Tundra Nenets inflection*. Mémoires de La Société Finno-Ougrienne 227. Helsinki.
Salminen, Tapani. 1998a. Nenets. In Daniel Abondolo (ed.), *The Uralic languages*, 516–547. London: Routledge.
Salminen, Tapani. 1998b. *A Morphological Dictionary of Tundra Nenets*. Helsinki: Finno-Ugric Society.
Salminen, Tapani. 2012. Tundra Nenets grammatical sketch. Ms, University of Helsinki. http://www.helsinki.fi/~tasalmin/sketch.html

Shih, Stephanie & Sharon Inkelas. 2014. A subsegmental correspondence approach to contour tone (dis)harmony patterns. *Proceedings of Phonology 2013*. LSA.
Smolensky, Paul. 1993. Harmony, markedness, and phonological activity. Ms, Johns Hopkins University. ROA-87.
Staroverov, Peter. 2014. *Splitting theory and consonant epenthesis*. PhD dissertation, Rutgers University.
Steriade, Donca. 1993. Closure, release, and nasal contours. In Rena A. Krakow & Marie K. Huffman (eds.), *Nasals, Nasalization, and the Velum*. (Phonetics and Phonology). New York: Academic Press.
Struijke, Caro. 2000. Existential faithfulness. A study of reduplicative TETU, feature movement, and dissimilation. PhD dissertation, University of Maryland.
Tatevosov, Sergei. 2016. Struktura i interpretatsiya nenetskogo glagola. Aktantno-aktsionalniye klassi i tipy spr'azheniya. *Voprosy Iazykoznaniya*.
Tereshchenko, Natal'ya M. 1947. *Ocherk grammatiki nenetskogo (iurako-samoedskogo) iazyka*. Leningrad: Uchpedgiz.
Tereshchenko, Natal'ya M. 1956. *Materialy i issledovaniya po yazyku nentsev*. Moskva & Leningrad: Izdatel'stvo AN SSSR.
Tereshchenko, Natal'ya M. 1965. *Nenetsko-Russkii Slovar'*. Moskva: Sovetskaya Entsiklopediya.
Tesar, Bruce. 2008. Output-driven maps. Ms, Rutgers University.
Tesar, Bruce. 2013. *Output-driven phonology. Theory and learning*. Cambridge: CUP.
Wolf, Matthew. 2008. *Optimal interleaving: serial phonology-morphology interaction in a constraint-based model*. PhD dissertation, Umass Amherst.
Zoll, Cheryl. 1996. *Parsing below the segment in a constraint based framework*. PhD dissertation, UC Berkeley.