Non-Segmental Morphology

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Abstract

Any investigation of non-segmental morphology ultimately leads to important questions about the modularity of grammar and the architecture of the phonology-morphology-interface in particular. Is morphology able to directly manipulate phonological structure to express morpho-syntactic features? Is the phonological grammar sensitive to specific morphological information and can trigger certain phonological operations only in the context of specific morphemes? In this chapter, some properties of non-segmental morphology are discussed that are interesting litmus tests for various theoretical approaches.

Keywords: morphology-phonology-interface, non-concatenative morphology, subtraction, tone, polarity, allomorphy, nonlinear affixation, cophonology

1 Introduction

Segmental morphology is usually taken to conform to a concatenative ideal where morpho-syntactic information is encoded by the addition of a stable set of segmental material. It hence allows a straightforward form-meaning mapping in the lexicon where, for example, affixes are stored in the mental lexicon as segmental strings. Non-segmental morphology where morpho-syntactic information is encoded by phonological alterations of the base, on the other hand, is a challenge to this concatenative ideal since it makes a form-meaning mapping less straightforward. Any investigation of non-segmental morphology thus ultimately leads to important questions about the modularity of grammar and the architecture of the phonology-morphology-interface in particular. Is morphology able to directly manipulate phonological structure to express morpho-syntactic features? Is the phonological grammar sensitive to specific morphological information and can trigger certain phonological operations only in the context of specific morphemes? In this chapter, some properties of non-segmental morphology are discussed that are interesting litmus tests for various theoretical approaches. Since non-segmental morphology is such a varied phenomena, such an endeavour is impossible with just a single case study. This chapter is thus rather typological in nature and points out some interesting phenomena that can be found in multiple non-segmental morphology patterns in the languages of the world. The theoretical relevance of these properties is discussed while comparing the predictions of four representative theories. It is hence not the aim of this chapter to summarize all relevant theoretical accounts or their historical development but rather to focus on some areas where relevant theories make interestingly different predictions.

Section 2 starts with an empirical overview over the varied non-segmental strategies that exist to mark morpho-syntactic features in the languages of the world. It reminds the reader of some classical examples of non-segmental morphology and classifies these patterns according to some general parameters of exponence. In section 3, a brief overview over the main theoretical distinction into piece-based and process-based accounts is given and the four specific representative theories that are discussed in this chapter are introduced. It also motivates why four phonological accounts are chosen; namely Generalized Nonlinear Affixation, Cophonology Theory, Antifaithfulness Theory, and a RealizeMorpheme-based account. The core part of this chapter can be found in section 4 where several properties of non-segmental morphology are discussed that are potential challenges for one or the other of these theoretical accounts. After pointing out that all four accounts have – in their basic architecture – potential problems in predicting the full range of attested non-segmental exponence strategies in section 4.1, two different aspects of locality are discussed, namely the attested range of target positions of non-segmental morphology within the base form (section 4.2) and the phenomenon of across-the-board non-segmental morphology (section 4.3). Section 4.4 points out that inherently cyclic accounts are more restricted in only predicting non-segmental changes that affect the base of the morphological construction and discusses potential counterexamples to this prediction. Finally, sections 4.5 and 4.6 focus on phonologically predictable and lexically conditioned allomorphy respectively and explore whether the different accounts can predict these allomorphy types from the same mechanisms that also predict non-segmental morphology in general. The main conclusion from this discussion given in section 5 is that both detailed investigations of single case studies and thorough typological studies of different aspects of non-segmental morphology are necessary to ultimately argue for one or the other class(es) of theoretical accounts and that many open questions remain on both these fronts.

2 A classification of different non-segmental exponence types

What makes the topic of non-segmental morphology (=NSM) especially intriguing from a theoretical perspective is the fact that it summarizes an extremely diverse set of phenomena. This is already apparent in the fact that the term "non-segmental" or the related term "non-concatenative" morphology is a negative one. I will follow this tradition and define NSM as exponent types that do not conform to the segmental ideal of a morpheme that consists of a fixed set of contiguous, disjoint segments that are added to a base in a fixed linear position while preserving this base faithfully (Bye and Svenonius, 2012). These phenomena are also often described as "process morphology" (e.g. in Inkelas, 2014), a term that highlights the fact that phonological processes apply to a base to mark a morpheme. In the following, the term "non-concatenative" is avoided that is often used with more or less equivalent meaning since it also covers segmental exponence that is not linearized as simple suffixation or prefixation (see the chapters on *morphcom013* and *morphcom037*).

Since the phenomena summarized as NSM are so diverse, it is helpful to classify the different non-segmental exponence types (=NSET) according to whether they obey or violate some core properties usually attributed to exponence.[1] One such classification relies on the two criteria of "Base Extension" and "Fixed Target", given in (1). The former highlights the fact that exponence is ideally additive and extends a base form. The English plural marker /-z/, for example, is an ideal segmental exponence strategy in a form like [dɒgz] 'dogs' where it leaves the base [dɒg] 'dog' intact and only extends it via adding a segment. The latter property of a fixed target describes the fact that exponence can ideally be described as having a characteristic phonological property that remains stable across all forms. Though the English plural suffix changes its voicing quality predictably depending on its phonological context, its defining property of being a coronal fricative remains stable in all contexts.

(1) Canonical Properties of Exponence (after Trommer and Zimmermann (2015), p.57+58)

a. Base Extension
Exponence for category C is base-extending if all forms of category C are extensions of the phonological representation of the base forms for C.

b. Fixed Target
Exponence for category C has a fixed target if all forms of category C share a characteristic piece of phonological representation.

[1] Another interesting classification of NSM is the one into templatic and a-templatic exponence; discussed in the excellent overview in Davis and Tsujimura (2014).

A list of NSET that I take to be exhaustive for the phenomenon of NSM is given in (2), together with a classification of whether they violate (✗) or conform (✔) to these canonical properties of exponence. Such a classification is not always straightforward and implies some level of theoretical abstraction – a point that will be discussed in the following subsections in more detail. The list in (2) groups the phenomena into NSET that are still relatively similar to a concatenative ideal of exponence (NSET-1), those that are very different from classical segmental exponence (NSET-10-12), and two different groups of non-segmental strategies inbetween those extremes (NSET-2-7) and (NSET-8+9). As can be seen, NSET can target rather different levels of the phonological representation and the same phonological operation can correlate to different NSET. Deletion of a whole segment is, for example, involved in Truncation (2-5), Subtraction (2-10), and potentially also Templatic Morphology (2-7) and a change of segmental length in C/V-Shortening (2-4), C/V-Lengthening (2-8), and potentially also Polarity (2-12). A change of the segmental specification, on the other hand, can result in C/V-Mutation (2-2) and potentially also Polarity (2-12) and a change of the tonal specification in both Tone Addition (2-1) and Tonal Overwriting (2-3).

(2) Classification of NSET[2]

		Fixed Target	Base Extension
1.	Tone Addition	✔	✔
2.	C/V-Mutation	✔	✗
3.	Tonal Overwriting	✔	✗
4.	C/V-Shortening	✔	✗
5.	Truncation	✔	✗
6.	Stress Shift	✔	✗
7.	Templatic Morphology	✔	✗
8.	C/V-Lengthening	✗	✔
9.	Reduplication	✗	✔
10.	Subtraction	✗	✗
11.	Metathesis	✗	✗
12.	Polarity	✗	✗

In the following, a brief discussion of these different NSET is given together with mostly well-known examples illustrating the variety of NSM. It has to be noted that several of these strategies are discussed in more detail in other chapters of this companion (see *morphcom001*, *morphcom008*, *morphcom041*, *morphcom052*, *morphcom072*, and *morphcom075*); a discussion of those will hence remain even shorter.

Before we turn to this brief illustration of the phenomenon, however, a potential difficulty in identifying NSM should be acknowledged, namely the fact that it often relies on a choice for a specific morpheme segmentation. As an example, consider the list of person-specific future markers from Aymara in (3). As we can see, only the 1(>3) future context (3-c) is taken to employ NSM that consists solely of V-Lengthening which applies to a final base vowel. However, there are multiple other suffixes (3-b) that exceptionally trigger lengthening of a preceding base vowel that is absent in comparable phonological contexts; instantiating a case of "morpheme-specific phonology". It might be possible to assume a different reasonable morpheme segmentation for (3) that would, for example, assume a more general V-Lengthening pattern for the future and simple segmental affixes for the contexts in (3-b). And any case of morpheme-specific phonology can of course always be reanalysed as an instance of extended exponence (see chapter *morphcom051*) consisting of a NSM and a segmental affix both associated with the same morphological meaning.

[2] C=Consonant, V=Vowel.

(3) Aymara: Future suffixes (Hardman, 2001, 112),(Coler, 2015, 529)

a.	2>1	-itaːta	b.	1>2	-ːma
	3(>3)	-ni		2(>3)	-ːta
	1.INCL(>3)	-ŋani		3>2	-ːtama
	3>1	-itani	c.	1(>3)	-ː
	3>1.INCL	-istani			

It is hence not surprising that the patterns of morpheme-specific phonology and of NSM are extremely similar and there are morpheme-specific phonology counterparts to all NSET discussed in this chapter (termed "Inkelas's generalization" in Sande et al. (2020); cf. especially (Inkelas, 2014, §3.4)). This close connection of NSM and morpheme-specific phonology is by no means an inherent problem: It simply points to the fact that any theoretical account of one phenomenon ideally can also capture the other one. There is no deep theoretical reasoning or unified list of criteria that underlies the classification of the data discussed in this chapter as NSM and not morpheme-specific phonology – I simply followed the descriptive sources for each language.

2.1 Base-extending with a fixed phonological target

The NSET that is still relatively similar to the additive ideal of a segmental morpheme is Tone Addition. Before we turn to a concrete example, it should be emphasized that the list of NSET in (2) distinguishes two types of tonal morphology, namely the addition of a tone to the base tone melody and the overwriting of base tones by a morphological tonal melody. Usually, both strategies are conflated under the single heading of "tonal morphology" or "grammatical tone" (but cf., for example, the typology in Rolle, 2018, that explicitly distinguishes these types as well). And indeed in many languages, it is phonologically completely predictable whether a tone is additive or replacive. In the Yucunany dialect of Mixtepec Mixtec, for example, the first person singular is marked by Tonal Addition of a morphological L-tone which creates a falling contour for bases ending in an H-tone or having a L.M- or LH.M-melody (4-a) but by Tonal Overwriting for bases with a H.M- or M.M-melody (4-b) (Paster and Beam de Azcona, 2004).[3]

(4) Predictable allomorphy between Tonal Addition and Tonal Overwriting in Yucunany Mixtec (Paster and Beam de Azcona, 2004, 71+72)[4]

	BASE	1.SG		
a.	nàmá	nàmáà	‘my soap’	L.H → L.HL
	vílú	vílúù	‘my cat’	H.H → H.HL
	tìtzī	tìtzīì	‘my stomach’	L.M → L.ML
	kàásā	kàásāà	‘my sister’s husband’	LH.M → LH.ML
b.	lā’lā	lā’là	‘my mucus’	M.M → M.L
	xá’nū̲	xá’nù̲	‘my cigarette’	H.M → H.L

However, there are also patterns of grammatical tone that are apparently either purely additive or replacive. An example for the former type can be found in Iau, a non-Austronesian language of Papua New Guinea (Bateman, 1990; Edmondson et al., 1992). Iau has eight contrastive tones that can be found on the predominantly monosyllabic words: Two level tones (2 and 3, where the former is higher) and six contour tones (falling 24, 23, 34, rising 21, 43, and a fall rise 243). The meaning of a verb stem in Iau is taken to be carried by segmental structure alone while the aspectual meaning is contributed solely by grammatical tonal melodies. In fact, all the contrasting eight level and contour tones of the language mark one verbal aspect category, illustrated in (5). That this is a purely additive tonal morphology system is apparent since multiple aspectual (complex) tonal melodies can cooccur on a single tone-bearing unit (=TBU).

[3]Throughout the paper, I use the standard abbreviations from the Leipzig Glossing Rules (Haspelmath et al., 2008) for morpho-syntactic categories.

[4]I follow the notation in Paster and Beam de Azcona (2004) where two vowel symbols are used for the diacritics of a contour tone. The language does not have phonemic vowel length and vowels with a contour tone are only "somewhat longer" (Paster and Beam de Azcona, 2004, 63). Underlining indicates nasalized vowels.

(5) 1. Tone Addition in Iau (Bateman, 1990, 36+37)

a.	tai	2	'pull'
	tai	3	'has been pulled off'
	tai	34	'pull off (process)'
	tai	21.34	'pull on, shake (hands)'
	tai	21.3	'have pulled on, have shaken (hands)'
b.	baui	3	'have arrived at'
	baui	34	'arrive at (process)'
	baui	3.24	'has finally arrived at endpoint location'

Another example for a purely additive tone morphology that is cited as such in, for example, Bye and Svenonius (2012) is the locative formation in the Dogon language Jamsay which simply adds an L-tone to the final vowel. Interestingly, this results in V-Lengthening for short final vowels since the mora as the TBU can only bear a single tone (e.g. [káː] 'mouth' – [kâː] 'in the mouth' and [nùmó] 'hand' – [nùmôː] 'in the hand' (Heath, 2008, 107)).

2.2 Non-base-extending with a fixed phonological target

If segments are taken to be bundles of features, C/V-Mutation is replacive and not base-extending since it overwrites at least one feature value with another. From a featural perspective, C/V-Mutation also has a fixed target, namely the new constant feature value that is shared by all mutated segments. This classification is not completely unproblematic given that there are certain segments that remain unchanged in many mutation patterns because they either already bear the feature or cannot bear it without changing 'too much'. An example for this can be seen in the C-Mutation example in (6) from Zoque, a Mixe-Zoque language from Southern Mexico (Wonderly, 1951). In Zoque, both first and third person are marked by C-Mutation of the initial consonant; the former by palatalization (6-a) and the latter by nasalization (6-b). As the examples show, there are several consonants that are not affected by these changes: Alveopalatal /ç/, for example, is never affected and nasalization only affects stops.

(6) 2. C-Mutation in Zoque (Wonderly, 1951, 117-121)

a.	pata	'mat'	p^jata	'his mat'
	burru	'burro'	b^jurru	'my burro'
	mula	'mule'	m^jula	'his mule'
	çapun	'soap'	çapun	'his soap'
b.	pama	'plate'	^{m}bama	'my plate'
	burru	'burro'	^{m}burru	'my burro'
	mok	'corn'	mok	'my corn'
	çapun	'soap'	çapun	'my soap'

C-Mutation is a well-attested NSET and abundant in, for example, Celtic (see chapter *morphcom052*) or Atlantic languages. For a detailed discussion of the counterpart of V-Mutation see the chapter *morphcom001*.

A corresponding example for Tonal Overwriting that is not base-extending since it results in non-realization of base-material is given in (7). It comes from Yoloxóchitl Mixtec (Palancar et al., 2015) and illustrates just one of many complex overwriting tonal morphology in Otomanguean languages. The language has four level tones (1 being the lowest and 4 the highest) and 5 contour tones (13, 14, 24, 32 and 42). An example for Tonal Overwriting in Yoloxóchitl Mixtec is the irrealis negative formation, shown in (7). The irrealis forms show the underlying lexical tone of verbs and in the negative form, the first TBU of the verb form is systematically realized with a rising ^{14} tone, overwriting the first underlying tone of either the root (7-a) or even a causative prefix (7-b).

(7) 3. Tonal Overwriting in Yoloxóchitl Mixtec (Palancar et al., 2015, 319)

	IRREALIS	IRREALIS.NEGATIVE	
a.	choʔ^{3}ma^{4}	choʔ^{14}ma^{4}	'squash'
	kaʔ^{1}an^{1}	kaʔ^{14}an^{1}	'talk'
	ka^{3}xi^{4}ta^{3}	ka^{14}xi^{4}ta^{3}	'grind'
b.	sa^{4}-naʔ^{1}a^{1}	sa^{14}-naʔ^{1}a^{1}	'teach'
	sa^{4}-ka^{3}sun^{2}	sa^{14}-ka^{3}sun^{2}	'fry'

Another NSET that is clearly not base-extending is C/V-Shortening, illustrated in (8) with the plural formation of Taubergrund German (Heilig, 1898; Seiler, 2008; Köhnlein, 2018)[5].

(8) 4. V-Shortening in Taubergrund German (Heilig, 1898, 78)

SINGULAR	PLURAL	
riːs	ris	'crack'
fiːʃ	fiʃ	'fish'
ʃniːts	ʃnits	'cut'
fleːk	flek	'stain'
diːʃ	diʃ	'table'

V-Shortening is also abundant in many West-Nilotic languages, often as one allomorph amongst other NSET (cf. the examples in (27)). I am not aware of an example of C-Shortening as NSET but C-Shortening is well-attested as morphologically conditioned phonology (e.g. in Wolof (Ka, 1994; Bell, 2003) or Korean (Tak and Davis, 1994; Ko, 1998)) and as has been discussed in section 2, these cases might reasonably be re-analysable as NSET.

C/V-Shortening is classified here as having a fixed target (namely a "short" segment of a certain type in a certain position) since I am not aware of any morphological V-Shortening in a language with a three-way length contrast for segments that results in a chain shift where superlong segments are shortened to long ones and long ones to short ones. As is discussed in 2.3, such patterns are indeed attested for the counterpart of V-Lengthening – the reason why this NSET is classified as not having a fixed target.

The NSM that is traditionally discussed as the most severe problem for concatenative or piece-based approaches to morphology (cf. section 4.1) is the deletion of whole segments to mark a morpho-syntactic category. Two types of segment-deleting morphology are usually distinguished: Truncation involves segment deletion that results in a derived form with a predictable size whereas Subtraction involves deletion of a segment (sequence) that has a fixed size (see Arndt-Lappe and Alber, 2012, for an excellent overview and literature). Consequently, Truncation is classified here as having a fixed target whereas Subtraction is not and exemplified in section 2.4. Since both patterns involve deletion of segments, they are trivially non-base-extending. The examples of Truncation in Italian (9) illustrate one of the two most common Truncation strategies, namely Truncation to a bisyllabic form.

(9) 5. Truncation in Italian (Krämer, 2009, 165)

amplificatore	ampli	'amplifier'
bicicletta	bici	'bicycle'
cinematografo	cine	'movie, cinema'
automobile	auto	'car'

As is very common for Truncation, it is rather difficult to identify a consistent meaning difference between the two forms in (9). Often, truncated forms are argued to be rather associated with different pragmatic factors which is one of the reasons for the ongoing debate whether Truncation should be considered a regular NSET (as is done here) or whether it should be taken to be extragrammatical (see, for example, Dressler (2000) and Bat-El (2000) on opposing positions). A discussion of this issue is beyond the scope of this overview (see also chapter

[5]Note that Köhnlein (2018) points to the interesting fact that there are also plural forms that show both V-Shortening and C-Subtraction (e.g. [kiːnt] 'child' – [kin] 'children' (Köhnlein, 2018, 625).

morphcom0008).

Stress shift as the exponent of a morpheme is seemingly not as common as some of the other NSET. An example is the continuative formation in the Salishan language Upriver Halkomelem that involves a neutralization of underlyingly contrastive stress with an initial stress for the forms in (10). Since there are phonologically predictable implications between length, stress and vowel quality in the language, stress shift is accompanied by additional changes (10-b) when, for example, unstressed vowels are reduced to schwa (cf. Zimmermann, 2013, for more discussion and literature). It has to noted, though, that stress shift is only one of several (non-)segmental allomorphs to form the continuative and non-continuative bases with initial stress show either V-Lengthening, Reduplication, or realization of /hɛ-/ in their continuative form (cf. (26) in section 4.5).

(10) 6. Stress Shift in Upriver Halkomelem (Galloway, 1993, 56+265)

	Non-continuative	Continuative	
a.	ɬəxʷə́ɬtsɛ	ɬə́xʷəɬtsɛ	'spit'
	ɬɛlqí	ɬɛ́lqi	'soak'
b.	tɬəwə́ls	tɬɛ́wəls	'bark (of dog)'
	ts'ɛtɛ́ːm	ts'ɛ́təm	'crawl'

Another example for morphological Stress Shift discussed in the theoretical literature is the past tense formation in Modern Greek that involves an overwriting of lexical stress with a consistent antepenultimate stress pattern (e.g. van Oostendorp, 2012). However, this pattern is an instance of morpheme-specific phonology rather than NSM since stress shift is only one exponent for the past which is also marked with a tense-specific set of segmental person-suffixes.

The NSET with the most obvious fixed target is Templatic Morphology. It has a special status in the list of NSET since it is not one strategy but the application of various NSET (in various combinations) to ensure that the derived form conforms to a certain prosodically defined target. Examples that have received a lot of theoretical attention include the broken plural formation in Arabic (e.g. McCarthy and Prince, 1990) or the incompletive formation in Rotuman (see McCarthy, 2000, for more literature). The latter is illustrated in (11) where it can be seen that V-Subtraction (11-a), Metathesis (11-b), V-Subtraction+V-Mutation (11-c), and diphtongization (11-d) apply to ensure that the incompletive form ends in a bimoraic foot.[6]

(11) 7. Templatic Morphology in Rotuman (McCarthy, 2000)

	Complete	Incomplete	
a.	tokiri	tokir	'to roll'
	tiʔu	tiʔ	'big'
b.	iʔa	iaʔ	'fish'
	seseva	seseav	'erroneous'
c.	hoti	höt	'to embark'
	mose	mös	'to sleep'
d.	pupui	pupu͡i	'floor'
	keu	ke͡u	'to push'

2.3 Base-extending without a fixed phonological target

C/V-Lengthening was classified in (2) as a NSET that is base-extending but has no phonological target. The former implies an abstract representation of length (a mora or a timing slot) where length is indeed 'added' to a segment, in contrast to a featural representation of length as a property of a segment (e.g. Chomsky and Halle, 1968). An example for V-Lengthening as the sole exponent for a morpheme is the first person formation in several Quechuan varieties with a phonemic vowel length contrast (cf. Adelaar and Muysken, 2004, §3.2.3). The illustrating

[6]The data is given in the transcription of McCarthy (2000); cf. McCarthy (1996) were all correspondences to the notation in the original source Churchward (1940) are explained in detail.

examples in (12) from Huallaga Quechua show that the first person subject agreement on the verb or the first person possessor for nouns is marked by V-Lengthening that applies to the final base vowel.

(12) 8. V-Lengthening in Huallaga Quechua (Weber, 1947, 54+176)

	Base		1.Sg	
a.	uma	'head'	umaː	'my head'
			cf. umajki	'your head'
	wasi	'house'	wasiː	'my house'
			cf. wasiki	'your house'
	ajwa	'go'	noqa ajwaː	'I go'
			cf. qam ajwanki	'you go'

An example for another language family with abundant morphological V-Lengthening is Western Nilotic (see Trommer, 2011, for examples and references). The counterpart of lengthening of a consonant as the sole morphological exponent is also well-attested in the languages of the world; an example are the so-called consonant gradation patterns in various Numic languages (cf. Haugen, 2008, for discussion and more literature). That C/V-Lengthening is characterized as not having a fixed target is due to the fact that there are languages with a three-way vowel length contrasts that employ segmental lengthening and lengthen short vowels to long ones and long ones to superlong ones (examples include North Saami (Bals Baal et al., 2012) and Shilluk (Remijsen and Ayoker, to appear)).

The by far most common NSET is presumably Reduplication, namely the copying of either a prosodically defined portion of the base or a whole base to express a morphological meaning (see chapter *morphcom072*). The only difference to segmental exponence is the fact that the segmental content that is added to a base is not stable across different contexts but depends on its base. Since Reduplication is discussed in a chapter on its own, only a brief example is given in (13). It illustrates partial prefixing Reduplication in the Salishan language Lushootseed (Urbanczyk, 2001), a language family well-known for their extensive use of Reduplication (e.g. van Eijk, 1998). Two different Reduplication patterns are shown in (13): Prefixing /CVC/-Reduplication marks the distributive (13-a) and prefixing /CV/-Reduplication the diminutive (13-b) in Lushootseed.[7]

(13) 9. Two partial Reduplication patterns in Lushootseed (Urbanczyk, 2001)

a.	bədáʔ	'child'	bəd∼bədáʔ	'children'	p.209
	júbil	'die, starve'	júb∼jubil	'they are starving'	p.221
	g^wád	'talk'	g^wád∼g^wad	'talk (a lot), speak up'	p.212
b.	χáləs	'hand'	χá∼χaləs	'little hand'	p.193
	χ'ít	'near'	χ'í∼χ'it	'a bit nearer'	p.194
	s-túbʃ	'man'	s-tú∼tubʃ	'boy'	p.204

2.4 Non-base-extending without a fixed phonological target

The first example for a NSET that drastically violates the ideal of a base-extending exponence with a fixed target is Subtraction as the non-realization of a prosodically defined set of segments. It usually targets a single segment but there are also cases where larger prosodically defined portions remain unrealized (cf. the Muskogean examples in 4.5 and 4.6). An example for Subtraction can be found in many German dialects where deletion of a final consonant marks the plural (Golston and Wiese, 1996; Köhnlein, 2018).[8] The examples in (14) are from the

[7]Note that the diacritic v́ marks stress here, not tone. In contrast to other Salishan languages, stress is fairly regular in Lushootseed and mainly falls on the first full vowel and on the first schwa in case no full vowel is present (but see Urbanczyk, 2001, §3.3.1 for more details).

[8]Subtraction underlies slightly different context restrictions in German dialects. The most likely target for Subtraction across dialects is a final stop that is homorganic to a preceding nasal. In Golston and Wiese (1996), this generalization follows if deletion is only possible if the place feature of the deleted consonant can be preserved on a preceding segment. The account in Köhnlein (2018), on the other hand, explains this restriction

Horath Franconian variety where Subtraction also marks the difference between the dative and nominative singular (^{1} and ^{2} notate the different (tonal) accents that also alternative between the two forms).

(14) 10. C-Subtraction in Horath Franconian (Köhnlein (2018):622, citing Reuter (1989):132-133,139-140)

NOM.SG	DAT.SG	
kamp^2	kam^1	'comb'
bant^2	ban^1	'ribbon'
gaŋk^2	gaŋ^1	'walk'
bilt^2	bil^1	'picture'

Another famous example for Subtraction affecting a final consonant as a NSET is the perfective formation in Tohono O'odham (Fitzgerald and Fountain, 1995; Fitzgerald, 2012) and an example for Subtraction affecting a vowel is the deletion of a final vowel to mark the direct object in many Aymaran varieties (e.g. Adelaar and Muysken, 2004, 272-274).

Another NSET that neither extends the base nor results in an obvious fixed target is Metathesis as the reordering of two segments. It is cited to mark the continuative or actual aspect form in many Salishan languages; an example from Saanich is given in (15) (Montler, 1986; Stonham, 2007).

(15) 11. Metathesis in Saanich (Montler, 1986, 121+129)

NON-CONTINUATIVE		CONTINUATIVE	
ƛ'pə́x̣-t	'scatter it'	ƛ'ə́px̣-t	'I'm scattering it'
t'^{θ}ɬə́k'^{w}-t sən	'I pinched it'	t'^{θ}ə́ɬk'^{w}-t sən	'I'm pinching it'
θɬə́q^w-t	'pierce it'	θə́ɬq^w-t sən	'I'm piercing it'
k'^{w}sə́ŋ	'he counted'	k'^{w}ə́səŋ	'he's counting'

It has to be noted, however, that there are doubts whether the actual formation in Saanich indeed involves Metathesis or rather (contrastive) /ə/-insertion (Leonard and Turner, 2010). In addition to being extremely rare, Metathesis as a NSET also shows two interesting restrictions. For one, it apparently never is the sole NSET on its own but is either part of an allomorphy pattern (cf. the examples in (26)) or is one NSET among many to ensure a template (as in Rotuman (11)). Secondly, there are apparently no examples of Metathesis between two consonants as a NSET; it always involves the reordering of a vowel and a consonant. These observations can be seen as crucially related since Metathesis is then understood as only one of several strategies to ensure a heavy syllable (that might be part of a larger template); something that can only be achieved by ordering a consonant into a new weight-contributing position. As is discussed in section 4.1, this generalization is important for piece-based accounts of NSM where Metathesis does not exist as "process" but is an epiphenomenon of prosodic node affixation. Under this perspective, Metathesis would in fact always result in a fixed target – a heavy syllable – and would have been misclassified in (2). I leave this discussion open here and refer the reader to the chapter *morphcom072* and, for example, Buckley (2011) for more discussion of Metathesis as a morphological process.

The final NSET that is neither base-extending nor results in a fixed target is morphophonological Polarity, defined here as a process that changes a certain phonological element that has a binary counterpart into its opposite to mark a morpho-syntactic category; it is hence different from what one might term "morphological polarity" (Baerman, 2007). The existence of true productive morphophonological Polarity is highly debated and it has been argued that some putative cases do not involve the productive and regular reversal of one phonological dimension into another (cf. de Lacy, 2012, 2020, for discussion and literature). A case at hand is the plural formation in the Yuman language Jamul Tiipay (∼Diegueño) that is widely cited as length Polarity (examples include Stonham (1994) or Wolf (2007)). As de Lacy (2012) argues, a closer

by formalizing Subtraction as coalescence rather than true deletion.

inspection of the data reveals that the plural is not expressed by predictable Shortening for all long base vowels and predictable lengthening for all short base vowels. This argumentation is based on the fact that 1) Shortening is only attested for very few stems[9], 2) there are long vowels that do not shorten in the plural, and 3) there are various other plural formations (segmental and non-segmental); the choice between them being mostly lexical.[10] I'm in fact only aware of two examples of morphophonological Polarity as the single exponent of a morpheme that have not been questioned or re-analysed, namely length Polarity in Anywa[11] and tonal Polarity in Kipsigis (cf. 4.3). The former is exemplified in (16) where it can be seen that the frequentative form has a long vowel if the base has a short vowel and a short vowel if the base has a long vowel (in addition, the frequentative is marked by C-Lengthening of the final consonant and also by Mutation of both certain final consonants and stem-vowels).

(16) 12. Length Polarity in Anywa (Reh, 1993, 44,244,245)

	Verb root		Frequentative stem
a.	bìl-	'soak sth.'	bíːlː-
	jʌ́ŋ-	'shake sth.'	jʌ̀ːŋː-
	búŋ-	'cover tightly'	búːŋː-
b.	càːn-	'tell'	cànː-
	kàːl-	'jump over'	kàlː-
	kaːt-	'weave basket'	katː-

3 The theoretical landscape

The classical dichotomy of theoretical accounts predicting NSM is the one into "process-based" and "piece-based" accounts[12]. One influential example for the former type is the theory of a-morphous morphology (Anderson, 1992) where word-formation rules apply in specific morphological contexts. This is thus a theory where the morphology can manipulate phonological structure and strict modularity does not hold. The latter models, on the other hand, implement some version of autosegmental affixation, pioneered by Lieber (1992). Although NSM is a morphological exponence strategy, the majority of specific analyses of NSM have been carried out in theoretical phonology. In this chapter, I will hence focus on theories of NSM within theoretical phonology and will restrict myself to optimality-theoretic (=OT) accounts (Prince and Smolensky, 1993/2004) to allow a better comparison.

Within OT-phonology, the closest correlate of a "process-based" account are theories where the phonological grammar has direct access to morphological information, either via morpheme-specific constraint rankings or via morpheme-specific constraints that can only be violated while evaluating the phonological output of a certain morphological construction. While a-morphous morphology is hence non-modular in allowing the morphology to access and even manipulate phonology, those accounts are non-modular in allowing the phonology to be sensitive to morphological information. All these accounts have in common that they cyclically manipulate base forms to build morphological constructions. I summarize those accounts under the heading "constructionist" in the following. Formalizations of piece-based accounts, on the other hand, are inherently phonological since those accounts are based on the assumption that NSM results from underlying representation of morphemes that are phonologically defective or incomplete. In

[9] In the corpus given in Miller (2001), 7 stems undergo Shortening and 136 undergo lengthening.

[10] Another famously discussed case of morphophonological Polarity is voicing Polarity in Dholou, a Nilotic language. However, it is accompanied by a segmental suffix and hence falls under what is taken to be morpheme-specific phonology in the terminology adopted here (for a critical discussion of classifying this as true Polarity and further literature, cf. de Lacy, 2012).

[11] Though it has to be noted that de Lacy (2012) questions the productivity of length Polarity in Shilluk and Dinka, two other West-Nilotic languages. Frequentative in Päri is another potential example (Trommer and Zimmermann, 2014) but it again involves the addition of a segmental suffix and is hence not NSM in a strict sense.

[12] A terminology used in, for example, Bermúdez-Otero (2012) and following up on the classical terminology of "item-and-arrangement" and "item-and-process" (Hockett, 1954).

those accounts, the morphology hence remains strictly concatenative and the phonology repairs marked and incomplete structure.

To highlight the different aspects of NSM that are of most relevance to any theoretical discussion, four representative theories are discussed in the following: One classical piece-based autosegmental account 3.1 and three representatives for constructionist theories 3.2 that make interestingly different predictions about certain aspects of NSM. In subsections 3.1 and 3.2, a brief overview over the main assumptions of these four representative accounts is given before their different predictions are put to the test with a discussion of some empirical properties of NSM in section 4.

3.1 Piece-based accounts

The negative definition of NSM as phenomena that do not conform to a concatenative ideal (see section 2) already implies that its full range is taken to be a notorious challenge for a purely concatenative view of morphology that puts together linearly ordered pieces of phonological information that are associated to lexical or morpho-syntactic meaning in the lexicon.

The first arguments for Autosegmental Phonology already showed that this pessimism is not warranted for tone (Goldsmith, 1976): Assuming tones as independent phonological elements that can exist without any association to a timing unit as morpheme representations on their own straightforwardly predicts Tonal Overwriting and Tone Addition. This autosegmental approach was then extended to segmental features (e.g. Lieber, 1992; Wiese, 1996) and to timing units/moras (e.g. Montler and Hardy, 1988; Samek-Lodovici, 1992). The culmination of these analyses is hence the general claim that all NSM is an epiphenomenon and the consequence of affixing phonological sub- or suprasegmental elements that are then subject to general phonological processes of the language. This research program will be termed "Generalized Nonlinear Affixation" in the following (=GNA; Bermúdez-Otero, 2012, 53). In contrast to the constructionist approaches discussed in 3.2, it relies on a modular view of grammar where the phonology has no direct access to specific morpho-syntactic information and the morphology is not allowed to manipulate phonological structure. Comprehensive overviews over this model and its assumptions about the architecture of the morphology-phonology interface are given in Bye and Svenonius (2012) and Bermúdez-Otero (2012). The GNA assumption can in principle be implemented in any phonological model (e.g. Lieber, 1992; Stonham, 1994, for pre-OT implementations) but an OT-approach is taken as the background for the following discussion. The central formalization in such a model concerns some overwriting-mechanism that ensures that realization of the affixed floating material is more important than realization of the underlying specification. This can be predicted by a variety of different constraints; examples include the family of *Float constraints (e.g. Wolf, 2005*b*) or the family of constraints demanding some (even phonetically unrealized) integration of all material in a containment-based OT version (e.g. Trommer and Zimmermann, 2014).

It is clear that the GNA account naturally accounts for what was termed "morpheme-specific phonology" as well which simply involves a morpheme representation that contains both segmental and floating sub- or suprasegmental material. For the Aymara example given above, this means that the general explanation for V-Lengthening remains the same, irrespective of whether the morphemes are taken to be as in (3) or subsegmented further. In the former morphological analysis, the suffixes would contain segmental material in addition to an unassociated mora and under the latter, the future morpheme would only contain a floating mora.

3.2 Constructionist accounts

As was summarized above, the constructionist accounts discussed here all share the assumption that different morphological constructions are subject to different constraint rankings but differ in how these different grammars emerge. In Cophonology Theory (=CT; see Inkelas and Zoll, 2007, for a summary and relevant literature), multiple constraint rankings co-exist within a language and are selected by certain morphological constructions or lexical classes. It is an inherently cyclic theory where words are built up by optimizing one construction at a time and hence by potentially multiple phonological evaluations with different cophonologies. If a construction now does not add any segmental material but the cophonology associated with this construction demands a certain phonological change, NSM arises. V-Shortening in Taubergrund German, for example, follows if the cophonology associated with the plural bans a long vowel (*V: ≫ Maxμ) though all other cophonologies of the language happily allow this marked structure (Maxμ ≫ *V:). For such a construction-specific phonology, it is hence irrelevant whether additional segmental material is present or not and CP offers a unified explanation of NSM and morpheme-specific phonology.

Another constructionist OT-account which makes interestingly different predictions is Transderivational Antifaithfulness Theory (=TAF; Alderete, 2001). The theory relies on the concept of antifaithfulness which assumes that every faithfulness constraint exists in a negative version demanding unfaithfulness between two corresponding forms. Antifaithfulness constraints crucially only exist for transderivational correspondence relations (Benua, 1997) and hence demand paradigmatic distinctiveness between two surface forms. Affixes in this theory can subcategorize for a certain transderivational correspondence relation which basically means that the relevant antifaithfulness constraints is activated. In the following, antifaithfulness constraints are notated with a morphological index to make clear that they are active only in certain contexts. As CP, it is a cyclic theory where every morphological concatenation involves a phonological optimization.[13] V-Shortening in Taubergrund German, for example, follows if the (segmentally empty) plural affix subcategorizes for a high-ranked antifaithfulness constraint that demands that not all moras of the surface form of the morphological base, namely the singular, surface in the plural ($\text{Max}\mu_{pl}$ ≫ Maxμ). In all other morphological contexts, this antifaithfulness constraint is irrelevant and general faithfulness constraints exclude any loss of vocalic length. As CP, TAF predicts morpheme-specific phonology from the same mechanism that also predicts NSM: An antifaithfulness constraint demands an unfaithful mapping for a specific phonological dimension between a base and its derived form and it is irrelevant whether additional segmental material is realized or not.

A third constructionist account that is similar to TAF in spirit since it relies on some concept of paradigmatic distinctness is the Realize Morpheme-based theory proposed in Kurisu (2001) (=RMT). As all other constructionist approaches discussed here, it is a cyclic theory that optimizes morphologically complex forms while having access to a base form. The central constraint is Realize Morpheme (=RM)[14] demanding that the output form must be phonologically different from its morphological base form. In the absence of any segmental input material that realizes a morpheme or in case realization of such material is blocked by markedness constraints, any conceivable phonological change is hence in principle a licit candidate to realize a morpheme. The specific change that applies to realize a certain morpheme is predicted from the ranking of faithfulness constraints indexed to the morphological construction under consideration. Our example of V-Shortening in Taubergrund German follows if $\text{Max}\mu_{pl}$ penalizing the loss of vocalic length in the plural is ranked below RM but all other faithfulness constraint indexed to the plural are ranked higher and thus block any other NSET (MaxS_{pl}, $\text{Dep}\mu\ _{pl}$,... ≫ RM ≫ $\text{Max}\mu_{pl}$).

In contrast to all the other accounts, it is inherently difficult for RMT to predict morpheme-specific phonology. As soon as an affix is present in the input in the form of segmental material, realization of this segmental material is already sufficient to satisfy RM and any additional phonological changes will be harmonically bounded. In Kurisu (2001), it is shown how enriching RMT with Sympathy Theory, an extension of OT that can solve opacity problems (McCarthy, 1999), can predict morpheme-specific phonology as well. An alternative solution is the re-analysis of a morpheme-specific phonology pattern into an instance of extended exponence containing a NSM pattern and a segmental affix (cf. the discussion in section 2).

[13] Interestingly, the input to every optimization is still the underlying representation for a morpheme in question, not an existing or possible output form.

[14] Slightly different concepts and definitions of such a constraint are discussed in the literature (cf. Wolf, 2005*a*, for a good overview and literature).

Though these three representatives of constructional accounts are rather different in their architecture and core assumptions, they all share the assumption that the phonological grammar can access specific morphological informations, either in the form of morpheme-specific constraints in TAF and RMT or in the form of morpheme-specific rankings in CT. In addition, they are all inherently cyclic and optimize the output of one morphological construction at a time. In contrast, the GNA account was assumed to be non-cyclic and to optimize the surface form of a complex morphological word in one step. The discussion in section 4 shows that especially this distinction into inherently cyclic and potentially non-cyclic accounts results in rather different predictions about possible NSM properties.

4 Some properties of non-segmental morphology

4.1 The phonological substance of non-segmental morphology

When it comes to the specific phonological substance of NSET, the falsifieability of the theoretical models compared here can be summarized as follows: Any NSET must be 1) the optimal result of a constraint ranking for CT, 2) the optimal strategy that violates a certain faithfulness constraint for TAF and RMT, or 3) the effect of realizing a (sequence of) phonological element(s) for GNA. As is discussed below, all these different predictions are apparently problematic for at least some NSET.

For CP, the question whether every NSET corresponds to one ranking of general constraints of course crucially relies on the inventory of markedness constraints. V- or C-Shortening are, for example, great candidates for operations that can be triggered by uncontroversial markedness constraints against long segments. And the research on Prosodic Morphology has shown that Truncation and Reduplication often show Emergence of the Unmarked Effects (e.g. McCarthy and Prince, 1994, 1995; Downing, 2006).

However, it is less straightforward to imagine an independently motivated inventory of markedness constraints that predicts the attested range of tonal morphology. The Iau example in (5) is already a good example to prove this point: Would one indeed need to assume constraints like HaveTone2, HaveTone21, HaveTone34, and so forth to predict the different Tone Addition patterns in different morphological contexts?

In Inkelas and Zoll (2007), such constraints ("Tone=H" and "Tone=LH") are indeed given for a CP account of Hausa but it is stated in a footnote that those are taken to be abbreviations for more general constraints (p.167). Though an all H-toned form can indeed arise if a high-ranked constraint *L penalizes any low tones and/or Specify demands a tonal specification for each TBU (in a language with only two tones), it is less clear what the independently motivated constraints resulting in LH or the many tonal melodies in Iau could be. The problem that the result of a NSET can be markedness-increasing and that this is a potential problem for CP accounts of NSM is also discussed in Trommer and Zimmermann (2015) with an example of C-Mutation in Nuer (p.63+64) and in Zimmermann (2017*b*) for length-manipulating morphology in general. Enriching the phonological constraint inventory with enough constraints to correctly predict the optimal surface forms for all morphological constructions hence makes the model similar to one where morpheme representations are replaced by constraints (e.g. Golston, 1996; Hammond, 1997). On the other hand, a CP account is of course not incompatible with a piece-based analysis in general or at least in the domain of tone. In the CP analysis proposed in Sande et al. (2020), for example, the tonal morphology of Kuria is in fact analysed with floating tones whose association can be determined by different cophonologies. However, such a superset theory potentially looses the restrictions of a CP account without sub- or suprasegmental morpheme representations. A floating morphological tone could, for example, easily be predicted to only associate until the next morpheme is added; a configuration that is in violation of the Strict Base Mutation that is cited as an important restriction for CP (cf. subsection 4.4).

Another challenge for CP is Polarity. Since the model does not have a constraint type that explicitly forces a change along a certain faithfulness dimension (in a certain morphological context), it faces the independent problem that standard OT cannot predict markedness reversals on the surface (Moreton, 2004). If, for example, a construction-specific ranking in CP predicts that a long vowel in a certain position is optimal, it is hard to explain why an underlying long vowel in exactly this position should shorten. As is discussed below for the GNA model, this might not be a severe undergeneration problem if the rare cases of Polarity can be reanalysed as the surface effect of some other process (see also de Lacy, 2020).

The discussion of enriching a CP account with floating tones already implies that a GNA account has no problem in predicting the free substance of tonal morphology: All simple or complex tonal specifications can also exist as underlyingly unassociated elements. The same holds for the free substance of C/V-Mutation that follows from assuming that potentially all segmental features can exist as unassociated elements that potentially overwrite base information.

Two (overlapping) classes of NSET, on the other hand, are apparent and often-discussed challenges for a GNA account, namely NSET that are subtractive in some respect (Truncation, C/V-Shortening, and Subtraction) and those that are neither base-extending nor result in a fixed target (Subtraction, Metathesis, and Polarity). There are at least two possibilities to predict the surface effect of Subtraction from the affixation of suprasegmental elements. In Köhnlein (2018), it is shown how subtractive processes (both V-Shortening and Subtraction) can fall out as an epiphenomenon from affixation of a foot and hence as an instance of Templatic Morphology. And in Trommer and Zimmermann (2014), it is argued that the assumption of containment where underlying elements remain in the structure and hence potentially enrich the phonological representation with unpronounced material can indeed predict C/V-Shortening and Subtraction from the affixation of moras that are defectively integrated into the structure (cf. also Trommer (2011) and Zimmermann (2017*b*) where the mechanism is extended to syllable affixation as well).

Metathesis, on the other hand, can fall out in a GNA account if it is a strategy to realize additional prosodic weight (cf. the discussion in 4.5). Similarly, Templatic Morphology and Stress Shift can follow if they are the least marked strategy to realize an additional prosodic unit (cf., for example, the claim in Zimmermann (2013) that stress shift is the realization of an unmarked foot that is affixed). And that the surface effect of Polarity can follow from non-segmental affixation is argued for in Trommer and Zimmermann (2014) where an analysis of length Polarity based on a floating mora is given. In a nutshell, a floating mora can associate without any problems to a vowel that is only associated to a single mora but if it associates to a vowel that is already underlyingly long, there are too many moras on this vowel and this marked structure results in a collateral non-realization in all but one mora. Finally, a potential account of tonal Polarity within GNA based on domino overwriting is sketched in 4.3. As this listing shows, there is no general explanation for NSET that are subtractive and those that are neither base-extending nor result in a fixed target within a GNA account; the model simply allows language-specific re-analyses of specific patterns. Given the rarity and specific contexts where those NSET are attested (cf. subsection 2.4), this might indeed be the right type of account for those patterns.

Interestingly, the three NSET that are neither base-extending nor have a fixed target are amongst the most straightforward ones under both RMT and TAF. C/V-Subtraction, Metathesis, and Polarity each violate one general faithfulness constraint and are predicted if morpheme-specific Max or Linearity respectively is ranked below RM or their antifaithfulness counterpart is selected by the relevant morpheme. The same holds for Polarity if it involves the reversal of a binary dimension that is protected by an Ident constraint. As the discussion above implied, this apparent strength of the accounts might in fact be a weakness if there are indeed so few instances of morphological Metathesis and Polarity that are confined to specific patterns. It is, for example, very easy to predict CC-Metathesis as a NSET in both these accounts; a NSET that is seemingly systematically unattested. Tonal morphology that was already discussed above as a potential problem for a CP account is also challenging for both these frameworks simply because the realization of complex tonal melodies as a NSET is not a minimal change that can be analysed as the optimal violation of a single faithfulness constraint (cf. subsection 4.3 for a more general discussion of this problem). Similarly, Templatic Morphology or Truncation as two NSET that potentially imply multiple faithfulness violations are inherently challenging. The general upshot of this discussion is that both RMT and TAF cannot – in contrast to CP – specify certain phonological properties of the derived form, they can only specify which unfaithful operation should apply.

4.2 Locality of non-segmental morphology

In the majority of examples given in section 2, some element at the left- or rightmost edge is affected by the NSET. A broader typological look at NSM confirms that this edge-orientation is indeed by far the most frequent pattern. A preliminary database for NSM that contains information about the positions within a base that are affected by a NSET is Gleim et al. (in progress). It focusses on what is called "featural affixes" which includes both NSM and morphologically conditioned phonology and does not cover all the NSET discussed here.[15] Of the 548 cases of featural affixes currently collected in this database, 305 are instances of NSM. The base positions which are affected by the different NSET are summarized in (17) for all these 305 patterns.[16] The parameters given in (17) are relativized to the expected host of the NSET: "Leftmost" for an instance of C-Lengthening hence targets the leftmost consonant (that might be preceded by a vowel) whereas "Leftmost" for a tonal morpheme involves association to the leftmost TBU. The parameter "Only" was chosen in case the relevant target is only present in its base once; a recurring example is NSM affecting a vowel in a language with only monosyllabic roots (e.g. the various Mutation and V-Lengthening/Shortening patterns in Western Nilotic (Trommer, 2011)). Instances where a NSM affects "All" targets within a base are discussed in more detail in section 4.3.

(17) Position of NSET in the base (305 patterns) (Gleim et al., in progress)

a.	Final/Rightmost	142	46.56%
	Initial/Leftmost	96	31.48%
	Only	28	9.18%
	All	15	4.92%
	Stressed position	4	1.31%
b.	2nd	14	4.59%
	Penult	6	1.97%

The percentages in (17) show that there is indeed an overwhelming tendency for NSM to affect the edges of its base. And within NSM affecting the edge, NSM at the right edge is more common than NSM affecting the left edge. This tendency is of course immediately reminiscent of the preference for suffixation over prefixation in the languages of the world (e.g. Greenberg, 1957). And the vast majority of positions in (17) have a second important correlation to discussions of segmental affixation: They seemingly directly correspond to the theory of pivot affixation in Yu (2007) that assumes that all segmental (and reduplicating) affixes are prefixes or suffixes to a limited set of phonological pivot positions (cf. also Fitzpatrick, 2004). More concretely, pivot affixation assumes that affixes subcategorize for being aligned at the left or right edge of a phonological pivot point that is either an edge pivot (e.g. the first consonant) or a prominence pivot (e.g. the stressed foot). In Mlabri, for example, the nominalizing marker /rn/ is realized as a suffix to the initial consonant – a subcategorization that results in consistent infixation (e.g.

[15] It excludes C/V-Shortening, C/V-Subtraction, Truncation, Metathesis, Polarity, Templatic Morphology, and Reduplication.

[16] These 305 cases are from 145 different languages. The distribution of different types of NSET are given in (i). Note that three patterns involve simultaneous Tone morphology and V-Lengthening; resulting in a total of 308 in (i).

(i) Sample of 305 NSM in Gleim et al. (in progress)

C/V-Mutation	130
Tone	98
C/V-Lengthening	69
Stress Shift	11

kwɛl 'to be rolled up', *krwɛl* 'spiral', (Yu, 2007, 79)). This theory hence explains infixation effects without a proper infixation operation or any phonological dislocation of affixes (in contrast to, for example, Prince and Smolensky, 1993/2002). Only the positions in (17-b) do not correspond to any of the pivots for suffixation or prefixation in Yu (2007).

What are now the predictions of the theoretical accounts when it comes to this typological tendency (=more NSM affects the right edge) and apparent typological restriction (=edge-orientation)?

For a piece-based GNA account, the preference for NSM affecting the right edge is identical to the typological preference of suffixes over prefixes since every NSM is the result of normal affixation. NSM affecting the right edge hence falls out from suffixing a non-segmental affix. When it comes to the expected base positions for NSM, the predictions of a GNA model depend on the specific assumptions about affix linearization. In a theory with phonological dislocation (cf. above), there is no inherent restriction on where NSM is realized in its base; it only has to be the optimal position for a certain NSET. A theory with pivot affixation generalized to non-segmental affixes that does not allow any phonological dislocation of morphemes, on the other hand, makes very restricted predictions about the potential base positions that can be affected by a NSET. Such an account of course implies that the pivots for non-segmental affixes are relativized to the relevant tier and, for example, the pivots for a mora affix are on the moraic tier. In Zimmermann and Trommer (2013), for example, it has been argued that for mora-affixation, a restricted pivot theory where only the last and first mora of a base can be targetted by prefixation and suffixation of a mora is indeed capable of deriving the typology of additive length-manipulating morphology. Under this perspective that non-segmental affixes are suffixed or prefixed to elements on the relevant phonological tier, even the positions in (17-b) are in fact compatible with a restricted set of pivots since all of them involve either instances of C-Lengthening of the first intervocalic (and hence lengthable) consonant or instances of tonal morphology or stress shift. How a tonal affix might indeed reach its seemingly non-local target position without "skipping" any elements on its tier can be illustrated with an example that has been argued to involve non-local tonal morphology, namely a morphological H-tone in Kuria that is realized on the fourth mora of its base (Marlo et al., 2015; Sande et al., 2020). Importantly, the three moras that are "skipped" by this morphological H-tone are all L-toned (or toneless); it is hence not the case that the H-tone infixes across contrasting tonal melodies. In this sense, the Kuria tonal morphology is hence indeed associated with the left edge; either because no other tone intervenes between the H-tone and this edge or because a L_3H-templates is realized at the left edge.

For all constructionist approaches, the target position of a NSET within its base must fall out from the independent inventory of phonological constraints. For TAF and RMT, one important constraint class for this localization of a NSM are positional faithfulness constraints (Beckman, 1998) that penalize changes in certain prominent positions. The common pattern of affecting a final/rightmost element hence could fall out if, for example, faithfulness constraints preserving information in the initial position exclude a NSET at the left edge and a version of a CONTIGUITY constraint penalizing changes/deletion/insertion within a morpheme forces it to apply at the other edge. For CP, an additional main mechanism are positional markedness constraints demanding a certain phonological structure in a certain position (e.g. HAVELONGV# to predict final V-Lengthening). And the Kuria analysis in Sande et al. (2020) is even based on a locality constraint that explicitly forces a morphological H-tone to move to a certain position ("Assign one violation for each floating tone that does not surface four moras from its input location", p.1237). This makes clear that NSM is in principle free to apply to every position of a base in these accounts. The preliminary empirical evidence suggests that this vastly overgenerates. Future research has to show whether and how the full typology of NSM is indeed locally restricted and whether constructionist approaches can potentially restrict the inventory of constraints to avoid any overgeneration problem.

4.3 Across-the-board non-segmental morphology

In all examples we saw above, only the minimal necessary change applied; i.e. only a single segment was changed in the C/V-Mutation cases or only a single TBU was overwritten in Tonal Overwriting. There are, however, also cases where multiple hosts are affected by a NSET without any obvious cause from the general phonology of the language, termed 'across-the-board' (=ATB) NSM in the following.[17] A famous example is Tonal Overwriting in the Chadic language Hausa. As can be seen in (18), the imperative is marked by a tonal melody LH that overwrites the tones of the (simplex or derived) base. Crucially, these tones are not only realized on two TBU's but overwrite the complete base tone melody. The trisyllabic forms in (18-b) show that the initial L-tone spreads in case the base has more than two TBU's, abbreviated as L_0H.

(18) ATB Tonal Overwriting in Hausa (Newman, 2000, 263), (Jaggar, 2001, 436-439)

	BASE		IMPERATIVE		
a.	káːwóː	HH	kàːwóː	LH	'bring (it)!'
	táːʃì	HL	tàːʃí	LH	'get up!'
b.	káràntáː	HLH	kàràntáː	LLH	'read it!'
	nánnéːmóː	HHH	nànnèːmóː sùː	LLH	'keep looking for them!'
	ɗáɗɗáukóː	HHH	ɗàɗɗàukóː	LLH	'bring (them all)!'

An interestingly different case of ATB NSM that has been extensively discussed in the literature is nasalization in the Arawakan language Terena (Bendor-Samuel, 1960) where first person marking involves nasalization of the initial segment with concomitant nasalization of all segments up unto the first stop or fricative (excluding /ʔ/), shown in (19). This first stop or fricative blocks further propagation of this process and is turned into its prenasalized counterpart (19-b).

(19) Terena 1sg C-Mutation (Bendor-Samuel, 1960, 350)

	3.PS		1.PS	
a.	ajo	'his brother'	ãj̃õ	'my brother'
	emoʔu	'his word'	ẽmõʔũ	'my word'
b.	owoku	'his house'	õw̃õᵑgu	'my house'
	ahjaʔaʃo	'he desires'	ãⁿʒaʔaʃo	'I desire'
	piho	'he went'	ᵐbiho	'I went'

An example for such a directional ATB pattern with blocking from tonal morphology comes from the associative (or possessive) construction in Etsako, an Edoid language. It is marked by overwriting a final L-tone on nouns with an H-tone. Crucially, all L-toned TBU's adjacent to this final TBU are raised as well (/únò/ H.L –> [únó] H.H 'mouth' and /àmɛ̀/ L.L –> [ámɛ́] H.H 'water' (Elimelech, 1976, 56+57)).

A final interestingly different example of ATB NSM is tonal Polarity in the Southern Nilotic language Kipsigis. In Kipsigis, nominal modifiers which include possessive pronouns, demonstratives, and adjectives, form their nominative via reversing the tonal specification for each TBU of the oblique form; exemplified in (20) with some adjectives. Note that the falling contour HL surfaces as H in the nominative – a repair that avoids the expected polar rising contour LH that is illicit in Kipsigis.

[17] This excludes cases where the interaction of regular phonological processes or restrictions results in apparent ATB NSM. An example would be morphological palatalization in many Biu-Mandaran languages that results in palatalization of all palatalizable consonants and vowels; a global effect that is predictable since vowels and consonants never contrast for palatalization within a word (e.g. Schuh, 2002). And a NSM might of course require multiple hosts if it is complex in itself. An example for this was the complex NSM in Anywa (16) discussed above or Mutation in Mokulu where the completive formation involves changing the initial consonant into a voiced one and changing the initial vowel into a high one (Roberts, 1994, 95).

(20) ATB Tonal Polarity in Kipsigis (Kouneli and Nie, 2021, e121)

	OBLIQUE		NOMINATIVE		
a.	jà	L	já	H	'bad.SG'
b.	áɲìɲ	H.L	àɲíɲ	L.H	'tasty.AG'
c.	tʃéptʃép-èːn	H.H.L	tʃèptʃèp-éːn	L.L.H	'swift-PL'
d.	míntìlíːl	H.L.H	mìntílìːl	L.H.L	'sour.SG'
e.	kárâːrán	H.HL.H	kàráːràn	L.H.L	'beautiful.SG'
f.	tórôːr-èːn	H.HL.L	tòróːr-éːn	L.H.H	'tall-PL'
g.	míntìlíːl-èːn	H.L.H.L	mìntílìːl-éːn	L.H.L.H	'sour-PL'

A list summarizing these and other examples for ATB NSM is given in (21). Directional ATB patterns with blocking as in Terena and Etsako are marked with "Dir" instead of "All" to make clear that not necessarily all elements of the base are overwritten. It has to be noted that Templatic Morphology is excluded in this list although its formation might indeed involve multiple applications of a NSET (e.g. multiple instances of Subtraction) since these multiple applications serve a higher purpose of satisfying a prosodically defined target.

(21) Examples for ATB NSM[18]

a.	*Tonal Overwriting*			
	Asante Twi	IMP	L	All
	Hausa	IMP	LH_0	All
	Kipsigis	NOM	LH_0L	All
	Igbo	e.g. MAIN.NEG	L	Dir
	Etsako	POSS	H	Dir
	Kipsigis	NOM	<polar>	All
b.	*V-Mutation*			
	Kalam Kohistani	SG.OBL/PL	e.g. [-back]	All
	Terena	1	[+nas]	Dir
c.	*C-Mutation*			
	Basque	DIM	[pal]	All

The examples above only include ATB NSM for Tonal Overwriting (22-a), V-Mutation (22-b), and C-Mutation (22-c). A putative case of ATB NSM involving V-Shortening can be found in Kimatuumbi where all long vowels of a stem are shortened if this stem is contained in the head of a syntactic phrase (§6.1 Odden, 1996). It is excluded from the current list since the status as NSM is not completely clear given that the process is triggered by the phrasal position of a word.[19] ATB application of some other NSET is reasonably excluded by the nature of the NSET itself, stress shift being an obvious example. However, the lack of any ATB pattern of, for example, C/V-Lengthening, Metathesis, or Subtraction is a potentially interesting typological gap that might warrant a theoretical explanation.

After this overview over ATB NSM patterns and a potential systematic restriction about unattested patterns, we now turn to a discussion of whether and how the four representative theoretical accounts predict the existence of ATB NSM. The assumption of RMT and TAF makes ATB NSM generally impossible. In both frameworks, a single NSM is sufficient to satisfy the triggering – RM or TAF – constraints and any further change is harmonically bounded by IO-Faithfulness constraints. Interestingly, Alderete (2001) mentions the option that TAF constraints can in principle be formulated with a different negator scope. Instead of the wide scope in the "standard" TAF constraints (22-a), the negator could scope over the consequent of the implication and hence require a total lack of faithfulness (22-b). It is concluded that such a TAF version is empirically unmotivated at least for the empirical area Alderete (2001) focusses

[18] Sources: Asante Twi (Paster, 2010, 115+116), Hausa (Newman, 2000, 262-263), Kipsigis (Kouneli and Nie, 2021), Igbo (Williams, 1976, 470), Etsako (Elimelech, 1976, 56+57), Kalam Kohistani (Baart, 1999*a*, 36+169), Terena (Bendor-Samuel, 1960), Basque (Hualde and Ortiz de Urbina, 2003, 39).

[19] If this indeed is an instance of NSM, it is also clearly non-local since it targets any long vowel irrespective of its distance to an edge (cf. the discussion in 4.2).

on, namely lexical accent. For the ATB NSM patterns of the "All" type in (21), however, (22-b) predicts exactly the correct outcome, namely a reversal of all values for a phonological dimension. Such a version of TAF theory was never discussed in detail and a lot of open questions especially about its predictive power remain.

(22) a. ¬IDENT(F): $\neg[\forall x \forall x' \forall F\ [xRx' \rightarrow y =_F y']]$
‘(At least) one pair of correspondent segments must differ in feature F.’
b. ¬IDENT(F)$_{\text{Narrow}}$: $\forall x \forall x' \forall F\ [xRx' \rightarrow \neg y =_F y']$
‘Every pair of correspondent segments must differ in feature F.’

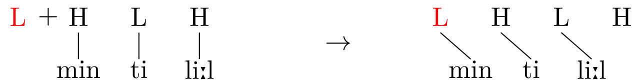
And even this extension of TAF theory that allows an "ATB" and "non-ATB" version of TAF constraints is unable to predict the directional "Dir" ATB patterns with blocking exemplified with Terena above given that it predicts changes in one phonological element or in all of them.

CP is in principle able to predict ATB NSM given that a cophonology evaluates the whole output form. Cases like Terena can hence easily follow if the 1SG-phonology demands both nasalization of the initial segment and nasal spreading that is blocked by voiced obstruents. That the former part of the account is not trivial (cf. the discussion in section 4.1) is already implicit in the account of "morphemic" harmony in Finley (2009): Though the analysis is based on lexically indexed constraints (=easily translatable into a CP account) which predicts the morpheme-specific nasal spreading, the initiator for nasalization in the 1SG is still a floating feature (cf. also Akinlabi, 1996, for such a mixture of a GNA and constructionist account). It is also not easy to see how the directional ATB pattern as in Etsako (and Igbo) can fall out in CP given that the morphological tone seemingly replaces an underlying tone and inherits all its associations. The spreading of the tone is hence not blocked by some independent phonological configuration but solely by an underlying property of the base; something which is seemingly impossible if the CP account only evaluates surface structure. Finally, the ATB Polarity in Kipsigis is of course problematic since Polarity is not a possible NSET in a CP account (cf. 4.1).

These are all examples where CP potentially undergenerates and cannot predict the existence of attested ATB NSM patterns. Interestingly, there is also a potential overgeneration problem if the collection of patterns in (21) is indeed taken to be a representative list of NSET that show ATB NSM. It is very easy to predict a cophonology that demands the avoidance of a certain marked structure throughout a base, including ATB Subtraction that deletes all coda consonants or ATB Metathesis that reorders consonants throughout a word in order to avoid any complex onsets. In fact, such markedness avoiding ATB NSM are the predicted default that we expect in CP: That NSM is usually restricted to a certain base position is only ensured by additional constraints.

At first glance, a piece-based GNA approach makes the same prediction as RMT: Every non-linear affix should be incorporated into the structure while minimizing additional faithfulness violations which seemingly excludes ATB NSM. Four independent solutions have been proposed in the literature that can predict ATB NSM from non-segmental affixation. For one, spreading of an underlyingly floating phonological element can follow as a Derived Environment Effect. For autosegmental association, the constraint ALTERNATION has been proposed that penalizes any new association between elements with the same morphemic affiliation (van Oostendorp, 2006). As soon as a "new" element is present that belongs to another morpheme, spreading is possible. In Terena, for example, high-ranked ALTERNATION would block any nasal harmony within morphemes but association of a floating [+nas] feature to multiple hosts can satisfy a lower-ranked constraint demanding nasal harmony without inducing an ALTERNATION violation. Secondly, it has been argued by Trommer (2022*a*) that tonal ATB NSM can result from circumfixation of multiple non-segmental affixes. Overwriting of all intervening elements on the relevant tier then follows if a high-ranked CONTIGUITY constraint demands that elements belonging to the same morpheme should be contiguous (cf. also Trommer (2015) for mora-circumfixation and lengthening morphology; a mechanism that might even predict ATB V-Shortening as in the putative Kimatuumbi case). Thirdly, tonal ATB patterns as the ones in Igbo and Etsako can follow under the assumption of sub-tonal features (e.g. Snider, 1999) whose association can "infect" a whole tone span, namely all the TBU's associated to the same tonal root node underlyingly (Trommer, 2022*b*). And finally, a mechanism of domino-overwriting is predicted under autosegmental association that can result in ATB Polarity as in Kipsigis. As Trommer (2022*b*) argues, prefixation of a sub-tonal floating register feature (low) can result in overwriting of all TBU's associated with an initial H (cf. the "infectious" overwriting discussed above). The overwritten and hence de-associated register (high) feature, on the other hand, must associate to the next tonal root node in order to avoid an unassociated tone feature that is not at the edge of a word. This mechanism of "domino"-overwriting is sketched in (23), abstracting away from the sub-tonal features for ease of exposition.[20] The effect of domino-overwriting after prefixation in (23) is in fact reminiscent of the result that is expected under the 1:1-association from left to right of the Association Conventions proposed in early autosegmental phonology (Goldsmith, 1976) if all the underlying tones in (23) were floating.

(23) ATB Tone Polarity as domino-overwriting (after Trommer, 2022*b*)
Input: Output:



Though GNA hence has no unified explanation for ATB NSM, different mechanisms can predict that floating non-segmental elements affect larger parts of the structure.

4.4 Cyclicity of non-segmental morphology

The constructionist accounts discussed in this chapter are all inherently cyclic: They derive one morphological construction or surface form of a morpheme at a time. From this cyclic architecture, it follows that they only predicts base-mutating NSM, namely morphologically triggered phonological changes on material that is already part of the base, never on material that is morphologically more outwards and hence optimized in a later cycle. This prediction is explicitly formulated as the "Thesis of Strict Base Mutation" (=SBM) in Alderete (2001).

In contrast, a piece-based GNA account is perfectly compatible with a cyclic or a fully parallel architecture where all phonological material of a complex word is evaluated at once. To highlight the contrasting predictions of the two classes of accounts, a non-cyclic GNA model is assumed here.[21] Such a model is crucially not restricted by the SBM and whether a non-segmental affix affects preceding or following material is decided by phonological linearity constraints alone. Cases where a NSM affects material that is morphologically more outwards are termed "anti-cyclic" in the following.

All the examples of NSM discussed so far are in accordance with the SBM. However, it is argued in Trommer (2022*a*) that the SBM does not hold for tonal Mutation. And a more general argument that SBM does not hold for Mutation is made in Trommer and Zimmermann (2022) based on an extensive typological study of 126 anticyclic Mutation patterns from 66 languages.[22] An example for anticyclic NSM can be found in Gã (Paster, 2000, 2003) where Tonal Overwriting applies to a morphologically more outwards subject prefix. Two background facts about the language are necessary before such an argument can be made. For one, the contrast between examples (24-a) and (24-b) which involve segmental markers for the progressive and future shows that tense-aspect markers appear closer to the root than the subject agreement prefixes.

[20] This is still a radical simplification of the original proposal in Trommer (2022*b*). The account also assumes that the nominative is in fact a circumfix that also consists of a floating suffixing full H-tone that ensures that every nominative form contains at least one H-tone.

[21] Though a GNA account within a cyclic optimization could still easily predict anti-cyclic NSM if unassociated sub- or suprasegmental material can remain unassociated across cycles.

[22] Both arguments are made for Mutation with or without additional segmental content and hence include morpheme-specific phonology.

(24) Tense-aspect prefixes follow subject prefixes in Gã (Paster, 2000, 59+65)

a. mḭ́-ŋ-ꜝhó
1SG-PROG-pass.by
'I am passing by'

b. m-á̰-ꜝhó
1SG-FUT-pass.by
'I will pass by'

Secondly, the subject prefixes have a tonal contrast as can be seen in the habitual forms in (25-a): First person /mí-/ surfaces as H-toned and third person /e-/ as L-toned (in fact analysed as toneless in Paster (2003)). This tonal contrast is neutralized in both the perfective and past forms that are segmentally identical but show a consistent H-tone on the subject prefix in the former (25-b) and an L-tone in the latter (25-c). Perfective and past are hence taken to trigger Tonal Overwriting. Crucially, these morphological tones surface on the subject prefix, not on the root. Given that the (tonal) tense-aspect marker is structurally inside the subject prefix, this hence instantiates anticyclic NSM that violates the SBM.

(25) Anticyclic Tonal Overwriting in Gã (Paster, 2000)

a.	HAB				
	mḭ́-ho-ɔ	'I pass by' (hab)	e-ho-ɔ	'he passes by' (hab)	p.61
	mḭ́-sɔle-ɔ	'I pray' (hab)	e-sɔle-ɔ	'he prays' (hab)	p.62
b.	PERF: Morphological H realized on subject prefix				
	mḭ́-ho	'I have passed by'	é-ho	'he has passed by'	p.51
	mḭ́-sɔle	'I have prayed'	é-sɔle	'he has prayed'	p.52
c.	PST: Morphological L realized on subject prefix				
	mḭ-ho	'I passed by'	e-ho	'he passed by'	p.44
	mḭ-sɔle	'I prayed'	e-sɔle	'he prayed'	p.44

Another example for anticyclic NSM is the possessive formation in Uspanteko, a K'ichean language (Bennett and Henderson, 2013). Possession (for local person) is marked by an H-tone that surfaces – as all H-tones of the language – on the penultimate vocalic mora of the word. For roots with a single mora, this tone will hence surface on a pronominal prefix (e.g. [kar] 'fish' – [ínkar] 'my fish'). That the pronominal prefixes are independent from the tonal morphology of possession is apparent since they surface without it in predicative constructions (e.g. [inkar] 'I am a fish'; all data from Bennett and Henderson (2013), 604+629). Given that the possessor morpheme is structurally inside of the pronominal prefixes (Bennett and Henderson, 2013, 605), this constitutes anticyclic NSM. An example for V-Mutation that violates the SBM can be found in the complex morphology of the Papuan language Nimboran where several affixes trigger morpheme-specific vowel changes for morphologically more outwards affixes and at least one of them is cited to have no further segmental content, hence instantiating an instance of anticyclic NSM (Inkelas, 1993, 575+576).

These cases hence show that the SBM is apparently too strong and purely cyclic approaches of NSM are too restrictive. A weaker version of the SBM is discussed (for tonal morphology) in Rolle (2018) where it is argued that anticyclic Mutation is only possible for non-overwriting NSM. However, the Gã example is already overwriting since at least the first person subject prefix must be tonally specified underlyingly. An extension of CP that can predict some types of anticyclic Mutation is Cophonology by Phase (Sande et al., 2020; Sande, 2020). In this model, all the morphemes within a phase are evaluated together; there is hence a wider visibility window for morpheme-specific phonology. This extension, however, might again be too unrestricted since it allows anticyclic Mutation across (multiple) morphemes as long as all of them are within a phase. At least the examples of anticyclic NSM I am aware of are always local in involving adjacent morphemes (cf. 4.6 for more discussion of this model).

4.5 Phonologically predictable non-segmental allomorphy

If the marking of a certain morphological category has different surface effects for bases with different phonological forms, the immediate question arises whether this is "true" allomorphy that requires the storage of different suppletive forms or constructions or whether the surface alternation is the result of predictable phonological processes of this language (see also the chapters *morphcom062* and *morphcom077*). This general question extends to NSM as well: There are cases that look like phonologically predictable non-segmental suppletive allomorphy (=PNSA) where different NSET or different instantiations of the same NSET alternate. A famous example is the emphatic adjective formation in Shizuoka Japanese (Davis and Ueda, 2002) that involves two different NSET and one segmental exponent. For bases that have a single voiceless consonant as their first intervocalic consonant, the emphatic is formed via C-Lengthening (e.g. /katai/ vs. /katːai/ 'hard'), for bases that have a closed first syllable, V-Lengthening applies (e.g. /zonzai/ vs. /zoːnzai/ 'impolite'), and in all other contexts, nasal insertion surfaces (e.g. /hade/ vs. /hande/ 'showy'; all data from Davis and Ueda (2002), 2) – an exponence strategy that is not even non-segmental given the typology in (2). Another example can be found in Tawala where the durative aspect is marked by (partial or full, cf. (27)) Reduplication for most verbs (e.g. /hopu/ vs. /hopu∼hopu/ 'go down') but by V-Lengthening in case the first two syllables of the verb are underlyingly identical (e.g. /totogo/ vs. /toːtogo/ 'be ill'; all data from Ezard (1984), 63+64). A few more examples for PNSA are listed in (26) to illustrate the variability of the phenomenon. The list distinguishes allomorphy between different NSET (26-a) from allomorphy between different concrete instantiations of the same NSET (26-b). Whether a NSET applies to a consonant or a vowel is, for example taken to be an instantiation of the same basic NSET (cf. V-Lengthening and C-Lengthening in (26-b)).

Most cases of Templatic Morphology can also be understood as PNSA given that it usually involves the application of (different combinations of) different NSET. Since the special status of Templatic Morphology was already discussed in 2.2, the list in (26) only lists cases that have not been explicitly discussed as such.

(26) Examples of phonologically conditioned non-segmental allomorphy[23][24]

	Language		Allomorphy between:		
a.	Tawala	DUR	Red	L:V	
	Upriver Halkomelem	CONT	Red	L:V	StrS
	Saanich	ACTUAL	Red	Met	
	Clallam	ACTUAL	Red	Met	V-Mut
	Hidatsa	IMP	S:V	Sub:V	
	Lomongo	VOC	S:V	Sub:V	
	North Saami	NOM	Mut:C	L:C	
b.	Shizuoka Japanese	EMPH	L:V	L:C	
	Hiaki	HAB	L:V	L:C	
	Alabama	IMP	L:V	L:C	
	Kalam Kohistani	SG.OBL/PL	T:H(L)	T:HL	T:L
	Tiddim Chin	OBL	T:M	T:H	T:L
	Koasati	PL	Sub:C	Sub:Rhyme	

The question for any theoretical account of NSM is whether PNSA needs to be analysed as "suppletive" and hence as the result of different underlying representations or constructions that are selected in different phonological contexts or whether such allomorphy can be handled by

[23] Abbreviations used here and in table (27): L=Lengthening, Met=Metathesis, Mut=Mutation, Red=Reduplication, Sh=Shortening, Sub=Subtraction StrS=Stress Shift, T=Tonal Overwriting.

[24] Sources: Tawala (Ezard, 1984, 63-65), Upriver Halkomelem (Galloway, 1993, §2.3.3+2.3.4), Saanich (Montler, 1986, §2.3.5), Clallam (Thompson and Thompson, 1971, §4.2.1), Hidatsa (Boyle, 2007, 201+202), Lomongo (Hulstaert, 1938, 157), Shizuoka Japanese (Davis and Ueda, 2002, 2), Hiaki (Haugen, 2003, 93), Alabama (Montler and Hardy, 1988), Kalam Kohistani (Baart, 1999*b*, 96), Tiddim Chin (Henderson, 1976, 11), Koasati (Kimball, 1991, §10).

the general phonology of the language with a single non-segmental exponent or construction stored for such a morphological context.

There are several arguments that GNA can predict PNSA that involves V-Lengthening, C-Lengthening, CV-Metathesis, and/or (CV-)Reduplication from the affixation of an unassociated mora since these operations potentially add prosodic weight. For Shizuoka Japanese, for example, Davis and Ueda (2002) have argued that all the NSET found in the emphatic formation add additional weight to the first syllable and can hence be accounted for by affixing a floating mora that needs to be integrated into the first syllable via V-Lengthening, C-Lengthening, or nasal epenthesis. Importantly, the choice between these strategies follows from the ranking of general markedness constraints of the language that penalize a certain strategy for a certain base (for example *CC excluding complex codas makes epenthesis impossible if the first syllable is already closed or No-VG penalizing voiced geminates excludes C-Lengthening for bases with a voiced consonant as coda).

Similar piece-based accounts based on mora-affixation have been proposed for PNSA in Saanich (Davis and Ueda, 2006; Stonham, 2007; Bye and Svenonius, 2012) and Alabama (Grimes, 2002). And even the allomorphy between C-Mutation and V-Lengthening in North Saami can be analysed as mora-affixation as is convincingly argued in Bals Baal et al. (2012). That affixation of higher prosodic units can also predict PNSA is the argument in Zimmermann (2013) where foot affixation is taken to predict the PNSA in Upriver Halkomelem given that all the NSET involved in the allomorphy ensure the best left-aligned foot that is possible for a certain base.

The challenge for a GNA account of phonologically predictable non-segmental allomorphy is hence to find one common supra- or sub-segmental denominator that can underlie all the non-segmental allomorphs and let the general phonology of the language choose between these strategies. An apparent challenge for such a reasoning are PNSA patterns where different tones are realized (e.g. Kalam Kohistani and Tiddim Chin in (26)). There are two obvious options to re-analyse such an instance in a piece-based account: Either the different grammatical tones are taken to have a sub-tonal feature in common (cf. Zimmermann, 2017*a*, where an account for a position-allomorphy is presented based on sub-tonal features) or all the surface-tones are taken to be part of a floating tonal sequence and markedness constraints ensure that only one is realized for each base.

A theory where this problem vanishes is RMT since the RM constraint can be satisfied by any conceivable phonological manipulation and it is predicted that all imaginable combinations of NSET can be part of a PNSA. Kurisu (2001) in fact discusses PNSA as one main argument for this theory and gives theoretical accounts of PNSA in Upriver Halkomelem and Saanich. In such an account, the different NSET that are part of a PNSA thus do not have to share a common – albeit abstract – phonological element. This apparent advantage of course might turn into an overgeneration problem if the typology of attested PNSA patterns turns out to be systematically restricted to certain combinations of NSET.

In TAF, on the other hand, different antifaithfulness constraints can easily predict that a certain morphological construction is associated with different NSET. It is, however, impossible to predict that those strategies are inherently in complementary distribution. That only one of them applies in a PNSA must thus follow from general phonological constraints. This beautifully works for the PNSA in Shizuoka Japanese since simultaneous application of more than one strategy of V-Lengthening, C-Lengthening, or nasal epenthesis results in a super-heavy syllable that is indeed impossible in the language. But it has been argued in Zimmermann (2017*b*) that this is not as easily possible for the PNSA in Upriver Halkomelemen were simultaneous application of, for example, Reduplication and V-Lengthening is perfectly possible without violating any general markedness constraints. A TAF account of PNSA must hence often rely on a suppletive analysis where different antifaithfulness constraints are selected for bases with a certain phonological shape (cf. also the critical discussion of TAF as an account of PNSA in Kurisu (2001):§4.3.2).

Similarly, there is no principled way in which different constructions can be in complementary distribution in a CP architecture. A non-suppletive account for PNSA in CP must hence basically recast the GNA insight and rely on a more abstract common element that all these strategies have in common. More concretely, a CP account of Shizuoka Japanese could assume a cophonology with a high-ranked constraint BeHeavy!$_{\#\sigma}$ demanding the first syllable to be heavy. The only difference to a GNA account would then be that the trigger for the different non-segmental operations is a high-ranked constraint demanding that the initial syllable must be heavy; the non-representational equivalent to an affixed floating mora.

4.6 Lexically conditioned non-segmental allomorphy

In the same sense that NSM can employ PNSA, it can also show lexically conditioned allomorphy (=LNSA) and hence cases where different NSET or different instantiations of the same NSET alternate to mark the same morpheme and the choice between these strategies is determined by lexical contexts. An example for a LNSA was already implied in the discussion of Jamul Tiipay in 2.4 where it was argued that this apparent case of Polarity rather involves lexically arbitrary classes of stems that either undergo V-Lengthening, add a segmental affix, or undergo V-Shortening to form their plural. Roots in Jamul Tiipay can hence be said to show lexically conditioned allomorphy between different NSET (and different segmental morphemes). In addition, there are many examples where different concrete instantiations of the same general NSET realize the same morphological content in different lexical contexts. A famous example is Subtraction in the Muskogean language Alabama which marks pluralization and targets either the final rhyme or the final consonant (Hardy and Montler, 1988; Broadwell, 1993). There is no apparent phonological or semantic criterion that predicts which of these Subtraction operations applies; the choice of one or the other is lexically determined by the root.[25] And finally, there are cases where a NSET is blocked in certain morphological or lexical contexts; something that might be summarized as a lexically conditioned allomorphy between a NSET and a ø-marker; a sub-type of what Sande (2020) terms "morphologically conditioned phonology with two triggers". An example can be found in Sacapultec where only an idiosyncratic class of nouns undergoes final V-Lengthening in their possessive forms (DuBois, 1981).

The list in (27) summarizes these and a few more examples for LNSA. As in (26), only NSET are listed; some of the patterns in (27) are hence more complex and also involve lexically conditioned segmental allomorphs (e.g. in Jamul Tiipay). The patterns in (27-a) are examples for an alternation between different NSET, the ones in (27-b) for alternations between different specific instantiations of the same general NSET, and the ones in (27-c) for alternations between a NSET and ø-marking.

Recall that Hiaki already appeared in the list of PNSA (26) since it also employs a phonologically predictable alternation between C-Lengthening and V-Lengthening for those roots that mark their habitual with C/V-Lengthening. In addition, there are roots that show Reduplication of either a monosyllabic- or bisyllabic portion of the base and the choice between those strategies is lexically determined (Tawala in fact employs a similar interaction of LNSA and PNSA). The pattern hence appears twice in the list below.[26]

The "..." notated in (27) for Amuzgo implies that the tonal morphology in Amuzgo is extremely complex and involves a huge number of tonal allomorphs (Kim, 2016, 2019; Palancar, 2021). In addition, there are glottal alternations as well, not even listed in (27). Amuzgo should be taken here as only one representative for other Otomanguen languages that are notorious for their complex tonal morphology full of LNSA (see Palancar and Léonard, 2016, for an excellent overview). The list in (27) also only contains a single Western Nilotic language, namely Nuer. Again, this language is only one representative for many complex LNSA patterns in many of these languages. Plural formation in Dinka, for example, apparently involves all the NSET listed for Nuer but also tone changes (Ladd et al., 2009). In addition, the NSET given in (27)

[25] Interestingly, the same allomorphy is phonologically conditioned in the closely related language Koasati (cf. (26)); a classification which is not uncontroversial (see, for example, Broadwell, 1993).

[26] The pattern is in fact more complex than that and Haugen (2003) discusses an additional habitual formation that involves both syllable-sized Reduplication and C-Lengthening.

for Nuer are not always in complementary distribution and combinations of various NSET can coexist; the allomorphy is hence even more complex.

(27) Examples of lexically conditioned non-segmental allomorphy[27]

	Language		Allomorphy between:			
a.	Jamul Tiipay	PL	L:V	S:V		
	Nuer	PL	L:V	S:V	Mut:V	Mut:C
	Tepecano	PL	L:C	Red		
	Hiaki	HAB	L:V/C	Red		
b.	Alabama	PL	Sub:C	Sub:Rhyme		
	Murle	PL	Sub:C	Sub:Rhyme		
	Hiaki	HAB	Red:σ	Red:$\sigma\sigma$		
	Tawala	DUR	Red:σ	Red:$\sigma\sigma$		
	Dinghai	DIM	Mut:V (+nas)	Mut:V (-back)		
	Amuzgo	2SG	T:53	T:31	T:...	
c.	Sacapultec	POSS	L:V	ø		
	Zuni	PL	L:V	ø		
	Aymara	ACC	Sub:V	ø		
	Japanese	compound	Mut:C	ø		

For all theoretical accounts of NSM, such a lexically conditioned allomorphy can of course be taken care of before the phonological optimization applies, i.e. by choosing a different allomorph (=different non-segmental morpheme representation) in a GNA approach or by assuming that the input into a constructionist optimization can contain different "allomorphs" for a morphological feature (e.g. PLURAL1 and PLURAL2 for Alabama). Such a solution is at least implied for the RMT account in Kurisu (2001) where a complex lexical index $\text{FAITH}_{\text{pl.cl1}}$ is assumed (p.88). In the following, it will be discussed whether it is also possible to explain these allomorphy patterns by the phonological component alone, i.e. by the same mechanisms that predict NSM.

Whether RMT can predict an interaction of different morphemes or constructions in the phonology crucially relies on the theory of constraint indexation and whether it allows that the stem of the construction under optimization can also be indexed to a faithfulness constraint. If this is possible, the fact that, for example, certain stems don't undergo V-Lengthening to form the possessive in Sacapultec follows from a ranking as in (28-a) where "Cl1" is an index to roots that undergo V-Lengthening. Similarly, Jamul Tiipay would follow under a ranking as in (28-b) where stem class I undergoes V-Lengthening to form the plural (violating $\text{DEP}\mu_{\text{pl}}$ and avoiding a violation of $\text{MAX}\mu_{\text{cl1}}$) and stem class II undergoes V-Shortening instead (violating $\text{MAX}\mu_{\text{pl}}$ and avoiding a violation of $\text{DEP}\mu_{\text{cl2}}$). Allomorphy patterns like in (27-b) follow from the same logic as long as all the different instantiations of a NSET can be attributed to a different faithfulness violations.

(28) RM account of lexically conditioned non-segmental allomorphy

a. Sacapultec: $\text{DEP}\mu_{\text{cl1}} \gg \text{RM} \gg \text{DEP}\mu_{\text{poss}}$

b. Jamul Tiipay: $\text{DEP}\mu_{\text{cl2}}$, $\text{MAX}\mu_{\text{cl1}} \gg \text{RM} \gg \text{DEP}\mu_{\text{pl}}$, $\text{MAX}\mu_{\text{pl}}$

However, the indexation in (28) combines two different theories of constraint indexation: In the model of Kurisu (2001), the indexed constraints apply to the whole output form even though these candidates do not contain any segmental material underlyingly affiliated with the category the constraint is indexed to. In contrast, the indexation that is necessary to block any change of a specific root as in (28) is more reminiscent of the locally restricted constraint indexation in, for example, Pater (2010) where an indexed constraint can only access phonological structure that at least contains some phonological material of the morpheme it is indexed to.

[27] Sources: Hiaki (Haugen, 2003), Tepecano (Mason, 1916, 328-330), Jamul Tiipay (Miller, 2001, 105), Nuer (Frank, 1999, §3.2.1), Alabama (Hardy and Montler, 1988, §3), Murle (Arensen, 1982, 40-46), Dinghai (Lin, 2004), Hiaki (Haugen, 2003), Tawala (Ezard, 1984, 63-65), Amuzgo (Kim, 2016), Sacapultec (DuBois, 1981, 187-188), Zuni (Newman, 1965, 57), Muylaq' Aymara (Coler, 2010, 74), Japanese (Rosen, 2016).

A similar argumentation holds for a TAF account: If it is assumed that there are also transderivational faithfulness constraint selected by certain morphemes, those could block certain NSET demanded by antifaithfulness constraints. In contrast to the RMT solution sketched in (28), this would not imply a different type of constraint indexation but simply enrich the theory with transderivational faithfulness constraints subcategorized for by certain morphemes.

In the classical CP architecture that is restricted by the SBM, it is clear that only the current morphological construction provides a cophonology; it is hence impossible that several cophonologies of embedded morphological structure interact. A CP model can of course be enriched with mechanisms that circumvent Strict Bracket Erasure and hence allow access to internal morphological constituents. One option would be the assumption that certain morphemes form a flat and hence ternary branching structure with their base (e.g. Orgun, 1996). Another solution would be the assumption of phase-based optimization as in Cophonology by Phase theory (cf. 4.4) which predicts that multiple morphemes can contribute to a cophonology and hence influence each other as long as they are part of the same syntactic phase. Consequently, patterns like (28) are taken as an important argument for the model of Cophonologies by Phase in Sande (2020). It is an open empirical question whether all instances of LNSA are indeed co-conditioned by morphemes that are part of the same independently motivated syntactic phase and hence would fall out in this model. In addition, a real argument for this wider visibility window would involve LNSA that involves morphemes that are phonologically non-adjacent (but within a phase) – none of the instances in (27) are of this type.

In a GNA account, LNSA can in principle follow from true phonological interaction of non-segmental affixes with other phonological contrastive specifications. Underspecification is one central representational mechanism that allows to explain why certain morphemes undergo a certain phonological process but others do not (e.g. Inkelas, 1995; Krämer, 2001) and can easily be extended to NSM where it predicts LNSA. Zimmermann (2017*b*), for example, shows how contrasts in underlying prosodic structure can predict different behaviour if a non-segmental affix is added and presents analyses for LNSA in Alabama and (parts of the pattern in) Jamul Tiipay. Subtraction in Alabama, for example, is analysed as an affixed empty syllable that remains defectively integrated and triggers non-realization of all material it dominates. In the default case, it dominates a vowel and a consonant (=rhyme deletion) but if the final segments of a root are underlyingly already integrated into a syllable node, it can only result in consonant deletion since the vowel is protected by its association to an underlying syllable node. It of course less straightforward how contrastive underlying specifications can predict the full picture of LNSA, especially cases of complex tonal LNSA exemplified with Amuzgo. A promising approach for complex patterns like these is to enrich a GNA approach with the assumption of Gradient Phonological Representations (Smolensky and Goldrick, 2016) and basically extend the LNSA approach presented in Rosen (2016) for Japanese rendaku to more complex cases. If it is indeed the case that all LNSA involve morphemes that are phonologically adjacent, a GNA account predicts such a restriction easily if phonological elements cannot re-order and be linearized in a different position on their tier – an important difference to the predictions of a Cophonology by Phase solution discussed above.

5 Summary

The discussion in section 4 pointed out various potential challenges for different classes of accounts predicting NSM but also concluded at various points that the ultimate verdict for one or against the other approach might still be an open question. An example is the fact that only the two constructionist approaches of TAF and RMT have a designated mechanism for morphophonological Polarity and Metathesis whereas GNA can only predict certain types of Polarity and Metathesis as an epiphenomenon of other processes (cf. section 4.1). The discussion of the putative Jamul Tiipay length Polarity illustrated how important a careful investigation of the relevant phonological and morphological facts is to prove that an apparent process is indeed what it looks like at first sight. Detailed case studies of the rare cases of apparent morphological

Polarity and Metathesis hence have to decide whether the re-analyses of certain surface "Polarity" and "Metathesis" effects possible in GNA are in fact sufficient to describe all putative cases of these non-base-extending NSET without a fixed target.

Another example was the discussion of an apparent locality restriction in sections 4.2, 4.4, and 4.6. If it is indeed the case that NSM is phonologically local and restricted to certain edge positions of its base, all three constructionist approaches discussed here are overgenerating whereas a GNA account can predict such a restriction from a general theory of infixation that excludes phonological dislocation. And when it comes to morphological locality, all strictly cyclic approaches are potentially too restrictive since they can only predict NSM conforming to the SBM. In addition, an account of LNSA requires an "allomorph" selection prior to the phonological module responsible for NSM. In contrast, a non-cyclic GNA approach can predict NSM that targets a morphologically more outwards constituent and also predicts that different non-segmental morpheme representations can interact and result in cooperative or blocking LNSA. These three areas all require more extensive typological studies to make a definite argument for one or the other phonological and morphological locality restriction.

The methodological conclusion from this chapter is thus that the diverse phenomenon of NSM is still in need of both more representative typological studies of NSET and more careful in-depth analyses of empirical generalizations in single languages.

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