Irreducible parallelism in phonology: evidence for lookahead from Mohawk, Maragoli, Sino-Japanese, and Lithuanian

Abstract

McCarthy (2013) asks whether there are phonological systems necessitating *irreducible parallelism* in grammar—systems requiring that multiple changes to the input apply in parallel, in a single derivational step. Such systems would necessitate a framework with *lookahead*: the ability to see from a given derivational step the results of applying multiple changes. This paper makes the following claims: (i) a variety of systems across languages, involving a diverse array of processes, require lookahead; (ii) these systems share the same abstract structure, despite superficial differences. Our evidence comes primarily from the distribution of stress, lengthening, and epenthesis in Mohawk; reduplication and hiatus repair in Maragoli; syncope and gemination in Sino-Japanese; and assimilation and epenthesis in Lithuanian. All these systems involve what we call a COMPARISON OF PROCEDURES. To best satisfy constraints, the grammar applies one change followed by another, unless the final result is dispreferred. In such a case, the grammar instead applies a different series of changes. We make the argument for lookahead in grammar by comparing the ability of two frameworks—Parallel Optimality Theory and Harmonic Serialism—to capture these systems. We show that Parallel OT captures them naturally, as it permits lookahead and therefore allows the grammar to compare entire procedures. HS, on the other hand, is challenged by them, as it forbids lookahead and thus does not permit the grammar to compare entire procedures unless the changes involved are specified to apply in a single derivational step. That the problem arises in connection with a diverse array of processes suggests that lookahead is not merely the reflex of a single exceptional phenomenon, but rather is a property of the grammar as a whole.

Keywords: lookahead, parallelism, Optimality Theory, Harmonic Serialism, Mohawk, Maragoli

1. Introduction

A recurring question in phonology is whether the grammar can look ahead to the result of applying multiple changes to the input. Theoretical frameworks differ with regard to whether or not they permit lookahead in grammar: lookahead capability constitutes a central feature in certain frameworks such as Parallel Optimality Theory, Harmonic Grammar and its non-serial versions (Smolensky & Legendre 2006 *et seq*), and Optimality Theory with Candidate Chains (McCarthy 2007, Wolf 2011 *et seq*); but other frameworks, including Harmonic Serialism, Serial Harmonic Grammar (Pater 2012 *et seq*), and traditional versions of SPE (Chomsky & Halle 1968), forbid lookahead, positing derivations and requiring decisions to be made without reference to future derivational steps. In the constraint-based framework of Parallel Optimality Theory (henceforth Parallel OT; Prince and Smolensky 1993/2004), for example, GEN can generate candidate outputs that differ from the input by an unbounded number of changes (assign stress, lengthen vowel, spread feature across segments, etc.). All candidates are compared in a single input-output mapping. As a result, the grammar has full lookahead: the ability to base decisions on the result of applying multiple changes to the input. On the other hand, in the serial instantiation of Optimality Theory, Harmonic Serialism (henceforth HS; McCarthy 2010a, McCarthy and Pater 2016, and references therein), GEN generates candidate outputs that differ from the input by at most one change. Constraint satisfaction is gradual: each successive input in a series of linearly ordered input-output mappings, or steps, differs from the previous one by at most one harmonically improving change (also called an operation; McCarthy 2010a, b). Within each step, the decision as to which candidate is optimal is made solely based on the candidates present at that step. That is, the grammar has no lookahead—no information about what candidates become available at subsequent steps of the derivation.

McCarthy (2013) asks whether there truly are phonological systems necessitating *irreducible parallelism* in grammar: that is, systems that require that multiple changes to the input apply in parallel, in a single derivational step. Prince & Smolensky (1993/2004) and McCarthy & Prince (1995) have argued that reduplication-repair phenomena as well as top-down interactions in stress systems necessitate parallel derivation as in Optimality Theory. Recently, however, McCarthy, Pater & Pruitt (2016) and McCarthy, Kimper & Mullin (2012) respectively show that the serial framework HS can express top-down interactions and reduplication-repair phenomena. Walker (2010) argued for parallel derivation based on a set of metaphony patterns, but Kimper (2012) shows that HS can derive them too, using constraints independently needed to capture typological generalizations about harmony. Hence, it remains an open question whether grammatical architectures with or without lookahead are more adequate empirically.

This article revives the question of whether the grammar has lookahead, and argues that it does. In particular, we argue that a variety of phonological systems across languages, involving a diverse array of processes, suggest that lookahead is needed in grammar. Moreover, we demonstrate that these cases all share the same underlying structure.

To illustrate here the basic thrust of our arguments, we present the case of Mohawk stress (Michelson 1988, 1989). In Mohawk, all words have a strictly bimoraic foot (Rawlins 2006 and REDACTED 2016). In environments where a closed syllable is footed, a monosyllabic foot is built, regardless of whether the syllable is occupied by an underlying or epenthetic vowel (the latter of which is transcribed as [e̲] below):

(1) **Underlying vowel** — **Epenthetic vowel**
/k-atirut-haʔ/ → [kati(ˈrut)haʔ] — /wak-nyak-s/ → [wa(ˈke̲n)yaks]

In environments where an open syllable is footed, one of two bimoraic foot shapes is formed, depending on whether the penult vowel is underlying or epenthetic (2). Bimoraic footing is guaranteed through one of two sets of changes, or PROCEDURES, as shown in the informal serial schema in (3). If the vowel is underlying, then a monosyllabic foot is built, and the tonic vowel is lengthened (3a). But if the vowel is epenthetic, then footing and lengthening would result in a long epenthetic vowel; hence, a disyllabic trochee is built instead (3b). The grammar must therefore look ahead to the result of footing *and* lengthening to determine which foot shape is to be formed.

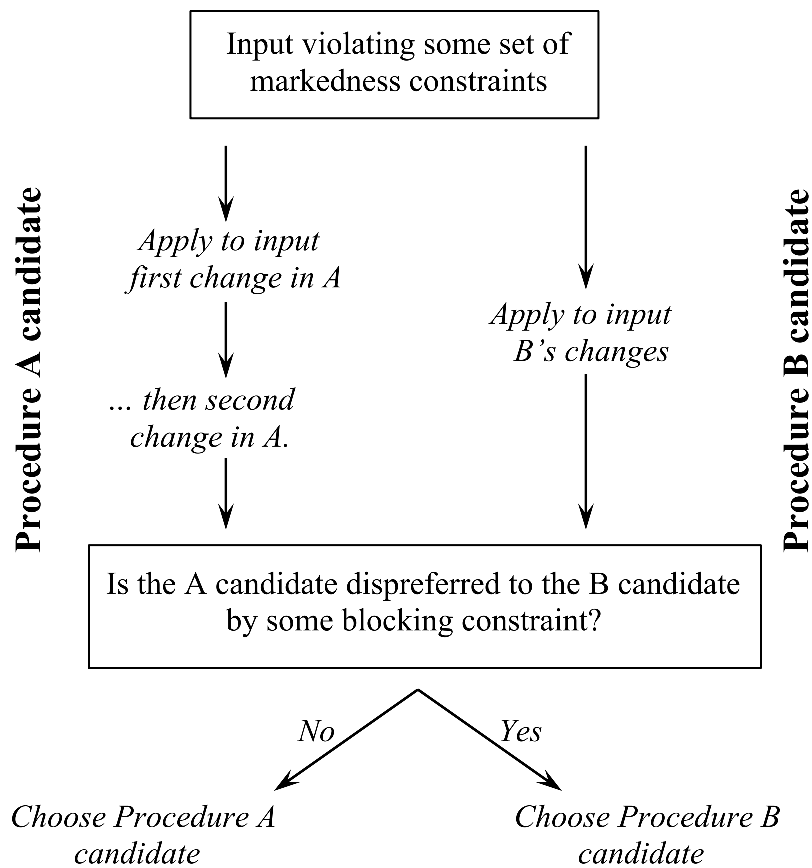
(2) **Underlying vowel** — **Epenthetic vowel**
/k-haratat-s/ → [kha(ˈraː)tats] — /te-k-rik-s/ → [(ˈte.ke̲)riks]

(3) a. *Build monosyllabic foot…* — *then lengthen tonic vowel.*
k-haratat-s → kha(ˈra)tats — kha(ˈra)tats → kha(ˈraː)tats

b. *Build disyllabic foot instead*
te-ke̲-rik-s → (ˈte.ke̲)riks, *te(ˈke̲ː)riks

The analysis of Mohawk involves what we call a COMPARISON OF PROCEDURES, displayed graphically in (4). To best satisfy constraints, the grammar applies one change followed by another (Procedure A), unless the total result is dispreferred. In such a case, the grammar instead applies a different set of changes (Procedure B).

(4)



An analysis based upon a comparison of procedures requires a theory that permits the grammar to look ahead to the result of applying multiple changes to the input. In particular, the grammar must look ahead to the final result of Procedure A to assess whether a constraint disprefers it, and apply Procedure B in the event that it does.

We claim that, in a number of languages, capturing the distribution of phonological processes requires that the grammar be able to compare entire procedures, and thus be able to look ahead to the result of applying multiple changes to the input. The systems of processes we focus on primarily are stress assignment and epenthesis in Mohawk, reduplication and hiatus repair in Maragoli, deletion and gemination in Sino-Japanese, and assimilation and epenthesis in Lithuanian. We make our argument by comparing the ability of two frameworks—Parallel OT and HS—to capture these systems. We show that Parallel OT captures them naturally, as it crucially permits lookahead and therefore allows the grammar to compare entire procedures. We contend that HS, on the other hand, is challenged by these systems, as it forbids lookahead: due to its gradualness requirement, it does not permit the grammar to compare entire procedures unless the changes involved are allowed to apply in a single derivational step. These changes are therefore irreducibly parallel, in the sense of McCarthy (2013). We examine possible reanalyses of these systems within HS, and show that they either fail to capture the data or miss significant generalizations. That the problem arises in connection with a diverse array of phonological processes suggests that lookahead is not merely the reflex of a single exceptional phenomenon (e.g., syllabification; McCarthy 2010b), but rather is a property of the grammar as a whole.

Some of the parallel analyses presented here have been motivated in prior literature, but so far have not been recognized to involve a comparison of procedures, and thus have not been recognized to pose problems for serial derivation. Our discussion of the novel observation that they involve a comparison of procedures is intended to make it easier for other researchers to recognize the need for such comparisons—and thus for a framework with lookahead capability—in other empirical domains.

This paper is organized as follows. Section 2 presents data on the distribution of footing, lengthening, and epenthesis in Mohawk, and motivates an analysis for them based on a comparison of procedures. We show that our analysis can be expressed in Parallel OT but not in HS, and further argue that it is superior to alternative serial analyses. In Section 3, we provide the abstract schema for a comparison of procedures. The rest of the paper shows that a variety of systems across languages, involving a diverse array of processes, each involve a comparison of procedures, fitting into the schema provided in Section 3. Section 4 gives an in-depth investigation into the distribution of reduplication and hiatus repair in Maragoli, while Section 5 covers syncope and gemination in Sino-Japanese, assimilation and epenthesis in Lithuanian, and other cases. We show that Parallel OT naturally accounts for all cases, but find that HS is challenged by each of them in the same way, due to its gradualness requirement. Section 6 concludes.

2. A comparison of procedures in Mohawk

We introduce the concept of a comparison of procedures with the case of Mohawk stress. We argue that the data must be analyzed by comparing two procedures applied to the input—monosyllabic footing together with vowel lengthening, versus disyllabic footing—and that to correctly account for the distribution of these procedures, the grammar must be able to look ahead to the final result of footing and lengthening. In this way, footing and lengthening are irreducibly parallel.

2.1 The data

All Mohawk data come from Michelson (1988, 1989). The page number is indicated next to each datum; page numbers marked with an asterisk are from Michelson (1989), and otherwise Michelson (1988).[1] Basic Mohawk stress is as follows. If an underlying vowel occupies the penult, then the penult receives stress. If the penult is closed, then no other stress-related

[1] See analyses of Mohawk stress in Michelson (1988, 1989), Potter (1994), Ikawa (1995), Piggott (1995), Hagstrom (1997), Rowicka (1998), Alderete (1999), Rawlins (2006), Houghton (2013), and Elfner (2016). We use the (1988) transcription system, but follow Michelson (1989), Rawlins (2006), and Elfner (2016) in leaving out allophonic processes like /h/ insertion before /rh/. [ʌ] and [u] are front and back nasal vowels, respectively, [y] a palatal glide, and [ts] an affricate.

processes take place (5). If the penult is open, then the tonic vowel is lengthened (6). Note that length is not contrastive in Mohawk, which suggests that vowels are underlyingly short (see Michelson 1988, p. 65).

(5) **Closed penult, underlying penult vowel: penult stress**

a.	/k-atirut-haʔ/	[ka.ti.ˈrut.haʔ]	1A-*pull*-HAB	53
b.	/k-ohar-haʔ/	[ko.ˈhar.haʔ]	1A-*attach*-HAB	53
c.	/te-wak-teny-u/	[te.wak.ˈten.yu]	DU-1P-*change*-STAT	122

(6) **Open penult, underlying penult vowel: penult stress, tonic vowel lengthening**

a.	/k-haratat-s/	[kha.ˈraː.tats]	1A-*lift*-HAB	53
b.	/wak-aruʔtat-u/	[wa.ka.ruʔ.ˈtaː.tu]	1P-*blow*-STAT	59
c.	/k-hyatu-s/	[ˈkhyaː.tus]	1A-*write*-HAB	53
e.	/ka-huweyʌ-Ø/	[ka.hu.ˈweː.yʌ]	NA-*boat*-NSF	142

Furthermore, [e̲] is inserted between the first two members of sequences of three consonants (7), and between oral consonant-sonorant sequences (8) (Michelson *op. cit.*). Like Rawlins (2006), Houghton (2013), and Elfner (2016), we analyze epenthesis in these environments, respectively, as avoidance of complex consonant clusters violating the Sonority Sequencing Principle (Steriade 1982, Selkirk 1984, Clements 1990, *a.o.*), and avoidance of rising sonority across syllable boundaries (i.e., the Syllable Contact Law; Murray and Vennemann 1983, Davis & Shin 1999, Rose 2000, Gouskova 2004 *et seq*).[2]

(7) **Complex consonant cluster avoidance**

a.	/s-k-ahkt-s/	[ˈskah.ke̲ts]	ITER-1A-*go.back*-HAB	135
b.	/wak-nyak-s/	[wa.ˈke̲n.yaks]	1P-*get.married*-HAB	135
c.	/te-k-ahsutr-haʔ/	[te.kah.su.ˈte̲r.haʔ]	DU-1A-*splice*-HAB	142

(8) **Bad syllable contact avoidance**

a.	/wak-ruhyakʌ-Ø/	[wa.ke̲.ruh.ˈyaː.kʌ]	1P-*suffer*-STAT	134
b.	/te-k-raʔnekar-us/	[te.ke̲.raʔ.ne.ˈkaː.rus]	DU-1A-*burst*-HAB	*41
c.	/t-ni-nuhweʔ-s/	[te̲.ni.ˈnuː.weʔs]	1IN-D-*like*-HAB	134

Epenthesis interacts with stress when [e̲] is inserted into the penult. If [e̲] occupies a closed penult, the penult gets stressed (9). If [e̲] occupies an open penult, however, the antepenult gets stressed (10). Finally, if the antepenult is open, the tonic vowel does not lengthen, but rather stays short.

[2] Note that [e̲] does not break up [Cy] and [kw] sequences, despite these sequences violating syllable contact when syllabified apart (Michelson 1988). We leave the extended analysis of Mohawk phonotactics to future research.

(9) **Closed penult, epenthetic penult vowel: penult stress**

a.	/wak-nyak-s/	[wa.ˈke̲n.yaks]	1P-*get.married*-HAB	134
b.	/te-k-ahsutr-haʔ/	[te.kah.su.ˈte̲r.haʔ]	DU-1A-*splice*-HAB	142
c.	/k-rho-s/	[ˈke̲r.hos]	1A-*coat, spread*-HAB	137
d.	/ak-tshe-ʔ/	[aˈke̲t.sheʔ]	1P-*container*-NSF	*42

(10) **Open penult, epenthetic penult vowel: antepenult stress, no vowel lengthening**

a.	/te-k-rik-s/	[ˈte.ke̲.riks]	DU-1A-*put together*-HAB	133
b.	/ʌ-k-r-ʌʔ/	[ˈʌ.ke̲.rʌʔ]	FUT-1A-*put.in*-PUNC	134
c.	/w-akra-s/	[ˈwa.ke̲.ras]	NA-*smell*-HAB	141
d.	/te-ʌ-k-ahsutr-ʌʔ/[3]	[tʌ.kah.ˈsu.te̲.rʌʔ]	DU-FUT-1A-*splice*-HAB	142

Note that the evidence for morpheme-internal epenthesis in (10c-d) is that such forms pattern like forms with epenthesis at morpheme boundaries (e.g. 10a-b) with respect to stress (Michelson 1988, 1989). In (11), for example, [e] alternates for length, rather than stress, in closed versus open syllables, which is typical of underlying vowels. In (12), however, [e̲] alternates with stress, rather than length, which is typical of epenthesis.[4]

(11) **Morpheme-internal [e]: No stress alternation**

a.	/t-ʌ-hsek-teny-u-ʔ/	[tʌh.sek.ˈten.yuʔ]	DU-FUT-2/1-*change*-BEN-PUNC	135
b.	/waʔ-te-k-teny-ʔ/	[waʔ.tek.ˈte.niʔ]	FACT-DU-1A-*change*-PUNC	135

(12) **Morpheme-internal [e̲]: Stress alternation**

a.	/te-k-ahsutr-haʔ/	[te.kah.su.ˈte̲r.haʔ]	DU-1A-*splice*-HAB	142
b.	/te-ʌ-k-ahsutr-ʌʔ/	[tʌ.kah.ˈsu.te̲.rʌʔ]	DU-FUT-1A-*splice*-HAB	142

2.2 The Mohawk comparison of foot-building procedures

Summarizing from above, closed penults in Mohawk always receive stress, whether the penult vowel is underlying (13a) or epenthetic (13b). In open penults, if the penult vowel is underlying, then the penult is stressed, and the tonic vowel is lengthened (13c). If the penult vowel is epenthetic, the antepenult is stressed, and no tonic vowel lengthening occurs (13d). Rawlins (2006) provides an elegant analysis of these facts in terms of the choice between two types of a *bimoraic trochee*, (ˈH) and (ˈL.L) (Mester 1994, Hayes 1995, McCarthy & Prince 1996). For the

[3] Note that vowels are deleted in hiatus contexts (Michelson 1988, 1989).

[4] A reviewer asks if epenthesis could be reanalyzed as deletion. For example, we could say that the underlying form of the 1P morpheme is /wake/, surfacing faithfully in (/wake-nyak-s/, [wa.ˈke̲n.yaks]) (9a) but undergoing hiatus-avoiding deletion in (/wake-aruʔtat-u/, [wa.ka.ruʔ.ˈtaː.tu]) (6b). This analysis is untenable, as it fails to resolve why [e] deletes even in non-hiatus-environments, where deletion would gratuitously violate syllable structure constraints. If /wake/ were underlying, for example, it would be difficult to explain why the final vowel deletes in e.g. [te.wak.ˈten.yu], *[te.wa.ke.ˈten.yu] (5c), in which no adjacent vowel can motivate hiatus repair. See Michelson (1988) for the complete argument.

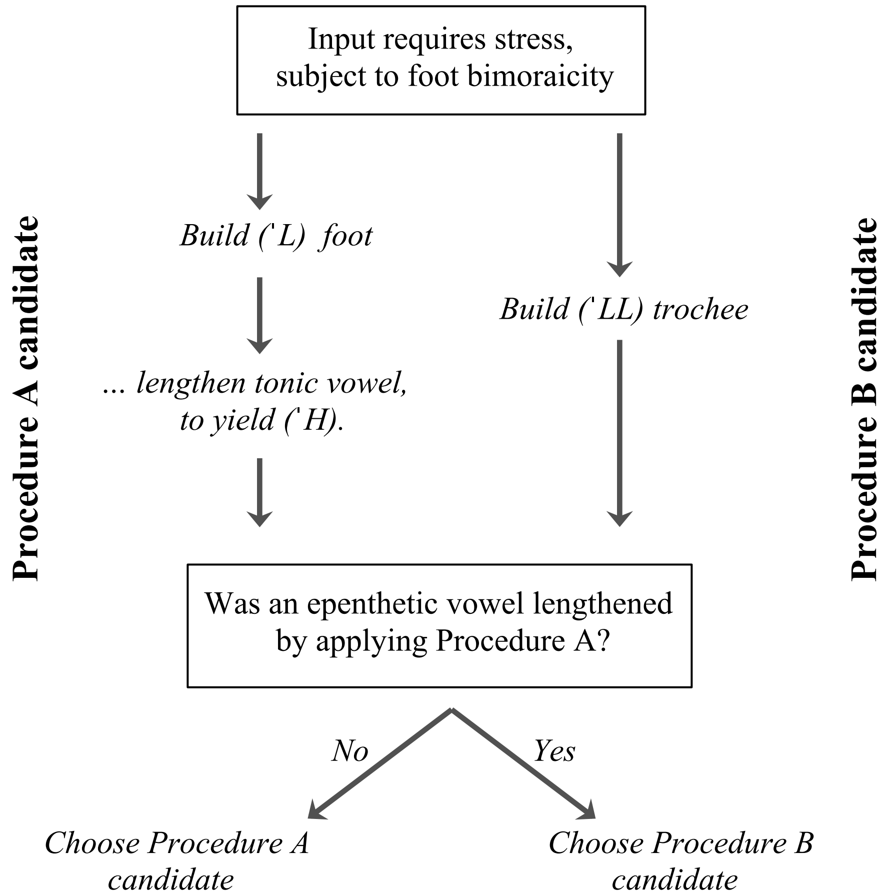
extended defense of the bimoraic trochee in Mohawk, see Rawlins (2006) and REDACTED (2016).

(13)		**Closed penult**			**Open penult**	
Underlying	a.	/CVCVCCV/ /k-atirut-haʔ/	[CV(ˈCVC)CV] [kati(ˈrut)haʔ]	c.	/CVCVCV/ /k-haratat-s/	[CV(ˈCVː)CV] [kha(ˈraː)tats]
Epenthetic	b.	/CVCCCV/ /wak-nyak-s/	[CV(ˈCe̲C)CV] [wa(ˈke̲n)yaks]	d.	/CVCrV/ /te-k-rik-s/	[(ˈCV.Ce̲)rV] [(ˈte.ke̲)riks]

Informally, Rawlins' Parallel OT analysis is as follows. A constraint demanding strictly bimoraic feet is undominated. Normally, this constraint is satisfied by a penult (ˈH), with coda consonants (13a-b) and vowel lengthening (13c) supplying the second mora. But when a constraint against long epenthetic vowels disfavors (ˈH) (e.g. *[te(ˈke̲ː)riks]), an (ˈL.L) trochee is built instead (13d).[5] Rawlins's analysis involves a COMPARISON OF PROCEDURES (formally defined in Section 3): to assess the optimal open penult form, the grammar must compre the final result of applying monosyllabic footing and lengthening to the result of applying disyllabic footing (14). Procedure A consists of monosyllabic footing and vowel lengthening (/k-haratat-s/ → [kha(ˈraː)tats]), while Procedure B consists of disyllabic footing (/te-k-rik-s/ → [(ˈte.ke̲)riks]). Procedure A applies by default, unless the result is a long epenthetic vowel, in which case Procedure B applies.

[5] Bennett (2012) and Houghton (2013) present similar cases involving the optimal choice between (ˈH) and (ˈL.L).

(14) **Mohawk comparison of foot building procedures**



In the following sections, we show that this analysis is easily expressed in Parallel OT, in which changes apply simultaneously, but is recalcitrant in HS, in which changes apply successively.

2.3 Mohawk in Parallel OT

The Mohawk comparison of foot building procedures is straightforwardly expressed in Parallel OT, using the constraints below. We follow Rawlins (2006) in employing FTBINμ, which expresses the preference for bimoraic feet, i.e. (ˈH), (ˈL.L) or (L.ˈL) (15a; Prince & Smolensky 1993/2004; definition from Rawlins 2006, Broselow 2008). We hereafter label this constraint FTBIN.

(15a)	FTBINμ: (hereafter FTBIN)	Assign a violation for each foot having more or less than two morae.

To derive the basic preference for (ˈH) over the other bimoraic feet, we follow Rawlins in employing FTHDR and FTHDL. FTHDL demands alignment of the left edge of the foot head with the left edge of a foot, and FTHDR demands alignment of the right edge of the foot head with the right edge of a foot (15b-c; e.g., Prince & Smolensky 1993/2004, McCarthy & Prince 1993a, Féry 1999, Rawlins 2006). We hereafter label these constraints as TROCHEE and IAMB respectively.

(15b)	FTHDL: (hereafter TROCHEE)	Assign a violation for every syllable intervening between the left edge of the foot head and the left edge of the foot.
(15c)	FTHDR: (hereafter IAMB)	Assign a violation for every syllable intervening between the right edge of the foot head and the right edge of the foot.

TROCHEE and IAMB together have the effect of rendering (ˈH) preferable to (ˈL.L) and (L.ˈL) (16). DEPμ is the low-ranked, violated constraint that militates against vowel lengthening in (ˈH) feet. Note that TROCHEE is omitted from the derivation of the comparison of procedures below, but is assumed to rank above IAMB, as it expresses the fact that (ˈL.L), rather than (L.ˈL), surfaces in environments where (ˈH) is ill-formed.

(16)

		/CVCV/	FTBIN	TROCHEE	IAMB	DEPμ
a.	☞	(ˈCV:)CV				*
b.		(ˈCV:.CV)	*!			*
c.		(ˈCV.CV)			*!	
d.		(CV.ˈCV)		*!		

We employ a few other constraints and rankings to capture other facts about Mohawk stress. NONFINALITY (i.e., the head foot of the prosodic word must not be final; Prince & Smolensky 1993/2004) >> ALIGN-R(Ft, PWd) >> ALIGN-L(Ft, PWd) accounts for the rightward orientation of the foot with respect to the word, taking into account the avoidance of word-final feet (17). We hereafter label these constraints as NONFIN, ALIGNR, and ALIGNL.

(17)

		/CVCVCV/	NONFIN	ALIGNR	ALIGNL
a.		CVCV(ˈCV:)	*!		**
b.	☞	CV(ˈCV:)CV		*	*
c.		(ˈCV:)CV.CV		**!	

Moving on from stress, *COMPLEX and SYLLABLECONTACT (hereafter SYLLCON) >> DEPV chooses candidates with epenthesis into triconsonantal sequences (18) and oral consonant-sonorant sequences (19), respectively.

(18)

		/CVCCCV/	*COMPLEX	SYLLCON	DEPV
a.	☞	CV.C<u>e</u>C.CV			*
b.		CVC.CCV	*!		

(19)

	/CVCrV/	*Complex	SyllCon	DepV
a.	☞ CV.Ce̲.rV			*
b.	CVC.rV		*!	

Finally, we follow Rawlins (2006) in interpreting avoidance of stressing epenthetic vowels in open syllables as avoidance of long epenthetic vowels (27) (see Urbanczyk 2001 for an argument that short vowels are relatively unmarked, as well as Ali et al. 2008, Gouskova & Hall 2009, Davidson 2010 for studies suggesting that epenthetic vowels tend to be shorter than even their short lexical counterparts). Following Rawlins (2006), we express this avoidance as a conjoined constraint against inserting two moras in the domain of the syllable—but hereafter, we label this constraint as DepVː.

(20) Depμ & Depμ_{syll} (= DepVː) — Assign a violation for the presence of two mora in the output that are not present in the input, within the domain of a syllable.

Moving on to the ranking, if an underlying vowel occupies an open penult, then the (ˈH)-building procedure applies (/k-haratat-s/ → [kha(ˈraː)tats]) (21). This is captured with FtBin, Iamb >> Depμ.

(21)

	/CVCVCV/	DepVː	FtBin	Iamb	Depμ
a.	☞ CV(ˈCVː)CV				*
b.	CV(ˈCV)CV		*!		
c.	(ˈCV.CV)CV			*!	

If an epenthetic vowel occupies an open penult, then (ˈL.L) is formed (/te-k-rik-s/ → [(ˈte.ke̲)riks]). DepVː >> Iamb rules out (ˈH) (22a~b), while FtBin >> Iamb rules out (ˈL) (22a~c).

(22)

	/CVCCV/	DepVː	FtBin	Iamb	Depμ
a.	☞ (ˈCV.Ce̲)CV			*	*
b.	CV(ˈCe̲ː)CV	*!			**
c.	CV(ˈCe̲)CV		*!		*

Thus, FtBin, DepVː >> Iamb successfully captures the choice between the two bimoraic foot-building procedures in Parallel OT.

As a final remark, forms with underlying vowels (/k-atirut-haʔ/ → [kati(ˈrut)haʔ]) or epenthetic vowels (/wak-nyak-s/ → [wa(ˈke̲n)yaks]) in a closed penult are trivially derived using the constraints and rankings already motivated. Neither profile could result in a long epenthetic vowel, and so (ˈH) surfaces on the penult, satisfying FtBin, Trochee and Iamb, and violating AlignR minimally to satisfy NonFin.

2.4 Mohawk in Harmonic Serialism

In this section, we show that under no ranking of the constraints introduced in Section 2.3 can HS express the comparison of bimoraic foot-building procedures. We make a proof by contradiction (McCarthy 2010b): the ranking needed to derive forms undergoing one procedure contradicts the ranking needed to derive forms undergoing the other.

In HS, the (ˈH)-building procedure requires two steps (*cf.* McCarthy 2008b, Pruitt 2012). First, a monomoraic foot is built (23a), and then lengthening takes place (23b).

(23) a. Step 1: /CVCVCV/ → CV(ˈCV)CV *Footing*
b. Step 2: CV(ˈCV)CV → [CV(ˈCV:)CV] *Lengthening*

For CV(ˈCV)CV to win at Step 1, it must beat (ˈCV.CV)CV. Because the former has a (ˈL) foot while the latter (ˈL.L), the former can only win if FTHDR outranks FTBIN (24).

	Step	/CVCVCV/	DEPV:	IAMB	FTBIN	DEPμ
(24) a.	1	☞ CV(ˈCV)CV			*	
b.	1	(ˈCV.CV)CV		*!		

IAMB >> FTBIN expresses a preference for (ˈL) over (ˈL.L) feet. This ranking was not required in the Parallel OT derivation, and it contradicts Rawlins (2006)'s proposal that FTBIN is strictly undominated. Nonetheless, the derivation converges on the correct form; in Step 2, FTBIN chooses (25a).

	Step	CV(ˈCV)CV	DEPV:	IAMB	FTBIN	DEPμ
(25) a.	2	☞ CV(ˈCV:)CV				*
b.	2	CV(ˈCV)CV			*!	

The derivation of (ˈH) entails IAMB >> FTBIN. While this ranking does not make the wrong prediction for (ˈH)-forms, the opposite ranking is required for the derivation of (ˈL.L)-forms (26). For the candidate in (26b) to win, FTBIN must rank above IAMB. Thus, the derivations of (ˈL.L) versus (ˈH) entail a ranking paradox between IAMB and FTBIN.

	Step	/CVC<u>e</u>CV/[6]	DEPV:	IAMB	FTBIN	DEPμ
(26) a.	1	💣 CV(ˈC<u>e</u>)CV			*	
b.	1	☹ (ˈCV.C<u>e</u>)CV		*!		

DEPV: cannot play the role of eliminating the monosyllabic candidate (26a), as it is not violated in this step. Rather, only in the following step, when lengthening does apply, is DEPV: violated

[6] We say 'Step 1' here for expository ease—in fact, we assume that epenthesis applied in a previous step. In 2.5.1, we consider an HS-based analysis of Mohawk that abandons the assumption that epenthesis precedes stress.

(27a).[7] But at this point in the derivation, it is too late to select (ˈL.L), as (ˈH) was already chosen. Either (27a) or (27b) will win, depending on the relative ranking of FTBIN and DEPV:.

(27)

	Step	/CV(ˈCe̲)CV/	DEPV:	IAMB	FTBIN	DEPμ
a.	2	💣 CV(ˈCe̲:)CV	*			*
b.	2	💣 CV(ˈCe̲)CV			*	

In other words, the grammar cannot see from Step 1 that subsequent lengthening would result in a long epenthetic vowel. Thus, footing and lengthening must apply in the same step, so that the (ˈH)-building procedure and the (ˈL.L)-building procedure can be compared, and their distribution derived. That is, footing and lengthening are irreducibly parallel.

2.5 Counter-analyses: in defense of Mohawk as a comparison of procedures

In the previous section, we showed that the comparison of bimoraic foot-building procedures analysis of Mohawk is incompatible with HS. In this section, we show that alternative serial analyses of the phenomenon fall short in capturing the data treatable in the Parallel OT analysis. This supports the claim that the stress-epenthesis interaction is best accounted for by comparing whole procedures.

Elfner (2016) offers an analysis of Mohawk stress couched within HS. Following Michelson's (1988, 1989) rule-based analysis, Elfner understands the variable location of stress in Mohawk to be the result of differential ordering of epenthetic processes relative to stress assignment. Epenthesis into CCC clusters occurs before stress assignment, yielding penult stress, while epenthesis into Cr clusters occurs after stress assignment, yielding antepenult stress (28).

(28)

Underlying Form	/wak-nyaks/	/wak-ras/
CCC-insertion	wa.ke̲n.yaks	-
PenultStress	wa.ˈke̲n.yaks	ˈwak.ras
Cr-insertion	-	ˈwa.ke̲.ras
Surface Form	[wa.ˈke̲n.yaks]	[ˈwa.ke̲.ras]

This analysis is naturally expressed in in HS. The constraint driving CCC-insertion, *COMPLEX, outranks the constraint driving stress application, PWDHD. This ranking compels insertion before stress assignment at Step 1 (29). In the following step, stress application applies (30).

(29)

	Step	/wak-nyaks/	*COMPLEX	PWDHD	SYLLCON
a.	1	☞ wa.ke̲n.yaks		*	
b.	1	ˈwaknyaks	*!		

[7] In order to properly assign violations to long epenthetic vowels, we assume that DEPV: can compare the outputs of intermediate mappings to the underlying form. Otherwise, the analysis has no chance of succeeding. See Hauser, Hughto & Somerday (2016) for a defense of faithfulness constraints in HS that compare outputs to underlying forms.

	Step	/wa.ke̲n.yaks/	*COMPLEX	PWDHD	SYLLCON
(30) a.	2	☞ wa.ˈke̲n.yaks			
b.	2	wa.ke̲n.yaks		*!	

The constraint driving Cr-insertion, SYLLCON, is ranked below PWDHD. Thus, penult stress assignment occurs at Step 1 (31). At Step 2, epenthesis occurs, resulting in antepenult stress (32).

	Step	/wak-ras/	*COMPLEX	PWDHD	SYLLCON
(31) a.	1	☞ ˈwak.ras			*
b.	1	wa.ke̲.ras		*!	

	Step	/ˈwak.ras/	*COMPLEX	PWDHD	SYLLCON
(32) a.	2	☞ ˈwa.ke̲.ras			
b.	2	wak.ras			*!

Elfner demonstrates a novel application of HS, deriving the above data using opaque derivations in which the surface stress position differs from the position of stress at the point of application. Nonetheless, a process of [a̲]-insertion demonstrates that the choice of foot types, rather than opacity, drives Mohawk stress.

[a̲] is inserted to break up any consonant clusters surrounding the noun-verb boundary in noun incorporation (33), and the boundary between a verb and a derivational suffix (34) (Michelson *op. cit.*).

(33) **[a̲]-insertion: Noun Incorporation**[8]

a.	/wak-nuhs=yʌ-Ø/	[wakˈ.nuh.sa̲.yʌ]	1P-*house-own*-STAT	158
b.	/hra-atʌ-yen=rho-s/	[ra.tʌ.ye.ˈna̲r.hos]	MA-SRF-*oil-spread*-HAB	157
c.	/te-hs-aʔar=rik-Ø/	[teh.sa.ˈʔaː. ra̲.rik]	DU-2A-*curtain-put together*-IMP	*48

(34) **[a̲]-insertion: Verb Derivation**

a.	/k-r=kw-as/	[ke̲.ˈra̲k.was]	1A-*fill-in*-UNDO-HAB	158
b.	/te-wak-iʔtsyuk=nyu-s/	[te.wa.kiʔt.syu.ˈka̲n.yus]	DU-1P-*sneeze*-DISTR-HAB	158
c.	/te-wak-ateryʌʔtakary=ht-u/	[te.wa.ka.te.ryʌʔ.ta.kar.ˈya̲h.tu]	DU-1P-be annoyed-CAUS-STAT	158

Evidence that [a̲] must be epenthetic, rather than underlying, is that [a̲] patterns like an epenthetic vowel, rather than underlying [a], with respect to stress ((35) versus (36)).[9]

[8] Following Michelson (1989), we gloss morpheme boundaries where [a̲] is inserted with '='.

(35) **Underlying [a]: No stress alternation**

a.	/k-ohar-haʔ/	[ko.ˈhar.haʔ]	1A-*attach*-HAB	53
b.	/yo-rist-aʔnʌtak-u/	[o.ris.taʔ.nʌ.ˈtaː.ku]	NP-*iron-stick*-STAT	164

(36) **Epenthetic [a̲]: Stress alternation**

a.	/ka-kuw=r-aʔ/	[ka.ˈkuː.wa̲.raʔ]	NA-*face-in*-NSF	164
b.	/k-at-nuw=yʌ-s/	[ka.te̲.ˈnuː.wa̲.yʌs]	1A-SRF-*muddy.water-put*-HAB	158

With respect to stress, [a̲] patterns nearly exactly like [e̲] with respect to the openness versus closedness of syllables. In particular, if [a̲] occupies a closed penult, the penult is stressed (37). If [a̲] occupies an open penult, the antepenult is stressed (38). The one difference between [a̲]- and [e̲]-epenthesis is that if [a̲] occupies an open penult, then tonic-vowel lengthening takes place, even though it does not in [e̲]-epenthesis (e.g., [ka.ˈkuː.wa̲.raʔ] versus [ˈte.ke̲.riks]). REDACTED (2016) provides an analysis of this asymmetry in terms of avoidance of highly sonorous [a] in the non-head of a foot (e.g. *[ka(ˈku.wa̲)raʔ]; see de Lacy 2006).

(37) **[a̲] in closed penult: Penult stress**

a.	/hra-atʌ-yen=rho-s/	[ra.tʌ.ye.ˈna̲r.hos]	MA-SRF-*oil-spread*-HAB	157
b.	/k-r=kw-as/	[ke̲.ˈra̲k.was]	1A-*fill.in*-UNDO-HAB	158
c.	/te-wak-iʔtsyuk=nyu-s/	[te.wa.kiʔt.syu.ˈka̲n.yus]	DU-1P-*sneeze*-DISTR-HAB	158

(38) **[a̲] in open penult: Antepenult stress, tonic vowel lengthening if antepenult open**

a.	/k-at-nuw=yʌ-s/	[ka.te̲.ˈnuː.wa̲.yʌs]	1A-SRF-*muddy.water-put*-HAB	158
b.	/te-hs-aʔar=rik-Ø/	[teh.sa.ˈʔaː. ra̲.rik]	DU-2A-*curtain-put.together*-IMP	*48
c.	/ka-kuw=r-aʔ/	[ka.ˈkuː.wa̲.raʔ]	NA-*face-in*-NSF	164
d.	/yo-swʌhk=r-aʔ/	[os.ˈwʌh.ka̲.raʔ]	NP-*board-in*-NSF	165

The fact that [a̲] and [e̲] *both* correlate with antepenult stress when occupying open penults highlights the explanatory failure of the HS account. If the location of stress is due to differential ordering of two epenthetic processes with respect to stress assignment, then there must be two distinct epenthetic processes. For [e̲]-insertion, one could claim that this is the case: [e̲] is inserted into CCC clusters prior to stress assignment, and into Cr-clusters after stress assignment (as in (28) above). The same cannot be said for [a̲]-insertion; there is a single process of insertion into clusters, always at the = boundary. Calling the constraint driving the process *C=C, no ranking of *C=C relative to PWDHD makes the right predictions: *C=C >> PWDHD predicts universally penult stress (/k-at-nuw=yʌ-s/ → kat.nu.wa̲.yʌs → *kat.nu.ˈwa̲.yʌs; (38a)), while

[9] Though we do not treat the qualities of the different epenthetic vowels in our analysis, we follow Rawlins (2006) in attributing the difference in quality between [e̲] & [a̲] is related to the latter's appearance at these boundaries. See Rawlins (2006) for an analysis of these facts.

PWDHD >> *C=C universally predicts antepenult stress (/te-wak-iʔtsyuk=nyu-s/ → te.wa.kiʔt.ˈsyu.k=nyus → *te.wa.kiʔt.ˈsyu.kan.yus; (37c)). For the HS account to extend to [a̲]-insertion, one would have to posit arbitrarily different processes of [a̲]-insertion, one *post hoc* process whose driving constraint is ranked above PWDHD in all cases of penult stress, and another *post hoc* process whose driving constraint is ranked below PWDHD in all cases of antepenult stress.

The foot-based Parallel OT analysis posits that a surface structure, i.e. the openness versus closedness of the syllable that the epenthetic vowel occupies, predicts the location of stress, while the HS analysis posits that an underlying structure, i.e. the consonant clusters that compel epenthesis, predicts the location of stress. The stress pattern for [a̲]-insertion shows that the former is borne out: when [a̲] is in a closed penult, the penult receives stress; and when [a̲] is in an open penult, the antepenult receives stress.

The Parallel OT analysis we invoke for these forms is nearly the same as the analysis invoked for forms with [e̲]-insertion. We need little more to account for emergence of antepenult (ˈH) when [a̲] occupies an open penult. We define below *NON-HD$_{FT}$/*a* (simplified from de Lacy 2006), which encodes the preference for low sonority segments in the non-head position of a foot (39). A tableau for these forms is given in (40) below. *NON-HD$_{FT}$/*a* >> ALIGNR prefers a less right-aligned foot over leaving [a̲] in the non-head position of a foot (40a~b).[10] DEPV: >> ALIGNR prefers a less right-aligned foot over a long epenthetic vowel (40a~d), while FTBIN >> ALIGNR prefers a less right-aligned foot over (ˈL) (40a~c).

(39) *NON-HD$_{FT}$/*a*: Assign a violation for a low vowel occupying the nucleus of the non-head syllable of a foot.

(40)

	/CVC=CV/	FTBIN	*NON-HD$_{FT}$/*a*	DEPV:	ALIGNR	IAMB
a.	☞ (ˈCV:)Ca̲CV				**	
b.	(ˈCV.Ca̲)CV		*!		*	*
c.	CV(ˈCa̲)CV	*!			*	
d.	CV(ˈCa̲:)CV			*!	*	

The closed-penult forms with [a̲] are accounted for in the same way that other forms with a closed penult are: [a̲] does not lengthen, and so (ˈH) surfaces on the penult, satisfying FTBIN, TROCHEE and IAMB, and violating ALIGNR minimally to satisfy NONFIN.[11]

[10] Note that *NON-HD$_{FT}$/*a* must make the decision between (40a) and (40b), not IAMB, because ALIGNR must rank above IAMB to derive the choice of (ˈL.L) over antepenult (ˈH) when [e̲] occupies an open penult ([(ˈte.ke̲).riks], *[(ˈteː).ke̲.riks]).

[11] We refer the reader to Rawlins (2006) (pp. 32-36) for arguments against Alderete (1999)'s Parallel OT analysis of Mohawk based on HEADDEP, and a defense of the approach we outline above, based on the avoidance of long epenthetic vowels. Data that challenge the HEADDEP approach for Mohawk in particular involve both [e̲]-epenthesis (Rawlins 2006, pp. 32-33) and minimal word augmentation (Rawlins 2006, p. 36). As it pertains to the latter, for example, avoidance of long epenthetic vowels explains why we see multiple epenthesis, rather than insertion of a long vowel, to resolve monosyllabism (e.g., /s-r-iht-Ø/ → [(ˈi̲.se̲.)riht], *[(ˈse:)riht] 2A-*cook*-IMP). HEADDEP cannot distinguish between these two alternatives (nor can even a tweaked version of HEADDEP targeting open syllables exclusively, as a reviewer brings up). The analysis we adopt can capture the effects without appealing to this constraint. See Elfner (2016) (pp. 263-265) for other arguments against HEADDEP for the analysis of stress-epenthesis interactions.

2.6 Summary

This concludes our discussion of Mohawk stress. We have argued for: 1) the necessity of an approach to the data that relies on a comparison of procedures to adequately express the generalizations underlying the stress-epenthesis interaction; 2) the necessity of lookahead in grammar to express this comparison of procedures, by comparing the Parallel OT analysis against the relatively unsuccessful HS analysis. Moreover, we show that an HS reanalysis nevertheless fails to solve aspects of the stress-epenthesis interaction. See REDACTED (2016) for the full Parallel OT analysis, which argues for the necessity of the bimoraic foot to capture basic stress, [e̲]-epenthesis, [a̲]-epenthesis and so-called subminimal word augmentation.

3. The general form of a comparison of procedures

The Mohawk stress system is readily analyzable in Parallel OT, but recalcitrant in HS. As we argue in Section 2.2, this is because an adequate analysis of the system involves a COMPARISON OF PROCEDURES: the grammar applies to the input a series of changes, unless the result is dispreferred; in such a case, the grammar applies a different series of changes. We define in (41) a schema of what we view to be the simplest case of a comparison of procedures.

(41) To best satisfy a given set of constraints, the grammar:

by default, applies to the input Procedure A, consisting of at least two changes;

INPUT $\rightarrow A_1 \rightarrow A_2$

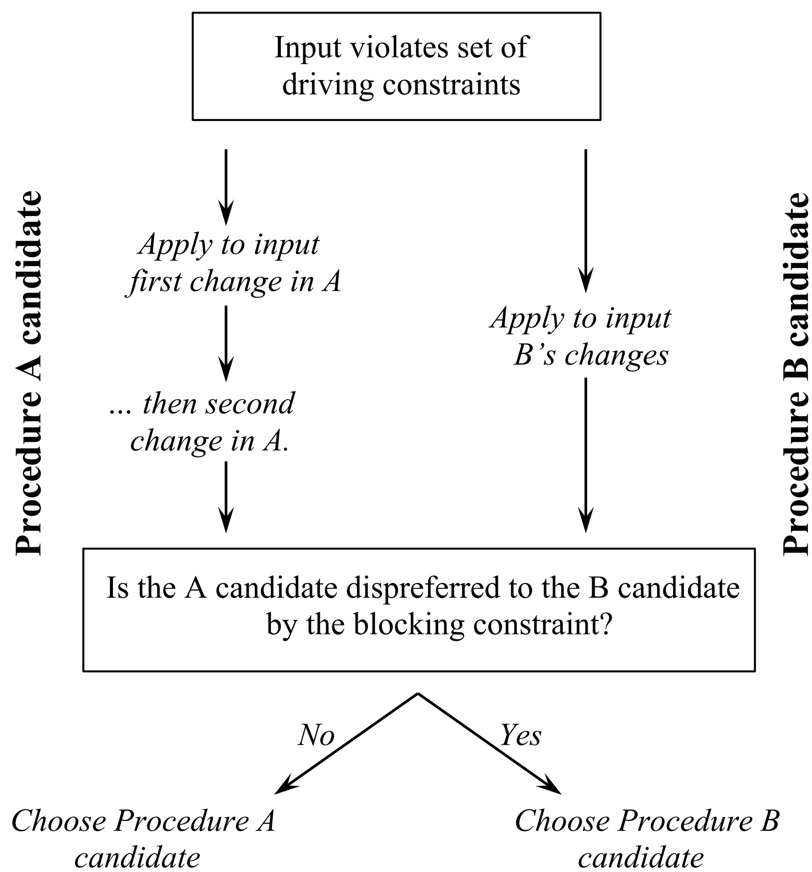
but if the full result of A is dispreferred, then the grammar applies a different procedure, Procedure B.

INPUT $\rightarrow B_1$ where B_1 is distinct from A_1

In (41), A and B cannot have identical first changes: if they did, then we could invoke a serial derivation in which the grammar simply applies A_1 to the input in the first step, and assesses in the second step whether or not to apply A_2 to the consequent, with no sense that the grammar needs to compare an *entire sequence of two or more changes* against another procedure. Note that, though Procedure A must consist of at least two changes, B can consist of zero, one, or more changes—for example, a dataset might necessitate the comparison of two procedures, one of which consists of three changes, and the other zero changes. Finally, we can envision even more intricate scenarios that require comparing procedures: for example, a dataset that necessitates an analysis whereby the grammar applies some change to the input, and thereafter compares the results of whole procedures applying to the consequent. To illustrate such a scenario, an input could undergo change C followed by A_1 and then A_2, unless the final result is dispreferred; in such a case, the input undergoes C followed by B_1. The crucial takeaway here is that at some point in the derivation, the grammar needs to base decisions on the result of applying multiple changes.

We nevertheless return to (41) to elaborate it further. In constraint-based terms, one or more constraints drive a set of inputs to undergo Procedure A or B (e.g., FTBIN in Mohawk drives the formation of some type of bimoraic foot). Procedure A applies by default, forced by some constraint that prefers it to Procedure B (e.g., IAMB in Mohawk, which prefers (ˈH) formation to (ˈL.L) formation). But for some inputs, the result of applying *the entirety of Procedure A* would violate another constraint—which we can call the blocking constraint—more than applying B would; in this case, B applies instead (e.g., DEPV: in Mohawk blocks (ˈH) formation when it would lengthen an epenthetic vowel, in which case (ˈL.L) is formed). In this scenario, candidates displaying entire procedures of changes must be compared: one displaying the full result of A—that is, multiple changes applied to the input—and one displaying the result of B, with A chosen unless the blocking constraint prefers B, in which case B is chosen. This scenario is depicted in the schema in (42) below. Every case discussed in this paper is argued to have this structure: each involves a comparison of procedures.

(42)



An analysis based upon a comparison of procedures requires a theory that permits the grammar to look ahead to the result of applying multiple changes to the input. A number of previously proposed frameworks are capable of expressing comparisons of procedures, including Parallel OT, Harmonic Grammar and its non-serial varieties (Smolensky & Legendre 2006 *et seq*), and OT with Candidate Chains (McCarthy 2007, Wolf 2011 *et seq*). In Parallel OT, for example, multiple changes apply to the input in a single derivational step, and so the grammar has access to whether the fully formed Procedure A candidate violates the blocking constraint, and so can select the Procedure B candidate in case it does. On the other hand, serial frameworks that do not permit lookahead cannot express a comparison of procedures. Examples include HS, classical SPE (Chomsky & Halle 1968), and Serial Harmonic Grammar (Pater 2012 *et seq*). In HS, for example, Procedure A changes apply one at a time, and the grammar cannot look ahead to subsequent steps to assess whether the result of fully applying A would violate the blocking constraint. In theories forbidding lookahead, then, cases claimed to involve a comparison of procedures must be reanalyzed. If no such analysis exists, or if the subsequent non-lookahead analysis fails to reflect using well-established concepts the insights that the lookahead analysis reflect, then the data would constitute evidence for theories that permit lookahead.

In the following sections, we present a variety of cases across languages that are straightforwardly described as involving comparisons of procedures. Like Mohawk, these cases are captured in Parallel OT, but lack an HS analysis that reflects the insights achieved by the lookahead analysis. They involve a diverse array of phonological processes, and so suggest that lookahead is not merely restricted to a single exceptional process applying in parallel with others (e.g., syllabification; McCarthy 2010b), but rather is a property of the grammar as a whole.

4. Paradoxical ordering of reduplication and glide formation in Maragoli

We first present a case, previously unreported in published literature, from Maragoli, a Bantu language spoken primarily in Kenya. A reduplication-repair interaction observed in the possessive paradigm in the language is straightforwardly described as involving a comparison of procedures, and thus constitutes evidence for lookahead in grammar. The language repairs stem hiatus prior to copying, unless the result is a complex onset; in such a case, copying applies first, and then hiatus repair. We summarize the case below, but for the full set of data, thorough analysis of them, and evidence for the psychological reality of the data patterns, see REDACTED (2018).

4.1 The data

The Maragoli data were obtained from a native Maragoli speaker in a UCLA Field Methods class in the winter of 2015. Some of the data below are also given in Leung (1991). In all cases where a form obtained in the class was also found in Leung (1991), the match was perfect.

Maragoli has two productive, entirely systematic hiatus repairs: glide formation (43a-d) and low vowel deletion (44a-b). We illustrate the processes as they apply to various noun-class and noun-class agreement prefixes in the language. Glide formation applies to the agreement prefixes given below when they come before vowels (43a-d). /i e/ and /o u/ surface as [j] and [w], respectively, neutralizing the height contrast between the vowel pairs.[12]

Glide formation

(43a)	vi-ɾa	vj-aːŋgɛ (/vi-angɛ/)	(43b)	e-ɾa	j-aːŋgɛ (/e-angɛ/)
	AGR8-this	AGR8-my		AGR9-this	AGR9-my
(43c)	mu-ɾa	mw-aːŋgɛ (/mu-angɛ/)	(43d)	go-ɾa	gw-aːŋgɛ (/go-angɛ/)
	AGR18-this	AGR18-my		AGR3-this	AGR3-my

[12] In hiatus repairs in the language, the surviving vowel undergoes compensatory lengthening unless it is word-final. In the latter case, lengthening is blocked (e.g., (/vi-a/, [vja]) = AGR8-of). In the data presented below, the vowel surviving hiatus repair is always final, so compensatory lengthening will play no role in the following discussion.

Low vowel deletion applies to the noun-class and noun-class agreement prefixes in (44a-b), so that /a/ elides before vowels:

Low vowel deletion

(44a)	ma-duːma	m-uːva (/ma-uva/)	(44b)	ga-ɾa	g-eːtu (/ga-etu/)
	NCL6-corn	NCL6-sun		AGR6-this	AGR6-1pl.POSS

In addition to hiatus repair, the language also has a process of reduplication to mark second- and third-person possessive categories in the language.[13] (45) displays examples of the possessive paradigm. Note that since all reduplicated forms occur in tandem with hiatus repair, it is impossible to show reduplication in isolation. Second- and third-person singular possessives are characterized by a one-to-many mapping between meaning and form: possession is realized as both a reduplicative prefix and a fixed-segment suffix, -ɔ (see Stonham 1994, Downing & Inkelas 2015 for a similar pattern in Nitinaht, and Hyman 1999 for the same pattern in Kalanga). RED in the glosses below foreshadow the OT-based analysis developed in the next section, in which we follow McCarthy & Prince (1986/1996) in assuming that material is copied into *reduplicants*: morphemes consisting of empty prosodic templates present in the input.

(45)	1p	2p	3p
Sing.	vj-aːŋgɛ AGR8-1sg.POSS 'my'	**viː-vj-ɔ** **RED-AGR8-2sg.POSS** 'your' (sg.)	**viː-vj-ɛ** **RED-AGR8-3sg.POSS** 'his/her/their' (sg.)
Pl.	vj-eːtu AGR8-1pl.POSS 'our'	vj-eːɲu AGR8-2pl.POSS 'your' (pl.)	vj-aːvɔ AGR8-3pl.POSS 'their' (pl.)

To explicate our point about lookahead in Maragoli possessives, it suffices to examine the behavior of only the second-person forms. We set aside third-person forms (see REDACTED 2016) for purposes of brevity. Before presenting the entire set of data to be analyzed in the following discussion, we first discuss three representative second-person possessives, given in (46a-c) below, to motivate the general structure of the underlying forms. In these data, we take the reduplicant to be located word-initially. The reduplicant vowel in all second-person possessives is long, which can be accounted for either with a constraint that forces reduplicant heaviness or by specifying that the reduplicant is underlyingly heavy (see Hayes & Abad (1989) and McCarthy et al. (2012) on heavy reduplication in Ilokano, and Blevins (1996) on heavy reduplication in Mokilese—these investigators take one or the other approach).[14] We opt to specify the reduplicant as underlyingly bimoraic. In (46a), the segmental content of the prefix *vi-* was copied and placed at the beginning of the word, and glide formation applied to the original

[13] Tarok (Robinson 1976), Kalanga (Hyman 1999), and Arosi (Lynch & Horoi 2002) also use reduplication to mark possessive categories.

[14] A merely apparent alternative approach is to say that length is a remnant of compensatory lengthening following hiatus repair in the base. For example, we could envision the following schematic derivation for [jɔː-j-ɔ]: RED-e-ɔ → RED-j-ɔː (glide formation with compensatory lengthening) → jɔː-j-ɔː (copying) → jɔː-j-ɔ (final vowel shortening). But [viː-vj-ɔ] and like forms deriving from Ci- prefixes suggest this cannot be the right approach: the copy vowel is long, and yet does not derive from a base vowel that was lengthened at any point in the derivation.

prefix vowel immediately preceding the final vowel. In (46b), the prefix *e*- underwent glide formation immediately before the final vowel, and the glide-vowel sequence was copied and placed at the beginning of the word. Similarly in (46c), the vowel in the prefix *ga*- underwent low vowel deletion immediately before the final vowel, and the resulting consonant-vowel sequence was copied and placed at the beginning of the word.

(46a) /RED-vi-ɔ/ → [viː-vj-ɔ]
RED-AGR8-your

(46b) /RED-e-ɔ/ → [jɔː-j-ɔ]
RED-AGR9-your

(46c) /RED-ga-ɔ/ → [gɔː-g-ɔ]
RED-AGR6-your

(47) displays the general structure of the second person possessives.

(47) /RED-AGR-ɔ/, RED = $\sigma_{\mu\mu}$

In (48), we present the set of second-person singular possessives that the Parallel OT analysis given in the following section accounts for. Possessive-marking reduplication interacts with hiatus repair in intricate, but systematic, ways.

(48)

Noun class	**Agmt. prefix**	**Ex. with prefix**	**2sg poss.**
Examples with glide formation			
1	/o/-	o-ɾa, ‘this’	wɔː-v-ɔ
3	/go/-	go-ɾa, ‘this’	guː-gw-ɔ
5	/ɾi/-	ɾi-lahe, ‘pretty’	ɾiː-ɾj-ɔ
8	/vi/-	vi-ɾa, ‘this’	viː-vj-ɔ
9	/e/-	e-ɾa, ‘this’	jɔː-j-ɔ
10	/zi/-	zi-ɾa, ‘this’	ziː-zj-ɔ
11	/ɾo/-	ɾo-ɾa, ‘this’	ɾuː-ɾw-ɔ
13	/to/-	to-ɾa, ‘this’	tuː-tw-ɔ
14	/vo/-	vo-ɾa, ‘this’	vuː-vw-ɔ
15	/ko/-	ko-ɾa, ‘this’	kuː-kw-ɔ
18	/mu/-	mu-ɾa, ‘this’	muː-mw-ɔ
Examples with low vowel deletion			
2	/va/-	va-ɾa, ‘this’	vɔː-v-ɔ
6	/ga/-	ga-ɾa, ‘this’	gɔː-g-ɔ
12	/ka/-	ka-ɾa, ‘this’	kɔː-k-ɔ
16	/ha/-	ha-ɾa, ‘this’	hɔː-h-ɔ

In the glide formation examples, forms with a CV- prefix behave like (/RED-vi-ɔ/, [viː-vj-ɔ]), while forms with a V- prefix behave like (/RED-e-ɔ/, [jɔː-j-ɔ]). All examples with low vowel deletion behave like (/RED-ga-ɔ/, [gɔː-g-ɔ]). We note that, in forms where a Co- prefix was copied (e.g., /RED-go-ɔ/, [guː-gw-ɔ] RED-AGR3-your), the reduplicant vowel always surfaces as high, even if the prefix is underlyingly mid. Furthermore, in (/RED-o-ɔ/, [wɔː-v-ɔ]), the base prefix undergoes vowel hardening, surfacing as [v] between vowels instead of [w] (see REDACTED 2018).

4.2 Maragoli reduplication and repair as a comparison of procedures

The central argument here is that a satisfactory account of Maragoli possessives involves a comparison of procedures, and thus necessitates a framework that permits lookahead such as Parallel OT. We illustrate this in (49a-b) using informal, schematic derivations of two forms involving reduplication and glide formation, (/RED-vi-ɔ/, [viː-vj-ɔ]) and (/RED-e-ɔ/, [jɔː-j-ɔ]). In (49a), on the one hand, glide formation takes place before copying to derive [jɔː-j-ɔ] from /RED-e-ɔ/:

(49a)	UR	/RED-e-ɔ/	UR	/RED-e-ɔ/
	Glide Formation	RED-j-ɔ	**Copying**	eː-e-ɔ
	Copying	jɔː-j-ɔ	**Glide Formation**	eː-j-ɔ
	SR	[jɔː-j-ɔ]	SR	*[eː-j-ɔ]

In (49b), on the other hand, copying must take place before glide formation, to derive [viː-vj-ɔ] from consonant-initial /RED-vi-ɔ/. This ensures a simplex onset in the reduplicant, avoiding the extra complex onset in *[vjɔː-vj-ɔ].

(49b)	UR	/RED-vi-ɔ/	UR	/RED-vi-ɔ/
	Glide Formation	RED-vj-ɔ	**Copying**	viː-vi-ɔ
	Copying	vjɔː-vj-ɔ	**Glide Formation**	viː-vj-ɔ
	SR	*[vjɔː-vj-ɔ]	SR	[viː-vj-ɔ]

This Maragoli reduplication-repair interaction, then, crucially involves a comparison of procedures. The data can be described as follows: the input undergoes hiatus repair followed by copying, unless the result is a complex onset; in that case, copying applies first, and then repair.[15] We now turn to a Parallel OT analysis of these possessives.

[15] Note that the interaction provides yet more evidence for the emergence of the unmarked (McCarthy & Prince 1994), in the sense that onsetless syllables and consonant-glide onsets are allowed in stems but avoided in reduplicants (*cf.* Steriade 1988, Hayes & Abad 1989 on onset-skipping).

4.3 Maragoli in Parallel OT

We illustrate below the Parallel OT analysis of the three representative possessives given in the prior section: two that show glide formation—(/RED-vi-ɔ/, [viː-vj-ɔ]) and (/RED-e-ɔ/, [jɔː-j-ɔ])—and one that shows low vowel deletion (/RED-ga-ɔ/, [gɔː-g-ɔ] RED-AGR6-your). In Parallel OT these possessives are easy to capture, as it permits the grammar to look ahead and assess the results of applying multiple changes to the input: copying and repair apply in one fell swoop, in whichever way best satisfies onset well-formedness constraints. The data can be accounted for straightforwardly with markedness constraints and faithfulness constraints enforcing input-output and base-reduplicant correspondence (BR-correspondence; see McCarthy & Prince 1995, 1997 for an introduction) (50). We focus on the forms showing glide formation first. NOHIATUS[16] and MAX-BR drive hiatus repair and copying. MAX-BR prefers a complete copy of the base to a partial copy ([j$_1$ɔː$_2$-j$_1$-ɔ$_2$] $\succ_{\text{MAX-BR}}$ *[eː$_1$-j$_1$-ɔ$_2$]). *COMPLEX blocks full copying where it would yield an extra complex onset; in such a case, partial copying takes place ([v$_1$iː$_2$-v$_1$j$_2$-ɔ$_3$] $\succ_{\text{*COMPLEX}}$ *[v$_1$j$_2$ɔː$_3$-v$_1$j$_2$-ɔ$_3$]).

(50) NOHIATUS: Assign a violation for each sequence of adjacent vowels.
*COMPLEX: Assign a violation for each complex margin.
MAX-BR: Assign a violation for every base segment that lacks a reduplicant correspondent.
IDENT-IO(syll): Assign a violation for every output segment disagreeing with its input correspondent on the value of [syllabic].

The tableaux below illustrate how glide formation and reduplication interact to select (/RED-e-ɔ/, [jɔː-j-ɔ]) and (/RED-vi-ɔ/, [viː-vj-ɔ]). MAX-BR favors full copying (51), but *COMPLEX >> MAX-BR favors partial copying where full copying would result in an extra complex onset (52).

(51)

	/RED-e-ɔ/	NOHIATUS	*COMPLEX	MAX-BR	IDENT-IO(syll)
a.	eː$_1$-e$_1$-ɔ$_2$	*!*		*	
b.	eː$_1$-j$_1$-ɔ$_2$			*!	*
c.	☞ j$_1$ɔː$_2$-j$_1$-ɔ$_2$				*

(52)

	/RED-vi-ɔ/	NOHIATUS	*COMPLEX	MAX-BR	IDENT-IO(syll)
a.	v$_1$iː$_2$-v$_1$i$_2$-ɔ$_3$	*!		*	
b.	☞ v$_1$iː$_2$-v$_1$j$_2$-ɔ$_3$		*	*	*
c.	v$_1$j$_2$ɔː$_3$-v$_1$j$_2$-ɔ$_3$		**!		*

[16] Though ONSET would work just as well for our purposes, see Orie & Pulleyblank (1998) for an argument for NOHIATUS in particular for handling hiatus repairs.

Here we see that reduplication and repair apply in a single step, in whichever way best satisfies onset well-formedness constraints—in the above tableaux, *COMPLEX. Parallel OT can capture these data because it permits the grammar to compare the two ways of applying multiple changes to the input.

The analysis requires little more to account for possessives involving low vowel deletion such as (/RED-ga-ɔ/, [gɔː-g-ɔ] RED-AGR6-your). We use MAXV (53), ranked lower than NOHIATUS so that low vowel deletion applies to resolve hiatus. We see in (54) that [gɔː-g-ɔ] is like [jɔː-j-ɔ], from (51): when *COMPLEX is not under threat of being violated, we get full correspondence between the stem and reduplicant.

(53) MAXV: Assign a violation for each input vowel lacking an output correspondent.

(54)

	/RED-ga-ɔ/	NOHIATUS	*COMPLEX	MAX-BR	MAXV
a.	$g_1aː_2$-g_1a_2-$ɔ_3$	*!		*	
b.	$g_1aː_2$-g_1-$ɔ_3$			*!	*
c.	☞ $g_1ɔː_2$-g_1-$ɔ_2$				*

4.4 Maragoli in Harmonic Serialism

McCarthy, Kimper & Mullin (2012) propose a sub-framework within HS, Serial Template Satisfaction, which captures patterns of reduplication and their interaction with phonology. Following McCarthy & Prince (1986/1996), Serial Template Satisfaction posits templatic morphemes, i.e. empty prosodic templates in the input that segmental content is copied into. Many constraint-based analyses in the past have posited base-reduplicant correspondence to drive copying, but because correspondence plays no role in HS, copying is driven by HEADEDNESS(σ) (abbreviated HD in tableaux), which demands that syllables be headed by segmental content (Selkirk 1995). Moreover, since copying segmental content into the template constitutes an operation in HS, copying violates a faithfulness constraint *COPY(seg) (abbreviated as *COPY in the tableaux). These constraints are defined below. For further explanation of these constraints, see McCarthy, Kimper & Mullin (2012).

(55) HEADEDNESS(σ): Assign a penalty for every syllable that does not contain a segment as its head.
*COPY(seg): Assign a penalty for copying any number of segments into the reduplicant.

We thus compare the Parallel OT account and HS account with the same constraints, except that we now use HEADEDNESS(σ) and *COPY(seg) in place of MAX-BR. Though Serial Template Satisfaction adopts empty prosodic templates as the form of the reduplicant morpheme, Serial Template Satisfaction does not signify RED in its underlying forms, and so below we write underlying forms of possessives with /$σ_{μμ}$/ when we discuss these templates in the context of the HS analysis.

Recall that (/$\sigma_{\mu\mu}$-e-ɔ/, [jɔː-j-ɔ]) requires repair to apply before copying in the serial analysis: $\sigma_{\mu\mu}$-e-ɔ → $\sigma_{\mu\mu}$-j-ɔ → jɔː-j-ɔ. To derive this, we must rank NoHiatus above HD (56a-b).

(56a)

	Step	/$\sigma_{\mu\mu}$-e-ɔ/	NoHiatus	HD	*Complex	*Copy
a.	1	☞ $\sigma_{\mu\mu}$-j-ɔ		*		
b.	1	$\sigma_{\mu\mu}$ (eː)-e-ɔ	*!*			*

(56b)

	Step	$\sigma_{\mu\mu}$-j-ɔ	NoHiatus	HD	*Complex	*Copy
a.	2	$\sigma_{\mu\mu}$-j-ɔ		*!		
b.	2	☞ $\sigma_{\mu\mu}$ (jɔː)-j-ɔ				*

But now since NoHiatus ranks above HD, we can never get the opposite order, namely the reduplication-repair order. To derive [viː-vj-ɔ] from /$\sigma_{\mu\mu}$-vi-ɔ/, HD must be ranked above NoHiatus so that copying applies before glide formation (57). The situation is analogous to the ordering paradox observed in the schematic rule-based derivations in (49a-b): changes driven by HD and NoHiatus cannot be applied in a fixed series, since both orders are required for the full paradigm. HS misses the generalization that reduplication and repair apply in whichever order yields a simplex onset—onset constraints such as *Complex play no role.

(57)

	Step	σ /\ μ μ / -vi-ɔ/	NOHIATUS	HD	*COMPLEX	*COPY
a.	1	💣 σ /\ μ μ -vj-ɔ		*	*	
b.	1	☹ σ /\ μ μ \/ viː-vi-ɔ	*!			*

In the second step of the derivation, the grammar would select \vjɔː-vj-ɔ\ or \$\sigma_{\mu\mu}$-vj-ɔ\ (the latter of which contains an empty reduplicant)—both undesirable intermediate forms—depending on the ranking between HD and *COMPLEX.

The HS account fails to capture the distribution between the repair-reduplication procedure on one hand, and reduplication-repair on the other, as it is unable to look ahead to the results of applying both orders to see which one of them would result in a simplex versus complex onset. Thus, the two processes must be treated as irreducibly parallel: they must apply in the same derivational step in order to capture the distribution between the two conspiring procedures.

4.5 Defense against an HS counteranalysis

A reviewer and an MFM conference audience member posed the question of whether an HS analysis of these data could be made to work if we distinguished word-initial onsetless syllables from onsetless syllables in other positions, so as to derive early repair in (/$\sigma_{\mu\mu}$-e-ɔ/, [jɔː-j-ɔ], *[**e**ː-j-ɔ]) but early copying in (/$\sigma_{\mu\mu}$-vi-ɔ/, [viː-vj-ɔ]). Suppose we used in the HS analysis *#V, which penalizes word-initial onsetless syllables (Flack 2009), together with NOHIATUS, which penalizes word-internal onsetless syllables. This section argues that such an analysis cannot be made to work, at least without even further modifications to the analysis that render it significantly less insightful than the lookahead analysis.

The data displaying reduplication and glide formation can be accounted for in HS by ranking *#V >> HD >> NOHIATUS. In (58a), high-ranking *#V forces repair to apply first to /$\sigma_{\mu\mu}$-e-ɔ/, yielding the intermediate form \$\sigma_{\mu\mu}$-j-ɔ\; in the second step of the derivation not shown, HD would force \$\sigma_{\mu\mu}$-j-ɔ\ to map to \jɔː-j-ɔ\. Moreover, since HD is ranked higher than NOHIATUS, forms like /$\sigma_{\mu\mu}$-vi-ɔ/ would undergo copying first, as in (58b), resulting in the intermediate form \viː-vi-ɔ\; in the second step not shown, repair would apply, yielding \viː-vj-ɔ\ as desired.

(58a)

	Step	σ (μ μ) / -e-ɔ/	*#V	HD	NoHiatus
a.	1	☞ σ (μ μ) -j-ɔ		*	
b.	1	σ (μ μ \ /) eː-e-ɔ	*!		**

(58b)

	Step	σ (μ μ) / -vi-ɔ/	*#V	HD	NoHiatus
a.	1	σ (μ μ) -vj-ɔ		*!	
b.	1	☞ σ (μ μ \ /) viː-vi-ɔ			*

Problematically, this approach fails to account for cases displaying low vowel deletion such as (/$\sigma_{\mu\mu}$-ga-ɔ/, [gɔː-g-ɔ]). The data necessitate that repair apply first, but the ranking above results in copying applying first (59). In the second step of the derivation, the wrong intermediate candidate \gaː-g-ɔ\ would be selected to satisfy NoHiatus.

(59)

	Step	σ /\\ μ μ / -ga-ɔ/	*#V	HD	NOHIATUS
a.	1	☹ σ /\\ μ μ -g-ɔ		*!	
b.	1	💣 σ /\\ μ μ \\/ gaː-ga-ɔ			*

To avoid this outcome, one might resort to breaking NOHIATUS into a set of quality-specific hiatus constraints, e.g. *aV and *[-low]V. Then, with the ranking *#V, *aV >> HD >> *[-low]V, we could derive early hiatus repair in (/$\sigma_{\mu\mu}$-ga-ɔ/, [gɔː-g-ɔ]) via high-ranking *aV, early hiatus repair in (/$\sigma_{\mu\mu}$-e-ɔ/, [jɔː-j-ɔ]) via high-ranking *#V, and early copying in (/$\sigma_{\mu\mu}$-vi-ɔ/, [viː-vj-ɔ]) via HD being ranked higher than *[-low]V. But even this analysis suffers a serious drawback. Constraint-based accounts of diverse repairs in Bantu and beyond have utilized a single NOHIATUS constraint as well as a set of lower-ranked faithfulness constraints to determine the repair for a particular hiatus (Rosenthall 1994; Casali 1995, 1997, 1998; Orie & Pulleyblank 1998; Senturia 1998; Baković 2007). Such an approach captures the fact that the various repairs all conspire to avoid the same output structure from surfacing, namely pairs of adjacent vowels. An analysis that posits quality-specific hiatus constraints dismisses this conspiracy as coincidence, failing to capture the broad generalization that these repairs, though diverse, militate against the same output structure.

4.6 Summary

Summing up, we find that the Maragoli system involves comparing whole procedures, suggesting the need for lookahead in grammar. The input undergoes hiatus repair followed by copying, unless the result is a complex onset; in that case, copying applies first, and then repair. Parallel OT can capture these data, as it permits the grammar to look ahead to the result of applying multiple changes to the input, and assess which candidate would result in a simplex reduplicant onset. On the other hand, HS fails to capture these data, because it applies changes one-by-one in a succession of derivational steps, without permitting the grammar to look ahead; it therefore cannot compare the copy-then-repair procedure against the repair-then-copy procedure to determine which one would result in a simplex onset. A reanalysis that merely distinguishes word-initial onsetless syllables fails to capture the entire dataset, while a reanalysis that subsequently adds quality-specific constraints misses the broad generalization that hiatus repairs conspire to avoid the same output structure, namely hiatus.

5. Additional cases involving a comparison of procedures

In addition to the Mohawk stress and Maragoli reduplication systems, there are a number of other phenomena that have previously been convincingly analyzed whose analysis turns out, as we will show, to involve a comparison of procedures. We first discuss Sino-Japanese root fusion, a phenomenon that has received much attention (e.g., Kurisu 2000, Kawahara et al. 2003, Ito & Mester 2015). The widely adopted analysis has so far not been recognized to involve a comparison of procedures, and thus has not been recognized to pose issues for serial derivation. The novel observation that this analysis involves a comparison of procedures sheds new light on the phenomenon itself, and the discussion of this case here is intended to make it easier for other researchers to recognize the need for comparisons of procedures in other empirical domains. We then discuss assimilation and epenthesis in Lithuanian (Baković 2005, Albright & Flemming 2013), and more briefly nasal spreading and deletion in Gurindji (Stanton to appear) and footing, metathesis, and syncope in Maltese (Anderson 2016), and show that each of the analyses previously motivated for these cases involve comparisons of procedures. All of these cases, which involve phonological processes from a diverse set of domains, convincingly necessitate irreducible parallelism, and therefore suggest that derivational lookahead is not merely a property associated with particular phonological processes (e.g., syllabification; McCarthy 2010b), but with the grammar as a whole.

5.1 Sino-Japanese root fusion

In Sino-Japanese, CVCV roots are commonly compounded together by a procedure called *root fusion* (Ito 1986, Tateishi 1989, Ito & Mester 1996). Representative forms from Ito & Mester (1996) are given in (69) and (70). The boundary-adjacent vowel deletes, and the resulting consonant cluster undergoes gemination (60a, 61a). But whenever this would produce a voiced geminate, the compound surfaces faithfully (60b, 61b).

(60)	*betu*	different	(61)	*niti*	sun
a.	bek-kaku	different style	a.	nip-pi	Japan[17] and the Philippines
	bes-soo	separate mail		nik-kaN	Japan and Korea
b.	betu-bin (*beb-bin)	separate carrier	b.	niti-bei (*nib-bei)	Japan and America
	betu-goo (*beg-goo)	separate issue		niti-maN (*nim-maN)	Japan and Manchuria

The system has been analyzed extensively in Parallel OT (e.g., Kurisu 2000, Kawahara et al. 2003, Ito & Mester 2015), but not in HS. It turns out that the analysis involves a comparison of procedures: apply syncope and gemination unless the result is a voiced geminate; in such a case,

[17] Note that *Nip-pon*, ‘Japan’, literally translates into “sun’s origin”. *niti* ‘sun’, at least when combined with the roots above, means ‘Japan’.

do nothing. The data lend support to a framework that permits the grammar to look ahead to the full result of applying vowel syncope and gemination.

To illustrate the Parallel OT analysis, we adopt the constraints given in Kurisu (2000) (62). Root fusion—that is to say, syncope and gemination—reflects a drive towards small prosodic words and an avoidance of clusters disagreeing in place, expressed by the constraints CODACOND and ALIGN(SYL,L; PRWD, L). Defaulthood of fusion is already enforced by the fact that the other procedure, doing nothing, fails to satisfy ALIGN(SYL,L; PRWD, L). Fusion violates MAXV and IDENT(place). The blocking constraint is *VOIGEM, violated when fusion results in a voiced geminate.

(62)

CODACOND:	Assign a violation for each coda consonant with its own place.
*VOIGEM:	Assign a violation for each voiced geminate.
ALIGN(SYL,L; PRWD, L):	Assign a violation for each left edge of a syllable that does not coincide with that of the prosodic word.
MAXV:	Assign a violation for each input vowel lacking an output correspondent.
IDENT(place):	Assign a violation for each output consonant disagreeing in place with its input correspondent.

CODACOND and ALIGN(SYL,L; PRWD, L) (hereafter ALIGN-L) drive root fusion (63), while *VOIGEM >> ALIGN-L blocks it when it would result in a voiced geminate (64).

(63)

	/tu-k/	CODACOND	*VOIGEM	ALIGN-L	MAXV	IDENT(place)
a.	tu-k			*!		
b.	tk	*!			*	
c.	☞ kk				*	*

(64)

	/tu-g/	CODACOND	*VOIGEM	ALIGN-L	MAXV	IDENT(place)
a.	☞ tug			*		
b.	tg	*!			*	
c.	gg		*!		*	*

We now turn to the HS analysis. For root fusion to apply at all in HS, CODACOND must be demoted below ALIGN-L (65). But then syncope will always apply, even where it would later yield a voiced geminate (66). *VOIGEM plays no role in blocking: the grammar cannot look ahead to determine if root fusion would produce a voiced geminate.

(65)

	Step	/tu-k/	*VOIGEM	ALIGN-L	CODACOND	MAXV	IDENT(place)
a.	1	tuk		*!			
b.	1	☞ tk			*	*	

	Step	/tu-g/	*VoiGem	Align-L	CodaCond	MaxV	Ident(place)
(66) a.	1	☹ tug		*!			
b.	1	💣 tg			*	*	

In light of the failed derivation in HS, one might invoke an analysis whereby the roots are underlyingly /CVC/ and the root-final vowel is epenthesized to avoid C# and voiced geminates in compounds. A reviewer brings to light that even the epenthetic analysis raises problems for serialism, as it too involves a comparison of procedures: if the underlying form is /t-g/, for example, then the grammar would have to look ahead to see that assimilating and voicing the first obstruent would result in a voiced geminate, inserting a vowel without applying any changes to the initial obstruent. Moreover, though early work on root fusion posited epenthesis (Ito 1986, Tateishi 1989, Ito & Mester 1996), more recent research has cast doubt on this possibility (Kurisu 2000, Labrune 2012, Ito & Mester 2015, building on Vance 1987): in particular, the quality of the final vowel is not predictable in a class of cases. Kurisu (2000) notes that the debate here is rendered meaningless under Richness of the Base (Prince & Smolensky 1994/2004), which requires that the grammar map inputs to legal surface forms without placing restrictions on underlying forms (so long as contrasts are preserved): the facts can be adequately captured without having to commit to one of the underlying forms, so long as the analysis maps *both* /CVC/ and /CVCV/ forms to appropriate outputs. With Richness of the Base, we can say that linguistic variation is reduced to differences in constraint ranking, rather than both ranking and input conditions; if HS wishes to maintain this tenet, then it would have to contend with underlying forms such as /CVC_1V-C_2VCV/.

5.2 Lithuanian assimilation-epenthesis

In Lithuanian, the verbal prefixes *ap-* and *at-* (67a) generally assimilate in voicing and palatality to following obstruents (67b), except when full assimilation would produce a geminate. In such a case, epenthesis applies instead, with concomitant palatalization before [i̲] (67c) (Baković 2005).[18] Baković develops an analysis of these data in Parallel OT, and Albright & Flemming (2013) shows that the analysis cannot be replicated in HS. We illustrate here why this is the case: the analysis involves a comparison of procedures.

Faithful forms (67a)	Assimilated forms (67b)	Epenthetic forms (67c)
ap-raʃʲiːtʲi,‘to describe’	a**b-g**autʲi,‘to deceive’	apʲ**i**-barʲtʲi (*a**b-b**arʲtʲi),‘to spill on’
ap-tarʲtʲi,‘to describe’	a**pʲ-tʲ**emʲdʲiːtʲi,‘to obscure’	apʲ**i**-bʲerʲtʲi (*a**bʲ-bʲ**erʲtʲi),‘to strew’
	a**bʲ-dʲ**egʲtʲi,‘to get’	
at-koːpʲtʲi,‘to rise’	a**d-g**autʲi,‘to get back’	atʲ**i**-duotʲi (*a**d-d**uotʲi),‘to give back’
at-rasʲtʲi,‘to find’	a**tʲ-pʲ**autʲi,‘to cut off’	atʲ**i**-dʲetʲi (*a**dʲ-dʲ**etʲi),‘to delay’
	a**dʲ-bʲ**ekʲtʲi,‘to run up’	

[18] See Pająk & Baković (2010) for a similar pattern in Polish.

Baković's account employs the constraints in (68). The AGREE constraints drive agreement between adjacent obstruents, DEP disprefers epenthesis, IDENT disprefers assimilation, and NOGEM prevents geminates from surfacing.

(68) AGREE[voi] Assign a violation for every pair of adjacent obstruents with different specifications for [voice].
AGREE[pal] Assign a violation for every pair of adjacent obstruents with different specifications for [palatal].
IDENT[voi] Assign a violation for every output consonant with an input correspondent disagreeing for [voice].
IDENT[pal] Assign a violation for every output consonant with an input correspondent disagreeing for [palatal].
DEP Assign a violation for every segment in the output that lacks a correspondent in the input.
NOGEM Assign a violation for two adjacent identical segments.

AGREE[voi], AGREE[pal] >> FAITH drives assimilation, with DEP >> IDENT selecting full assimilation rather than epenthesis as the default procedure for resolving agreement (69). NOGEM >> DEP, however, selects the epenthesis candidate in environments where full assimilation would yield a geminate (70).

(69)

	/p-d^j/	AGREE[voi]	AGREE[pal]	NOGEM	DEP	IDENT[voi]	IDENT[pal]
a.	p-d^j	*!	*!				
b.	p^ji-d^j				*!		
c.	☞ b^j-d^j					*	*

(70)

	/p-b^j/	AGREE[voi]	AGREE[pal]	NOGEM	DEP	IDENT[voi]	IDENT[pal]
a.	p-b^j	*!	*!				
b.	☞ p^ji-b^j				*		
c.	b^j-b^j			*!		*	*

HS cannot capture the distribution of assimilation and epenthesis using Baković's constraints, provided that voicing and palatality assimilation apply in separate steps (Albright & Flemming 2013). Assimilation requires two steps to satisfy both AGREE constraints, while epenthesis requires only one. Thus, for assimilation to ever apply, at least one of the AGREE constraints must be demoted below DEP (71).

(71)

	Step	/p-d^j/	NOGEM	AGREE[voi]	DEP	AGREE[pal]	IDENT[voi]	IDENT[pal]
a.	1	p-d^j		*!				
b.	1	☞ b-d^j					*	
c.	1	pi-d^j			*!	*		

The result is that epenthesis will never apply. Because HS cannot look ahead to determine if full assimilation would violate NoGem, it cannot block it from applying (72).

		Step	/p-bʲ/	NoGem	Agree[voi]	Dep	Agree[pal]	Ident[voi]	Ident[pal]
(72)	a.	1	p-bʲ		*!				
	b.	1	💣 b-bʲ					*	
	c.	1	☹ pi-bʲ			*!	*		

As long as voicing assimilation and palatality assimilation cannot occur in a single step, HS fails to capture Lithuanian agreement. In this way, the assimilatory processes must be irreducibly parallel.

One might be tempted to give an HS analysis of epenthesis here in terms of avoidance of sufficiently similar adjacent segments, rather than geminate avoidance. If, for instance, NoGem were replaced with a constraint disfavoring sequences like [pʲbʲ] or [bbʲ], then epenthesis could apply instead of assimilation in step 1, in cases where full assimilation would yield a geminate. This reanalysis misses a broad, crosslinguistic generalization: Baković (2005) crucially shows that the features that epenthesis ignores for the sake of breaking up sufficiently similar segments are voicing and palatality, the very same features that are involved in assimilation in the language. Baković shows that this property of identity avoidance—the features ignored for purposes of antigemination are those that assimilate independently in the language—holds across a significant variety of languages (see also Pająk & Baković (2010) for additional evidence from Polish on the tight relationship between assimilation and antigemination). Baković argues that the relationship between assimilation and antigemination is captured if CON only includes Agree constraints, which drive assimilation, and NoGem, which drives antigemination where assimilation would result in a geminate. A reanalysis in terms of constraints against sequences like [pʲbʲ] or [bbʲ] dismisses this generalization as coincidence.

5.3 Additional cases turning out to involve a comparison of procedures

We briefly discuss other cases previously argued to be challenging for HS that turn out to involve a comparison of procedures. Stanton (to appear) finds that the distribution of nasal clusters in Gurindji poses difficulties for HS under the assumption that nasal clusters spread nasality leftwards. In Gurindji (McConvell 1988), two nasal clusters cannot cooccur in a word; in the event that suffixation places two NCs together in a word, the latter cluster denasalizes (/NC...NC/ → [NC...C]). Stanton's analysis of these facts turns out to involve a comparison of procedures: nasality spreads leftwards from the latter NC cluster (/kajira-mpal/ → [kã̃j̃ĩr̃ã-mpal] 'across the north'), unless spreading results in a NCṼ cluster; in this case, the latter NC is denasalized (/kankula-mpa/ → [kãnkula-**p**a], [*kã**nkũ**l̃ã-mpa] 'on the high ground'). Parallel OT can express this analysis because spreading through multiple segments takes place in a single step; the grammar can thus look ahead to see if the complete result would yield an NCṼ cluster. In HS, however, spreading is an iterative, multistep procedure (McCarthy 2011, Kimper 2011a), and so the NCṼ cluster will not be visible in the derivation until nasality has already begun spreading. The salient apparent reanalysis of these facts is that the alternation is long-distance nasal cluster dissimilation rather than nasal spreading—but see Stanton (to appear) for several arguments against such an approach (including, for example, the observation we do not observe other kinds of cluster dissimilation in the typology).

Finally, Anderson (2016) compares Parallel OT and HS with regard to how well they can capture the distribution of footing, metathesis, and syncope in Maltese data (Hume 1990). Maltese words demand right-aligned, disyllabic trochaic feet, with a heavy stressed syllable. In our terms, well-formed feet are built by comparing procedures: syncope occurs following footing to satisfy the aforementioned conditions on feet (/jɪ-bdɪl-u/ → (ˈjɪ-b.dɪ)l-u → (ˈjɪ-b.dl-u) 'they change'), but where syncope would result in a sonority reversal, CV-metathesis occurs as the next best option for satisfying these constraints (/jɪ-ʃrɔb-u/ → jɪ-ʃɔrb-u → jɪ-(ˈʃɔr.b-u); /jɪ-ʃrɔb-u/ → (ˈjɪ-ʃ.rɔ)b-u → *(ˈjɪ-ʃ.rb-u) 'they drink'). Anderson finds that this is naturally expressed in Parallel OT, but is challenging for HS, which cannot look ahead to the full result of footing and syncope. Anderson assesses whether other serial analyses involving monosyllabic feet or feet aligned to the right edge of the word at the beginning of the derivation could capture the data, and suggests that each of them is unworkable for the data.

6. Conclusion

In this paper, we have argued that a variety of systems across languages, involving a diverse array of processes, are best understood to require lookahead in grammar. These cases each involve a comparison of procedures: apply one change followed by another unless the final result is dispreferred; in such a case, apply a different series of changes (or a single change, or none). The breadth of cases from Mohawk, Maragoli, Sino-Japanese, Lithuanian, Gurindji, and Maltese can be derived in Parallel OT but are recalcitrant in HS, as a result of requiring lookahead to the extent that whole procedures need to be compared. Apparent HS reanalyses of the cases we have compiled, such as those that have been posited previously and novel ones considered here, we argue either fail to capture the full set of data or miss important generalizations within or across languages. Given that a diverse array of processes can be involved in comparisons of procedures suggests that lookahead is not merely the reflex of a single phenomenon (e.g., syllabification) applying in parallel with others, but rather is a property of the grammar as a whole.

As a final note, we are not suggesting that strong arguments for serialism do not exist. As pointed out previously, Parallel OT generates a variety of patterns previously claimed to be unattested, while HS avoids them (Wilson 2006, McCarthy 2007, Pruitt 2010, Jesney 2011). Putting those results together with those of this paper, perhaps a less restrictive theory of grammar that combines serial application with lookahead capability would be the most appropriate (e.g., Optimality Theory with Candidate Chains; McCarthy 2006, 2007b; Wolf 2008, 2011; *a.o.*). Nevertheless, the viability of serialism not indexed to morphosyntactic strata remains an open question. Patterns claimed to be unattested could always turn out to exist (see esp. Hayes 2018; e.g., Caballero 2006, Becker & Jurgec 2016, McCollum & Essegbey 2018). Strong evidence for serialism would consist of attested, productive phonological systems that require reference to intermediate forms. McCarthy (2008) surveys a variety of apparently extant stress-syncope interactions and finds that they challenge Parallel OT but can be treated in HS. Nevertheless, recent research casts doubt on the productivity of stress-syncope interactions, and suggests that learners are unable to actually acquire them (Bowers to appear). Thus, more cases should be accumulated before assessing whether combining parallel and serial architecture is warranted.

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