Operational Exponence:
Process Morphology in Harmonic Serialism*

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The Challenges of Complex Morphology to Morphological Theory

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1 Introduction

- Morphological processes are not as limited as general phonological ones.
- They can involve more dramatic effects: reduplication, subtractive truncation, arbitrary featural changes, etc.
- These types of morphology have motivated some accounts of morphological exponence as (potentially) something other than the concatenation of morphs—as the processes themselves.
- Wolf (2008) and Kimper (2009) form partial implementations of this idea in a serial optimization framework.
- I extend their proposals, treating the proper exponents of morphemes as operations.
- The theory is realizational in nature (see e.g. Stump, 2001; Xu, 2007)—here the presence of operational exponents is motivated by correspondence constraints.

2 Framework and Proposal

2.1 Optimal Interleaving

Wolf (2008) proposes a theory of morphology called Optimal Interleaving:

1. Morphology and phonology happen in the same component.
2. The phonology gets a morphosyntactic tree as input.
3. The phonology is realized by a grammatical framework like Harmonic Serialism.
4. Morphemes are matched by *morphs*—ordered pairs of features and phonological material.

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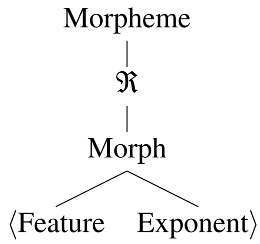
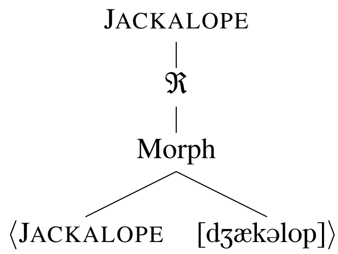
(1) Wolf's Structure for Morphemes:



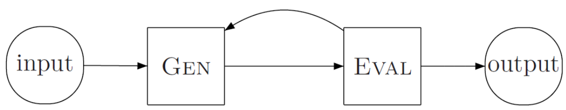
(2) Example Structure:



2.2 Harmonic Serialism

Harmonic Serialism (Prince and Smolensky, 1993/2004; McCarthy, 2000; McCarthy, 2010) is a serial version of Optimality Theory. Candidates are evaluated with respect to a full constraint ranking in a series of steps.

Evaluation proceeds in a loop:



1. Input is passed to GEN.
2. GEN creates a finite set of candidates differing in at most one respect from the input.
3. EVAL chooses a winner *w* from this set.
4. If *w* is not the same as the input, *w* is given to GEN as a new input and the loop returns to (2).
5. Otherwise the derivation converges with *w* as the output.

2.3 Structure of Morphemes

Wolf (2008) defines lexical items by their insertion operations. For theoretical purposes the item *jackalope* is essentially the following operation:

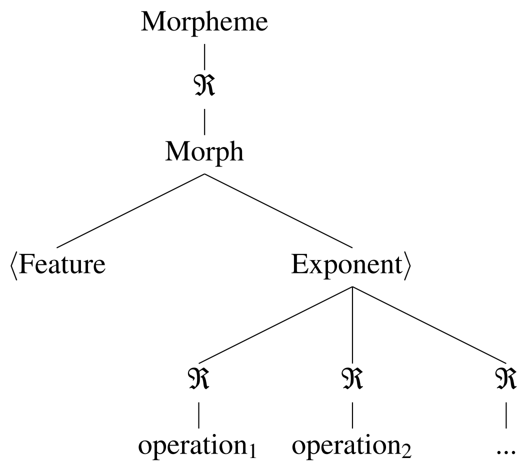
(3) INSERT(⟨JACKALOPE, [dʒækəlop]⟩))

That is, the lexical item consists of the insertion of the ordered pair of the features and phonological exponent of *jackalope*. He mentions that we can actually think of these as two parallel insertion operations:

(4) ⟨INSERT(JACKALOPE), INSERT([dʒækəlop])⟩

- Wolf further suggests that the right half need not be an insertion operation—that perhaps other operations might be helpful as exponents.
- I take the extreme view: all exponents are operations.
- Further, I take the full structure of morphemes to allow for multiple exponents (Kimper, 2009).

(5) Proposed Structure for Morphemes:



(6) **Morphemes:**
The morphosyntactic features that are provided as input to the phonology.

(7) **Morphs:**
Ordered pairs of features and sets of exponents.

The relationship between the morpheme and morph levels is governed by constraints like the following:

(8) MAX-M(F): (adapted from Wolf, 2008)
Assign a violation for every instance φ of the feature F at the morpheme level that lacks an instance φ' of F at the morph level, such that $\varphi \mathfrak{R} \varphi'$.

These constraints penalize any feature present in the input tree but not found in any morph in the output.

(9) **Exponents:**
The operations which provide the phonological expression of a morphosyntactic feature.

Morphs are related to exponents by the following constraint family:

(10) MAX-E(F): (adapted from Kimper, 2009)
Assign a violation for a feature F and its corresponding exponent e, assign a violation mark if F is present but e is not.

These constraints penalize any exponent present in the input not realized in the output.

2.4 Operations as Exponents

- In this proposal, morphs stand in relation with *operations*, not the phonological material they may (or may not) insert.
- This mechanism requires additional information from candidates, however. If operations are exponents and if their presence is motivated by MAX constraints, it must be possible to tell at each step whether an operation has been applied.
- Not all operations are obviously recoverable—a truncated string can easily look like a string that has not undergone truncation, for example.
- I therefore propose that a description of a morpheme is present in a candidate if the operation was applied in the creation of that candidate.
- Loosely speaking, a "record" of the morphological operations applied in the construction of a candidate *remains* in the candidate and is accessible by the grammar.

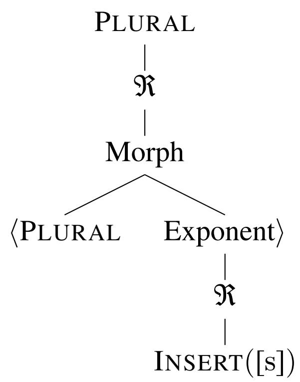
The explicit steps of exponent spellout are then:

1. The exponent's operation is applied to the candidate.
2. That operation's description is inserted into the candidate.

2.5 Concatenative Morphology: English Plurals

Morphological processes typically thought of as the simple concatenation of phonological strings are similarly simple within this theory. By way of example, the basic representation of the English plural (ignoring allomorphy) is something like the following:

(11) Simplified English Plural:



So the final output for the plural of *jackalope* will contain both the final phonological content and the two lexical insertion operations used to create it:

(12) [dʒækəlops], INSERT([dʒækəlop]), INSERT([s])

This form results by just ranking the appropriate MAX-M and MAX-E constraints above competing Markedness. These motivate the insertion of the two morphs and their related phonological material.

3 Subtractive Truncation

Some languages have *subtractive* morphology. That is, some feature is expressed by deleting phonological material of a particular form, rather than adding it.

3.1 Basic Analysis

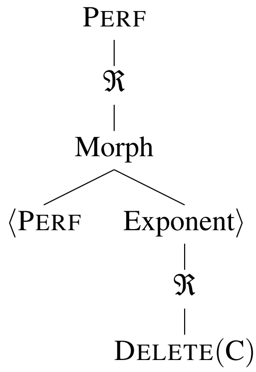
The Tohono O'odham perfective is formed by the deletion of a final consonant:

(13) a. huhag 'haul' → huha 'hauled'
b. gatwid 'shoot' → gatwi 'shot'
c. maːk 'give' → maː 'gave'

Subtractive morphology is not simple to recover—it is impossible to determine whether it has applied from just the surface string.

We can represent the subtractive morpheme as the following:

(14) Tohono O'odham Perfective:



Wolf (2008) uses MIRROR (an instantiation of the Mirror Principle) to place affixes (and other morphemes). I adapt this constraint as follows:

(15) MIRROR: (adapted from Wolf, 2008 for operational exponence)
Assign a violation for every segment between the right (left) edge of the domain affected by a prefix (suffix) operation and the edge to which it attaches.

With this definition we can analyze Tohono O'odham subtractive truncation with high-ranking morphological MAX and MIRROR over lower-ranked MAX-IO to allow deletion for morphological reasons:

(16) a. Step 1:

HAUL, PERF[1]	MAX-E(HAUL)	MIRROR	MAX-E(PERF)	MAX-IO
a. ∅	*!		*	
b. ☞ huhag, INSERT(huhag)[2]			*	

b. Step 2:

HAUL, PERF huhag, INSERT(huhag)	MAX-E(HAUL)	MIRROR	MAX-E(PERF)	MAX-IO
a. huhag, INSERT[3]			*!	
b. ☞ huha, INSERT, DELETE(C)				*
c. huag, INSERT, DELETE(C)		*!*		*
d. uhag, INSERT, DELETE(C)		*!***		*

c. Step 3: Convergence

The formulation of exponence-by-operation is very important here. If no description of the operation were left in the candidate, the optimization would have no way of knowing that truncation had occurred.

[1]For simplicity I do not include the steps of morph insertion motivated by MAX(M) constraints. These are assumed high-ranked throughout this presentation.

[2]I omit morphological inputs in the candidate descriptions.

[3]I shorten operation descriptions on their second appearance. They are assumed to be no different from one occurrence to the next.

If descriptions are not available, this leaves two possibilities:

1. The grammar can distinguish truncated candidates within a step but does not permanently mark them as truncated.

   This leads to overapplication and derivations such as: huhag → huha → hua → ua.

2. The grammar cannot distinguish truncated candidates, even within one step.

   This leads to non-application: huhag → huhag.

3.2 Blocking of Truncation

Lardil uses a process of final-vowel truncation to form the nominative (also known as the uninflected form) of a noun (with potential additional phonological deletion of consonants) (Wilkinson, 1988):

(17)

	‘flame’	‘husband’
Nominative	yalul	yukař
Accusative	yalulun	yukařpan
Future	yaluluṛ	yukařpaṛ

Lardil has an independent restriction that words must be minimally bimoraic, with violations solved by augmentation of [a]:

(18)

	‘thigh’	‘shade’
Nominative	teřa	wika
Nonfuture	teřin	wikin
Future	teřuṛ	wikuṛ

However, the final vowel of a bimoraic form is not truncated—truncation is blocked by the minimal word restriction:

(19)

	‘inside’	
Nominative	wiṭe	(*wiṭ, *wiṭa)
Nonfuture	wiṭen	
Future	wiṭeṛ	

In the theory of subtractive truncation proposed here this can be modeled as a simple constraint interaction with a constraint enforcing minimum word size:

(20) MINWD($\mu\mu$):
Assign a violation for every word that is not at least bimoraic.

The ranking is otherwise the same as in Tohono O'odham. The derivation proceeds as before but is blocked from truncation by MINWD.

(21) a. Step 1:

INSIDE, NOMINATIVE	MAX-E(INSIDE)	MIRROR	MINWD	MAX-E(NOM)
a. ∅	*!			*
b. ☞ wiṭe, INSERT(wiṭe)				*

b. Step 2:

INSIDE, NOMINATIVE wiṭe, INSERT(wiṭe)	MAX-E(INSIDE)	MIRROR	MINWD	MAX(NOM)
a. ☞ wiṭe, INSERT				*
b. wiṭ, INSERT, DELETE(V)			*!	
c. wṭe, INSERT, DELETE(V)		*(!)	*(!)	

c. Step 3: (Convergence)

MINWD blocks the nominative morph's exponent from ever being applied, leaving a form without truncation as optimal. This sort of blocking is found in concatenative morphology and analyzed in a similar way. It is a strength of this theory that the account of more general blocking of morphology is parallel.

4 Spokane Repetitives

Spokane shows an unusual pattern: the repetitive is expressed by the infixation of *e* and the glottalization of all sonorants in a word (Carlson, 1980):[4] This sort of glottalization pattern is unknown apart from related Inner Salishan languages and others in the area.

(22) a. lčˀəntén
'I tied it'
b. lˀečˀənˀténˀ
'I tied it over and over'

When the initial vowel is stressed *e* appears before the root in a syllable formed with a copy of the root-initial consonant:

(23) a. níčˀəntxʷ
'you cut it'
b. nˀenˀíčˀənˀtxʷ
'you kept cutting'

[4] I adopt Carlson's orthography except that I notate the glottalized consonants with superscript glottal stops.

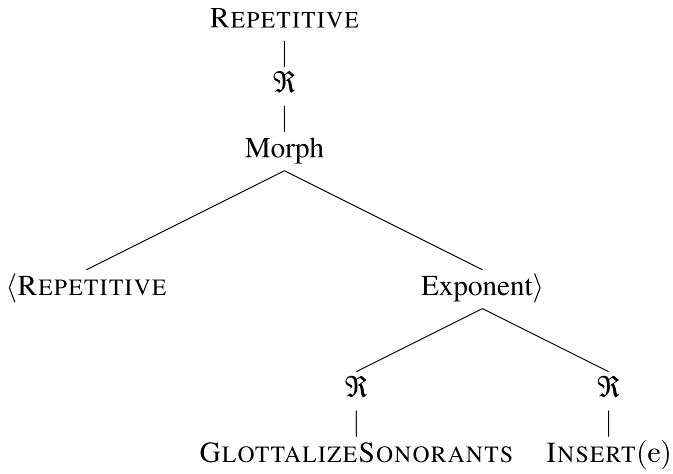
This type of pattern has been analyzed as an affix *e* with a floating glottal feature (e.g. Idsardi, 1991) that spreads to the sonorant consonants in the word.

This is a worrisome analysis:

- Harmony processes like this are not otherwise observed.
- Rather than revising a universal phonological theory of harmony, it is fruitful to seek a language-specific solution in the morphology.

The arbitrary and morphologically-conditioned nature of sonorant glottalization makes it natural to account for with operational exponence. The repetitive can be defined as follows:

(24) Spokane Repetitive:



The operation GLOTTALIZESONORANTS replaces all unglottalized sonorants in its input with their glottalized counterparts.

(25) a. Step 1:

TIE, REPETITIVE	MAX-E(TIE)	MAX-E(REPETITIVE)	ID-IO
a. ∅	*!	**	
b. ☞ lčˀəntén, INSERT(lčˀəntén)		**	

b. Step 2:

TIE, REPETITIVE lčˀəntén, INSERT(lčˀəntén)	MAX-E(TIE)	MAX-E(REPETITIVE)	ID-IO
a. lčˀəntén, INSERT		**!	
b. ☞ lečˀəntén, INSERT, INSERT(e)		*	
c. lˀčˀənˀténˀ, INSERT, GLOTTSON		*	*!**

c. Step 3:

TIE, REPETITIVE lečˀəntén, INSERT, INSERT(e)	MAX-E(TIE)	MAX-E(REP)	ID-IO
a. lečˀəntén, INSERT, INSERT		*!	
b. ☞ lˀečˀənˀténˀ, INSERT, INSERT, GLOTTSON			***

d. Step 4: Convergence

4.1 Properties of Morphological Operations

4.1.1 Learning Operations

- Operations such GLOTTALIZESONORANTS are unlike those usually proposed in phonology.
- That operation in particular contains a universal quantification over the sonorants in the word and makes a targetted, specific featural change. If such operations are possible, we need an explanation as to where they come from.
- In Wolf's (2008) account operations are learnable to some extent—the lexical insertion operations require explicit learning about a particular language's lexical items. If we allow for other types of operations—and not just their parameters—to be learnable, we can derive more complex processes in morphology.
- If "unnatural" constructions such as sonorant glottalization can only arise by operation construction and not e.g. constraint reranking we might have an account for their rarity.
- They should be easily analyzable with constructed operations (as is shown here) but these operations need not be easy to construct in the first place. Thus a pattern can have consistency and persistence once created, but need not be created often in disparate linguistic situations.
- This idea further seems to predict that processes that are more language specific are more likely to be associated with particular morphemes. This seems to be roughly correct.

4.1.2 Power and Construction of Operations

In the above I set no bounds on the types of operations that can be exponents. What are these bounds? If they are learned as proposed, what are the schemata or components from which these operations are built?

Some tentative statements on such a set of components can be made. It must minimally contain:

- Insertion for concatenative morphology, floating morphemes, and the like.
- Deletion for truncation.
- Copying for reduplication.
- Edge specifications for prefix/suffix distinctions.
- Existential quantification.
- Universal quantification for Spokane and the like.

This set is potentially very powerful, however. Further work is needed to determine its true contents and the mechanisms by which they combine.

5 Conclusion

- I proposed an approach to morphology in which the exponents of morphemes are operations, not phonological strings.
- The application of operations is motivated by a family of MAX constraints and includes a concomitant insertion of the description of the operation into the candidate string.
- I showed that this approach has advantages in accounting for subtractive truncation and language-idiosyncratic morphology generally.
- This model is explicitly compatible with multiple exponence.

6 References

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