Process morphology in a realizational theory*

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1. Introduction

This paper provides an analysis of scalar tone shift in Guébie as constraint-driven and morphosyntactically conditioned, rather than triggered by a particular abstract underlying representation. Much recent literature has claimed that all morphology involves affixation of morphemes with underlying (abstract) phonological representations (Benua 1997, Alderete 2001, Wolf 2007, Gouskova & Linzen 2015, Zimmermann 2013, Trommer & Zimmermann 2014, Köhnlein 2016). However, subtractive, scalar, metathesizing, and replacive morphology pose challenges for the item-based view. Hockett (1954), Anderson (1992) famously raise this debate, both coming down in favor of the need for process morphology. Here I look at a novel pattern of scalar tone shift from Guébie (Kru), reraising Anderson (1992)[63]'s question: "Is it possible to reduce all of morphology to affixation [...]? If not, the item-based theory should probably be rejected." I demonstrate that indeed there is no workable underlying representation of the Guébie imperfective morpheme. On the basis of Guébie scalar tone shift and countless other morphologically conditioned phonological processes across languages, we should give up a purely item-based view of morphology. I propose an alternative solution based in the morphological operations of Distributed Morphology (Halle & Marantz 1994) and construction-specific constraint-based phonology.

2. Guébie scalar tone shift

Guébie is a tonal language with four distinct tone heights, marked here with numbers 1-4 where 4 is high[1]. Attested tone melodies on lexical roots include all level tones (1, 2, 3, 4), along with the following contours: 23, 24, 41, 42, 31, 32.

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[1]The data presented here come from three fieldtrips to Gnagbodougnoa, Côte d'Ivoire along with eight months of working with a Guébie speaker in the US. There are 7,000 Guébie speakers spread across seven villages, only one of whom is monolingual.

Word order in Guébie alternates between SAuxOV and SVO. When auxiliaries (which mark aspect, polarity, and mood) are present (SAuxOV), there is no inflection on verbs (1a). However, when there is no auxiliary (SVO), the verb surfaces immediately after the subject. In exactly these SVO cases, the verb is inflected for aspect (1c), (2a). Nothing can ever intervene between subject and auxiliary or subject and inflected verb.

In all contexts except SVO clauses with imperfective aspect, any given verb surfaces with a consistent tone melody (1a)-(1c).

(1) *Default tone constructions*

a. *Future: SAuxOV*

e^{4}	ji^{3}	ɟa^{31}	li^{3}
1SG.NOM	FUT	coconuts	eat

'I will eat a coconut.'

b. *Imperative: V*

li^{3}
eat.IMP

'Eat!'

c. *Perfective: SVO*

e^{4}	li^{3}	ɟa-be$^{3.1}$	kubə$^{3.1}$
1SG.NOM	eat.PFV	coconuts-SG	yesterday

'I ate a coconut yesterday.'

However, in imperfective SVO contexts, tone on the verb surfaces one step lower on the four-height tone scale, (2a).

(2) *Tone one step below default in imperfective constructions*

a. *Imperfective: SVO*

e^{4}	li^{2}	ɟa^{31}	koko$^{4.4}$
1SG.NOM	eat.IPFV	coconuts	everyday

'I eat coconuts everyday.'

The perfective and imperfective form of a verb are segmentally and syntactically identical, but their tone differs. Here we see a tone change triggered by a particular morphosyntactic environment, similar to the tonal overlay phenomena recently discussed by McPherson & Heath (2016), though the Guébie data are scalar.

Only the first level tone of a polysyllabic verb or contour is affected by the scalar tone shift, (3).

(3) *Only the first tone lowers*

a. ju^{4} gbala$^{3.4}$ si^{3}
boy climb.PFV trees
'A boy climbed trees'

b. ju^{4} gbala$^{2.4}$ si^{3}
boy climb.IPFV trees
'A boy climbs trees'

c. ɟaci$^{23.1}$ pa^{31} gɔlɔ$^{3.3}$
Jachi flip.PFV boat
'Jachi flipped the boat.'

d. ɟaci$^{23.1}$ pa^{21} gɔlɔ$^{3.3}$
Jachi flip.IPFV boat
'Jachi flips the boat.'

Given the data in (3), we can restate the imperfective scalar tone shift by saying that the first tone level of a verbal tone melody surfaces one step lower in imperfective contexts than elsewhere, (4).

(4) *Imperfective scalar tone shift*

Default tone	$\gg$	**Imperfective tone**
4		3
3		2
2		1
1		1

When a verb is low-toned by default, we might expect it to lower further, to a super-low, 0, in the the imperfective. Instead, it remains tone 1. However, the result is not complete neutralization between perfective and imperfective contexts; instead, contrast between perfective and imperfective verbs is maintained by raising the final tone of the subject when the verb is already low, (5).

(5) *Contrast for low-toned verbs maintained by raising the preceding tone*

a. ɟaci$^{23.1}$ pa^{1}
Djatchi runPFV
'Djatchi ran'

b. ɟaci$^{23.2}$ pa^{1}
Djatchi run.IPFV
'Djatchi runs'

The default low tone, 1, on the verb 'run' in (5) does not lower in imperfective contexts, but we see a change in the final subject tone between perfective and imperfective contexts.

This scalar subject raising occurs even when the result is a super-high tone, tone 5, which is not found elsewhere in the language, (6).

(6) *Contrast is maintained even when it results in a super-high tone*

a. $\underline{e}^{4}$ pa^{1}
1SG.NOM run.PFV
'I ran'

b. $\underline{e}^{5}$ pa^{1}
1SG.NOM run.IPFV
'I run'

Another way to think of the scalar tone shift in Guébie is as affecting the difference in tone height between the subject and inflected verb, where the difference increases by one between the perfective and imperfective. This consistent and phonologically predictable tone change is represented formulaically in (7), where FST stands for Final Subject Tone, and IVT stands for Initial Verb Tone. *n* represents some number, namely, the difference between subject and verb tone in perfective contexts.

(7) *Consistent arithmetic relationship between perfective and imperfective*

Perfective	**Imperfective**
FST - IVT = n	FST - IVT = n + 1

This shift is not a case of assimilation to or dissimilation from a tonal target, but rather is a relational shift in tone. The table in (8) shows all possible tone combinations between perfective and imperfective for a subject with default tone 2. When a default tone 2 subject is followed by a default high- or mid-high-toned verb, the difference between subject and verb tone decreases in the imperfective. However, when a tone 2 subject is followed by a mid- or low-toned verb, the difference between subject and verb tone increases in the imperfective.

(8) *Tone shift patterns for a subject with tone 2*

	Perfective	**Imperfective**	**Change in tone difference**
a.	2 4	2 3	Decrease
b.	2 3	2 2	Decrease (to equal)
c.	2 2	2 1	Increase
d.	2 1	3 1	Increase

The difference between subject and verb tones is not always further apart in the imperfective than perfective (i.e. a,b); however, there is always more of a pitch drop between subject and verb in the imperfective than perfective. If there is a default rising melody between the final subject and initial verb tone, that rising melody will level out to less of a rise, or to a level melody in the imperfective. A level melody will result in fall, and a falling melody will become an even steeper fall.

This scalar tone shift is situated within the larger context of Guébie grammatical tone phenomena, as described by Sande (2017). The next section details an analysis of this particular scalar shift.

3. Scalar shift in Distributed Morphology

3.1 Considering existing options

3.1.1 Underlying representations

Following work on process morphology as item-based (Benua 1997, Alderete 2001, Wolf 2007, Gouskova & Linzen 2015, Zimmermann 2013, Trommer & Zimmermann 2014), we could start by asking what the underlying representation of the imperfective morpheme is in Guébie. Or, in Distributed Morphology (DM) terms, what is the vocabulary item inserted in imperfective contexts?

One hypothesis is that the imperfective is a floating tone or feature. For example, a floating falling tone 41 could result in verb tone lowering (an effect of the lower half of the contour) but subject tone raising (an effect of the high, tone 4, portion). However, 41 is found elsewhere in the language, and does not trigger raising or lowering of nearby tones. There is no reason to believe that a given tone should trigger a raising or lowering process in this one context (imperfective), but nowhere else in the language. This weakens the argument that the imperfective morpheme is a floating tone. Additionally, a floating element would need to be responsible for subject tone raising in certain contexts (when the verb is already low), but verb tone lowering otherwise. There is nothing about a particular underlying tone melody, say 41, which says it should affect the following element sometimes, and the preceding element elsewhere. This context sensitivity would need to be derived via rules or constraints.

We could also consider a floating tone feature. A number of tonal features for four-tone-height languages have been proposed. One example from Yip (1980) is given in (9).

(9) *Proposed features for 4-tone systems*

	4	3	2	1
Upper	+	+	-	-
High	+	-	+	-

In Yip's proposed set of binary features, along with other binary feature sets (Clements 1983, Bao 1999), there is a single-feature difference between high and mid-high tones, and a single-feature difference between mid and low tones, but there are two feature values differentiating mid-high (tone 3) from mid (tone 2). This means that a single floating feature cannot be responsible for the shift from 4-to-3, 3-to-2, and 2-to-1 tone shifts in Guébie. See Contreras (1969) for perhaps the first discussion of why binary features like those in (9) fail to account for scalar phenomena. If we assume that scalar lowering in imperfective contexts is a unitary phenomenon, a floating-feature account does not work[2].

No matter what we posit as the underlying representation (UR) of the imperfective feature, we would need to state in rules or constraints that the effect of that UR involves lowering the verb tone one step in imperfective contexts, unless the verb tone is already low, in which case the subject tone raises. In sections 3.2 and 3.3 I demonstrate that we can derive morphosyntactically conditioned scalar tone shift via DM operations and phonological constraints without requiring any abstract UR. First, in section 3.1.2 I demonstrate that current DM tools cannot satisfactorily handle productive morphologically conditioned phonological processes.

3.1.2 Suppletive allomorphy

In DM, morphologically conditioned phonology, including process morphology like umlaut or scalar shift, is often modeled as suppletive allomorphy (Halle & Marantz 1993, 1994, Embick & Noyer 2007, Embick & Halle 2005, Harley 2014, Siddiqi 2009, Haugen & Siddiqi 2013). Here I argue that suppletive allomorphy does not adequately account for morphologically conditioned phonology.

Suppletive Allomorphy involves separately listed lexical items or vocabulary items, each inserted into a derivation in distinct morphosyntactic environments before the phonological grammar applies[3,4]. In the early days of DM, suppletive allomorphy was only possible for functional morphemes. Now, though, most DM practitioners agree that both lexical and functional elements can have listed allomorphs (Siddiqi 2009, Harley 2014, Toosarvandani to appear). For the verb 'eat' in Guébie, which I will use in a number of examples throughout this and the following sections, there would be two lexically listed allomorphs on a suppletive allomorphy account, (10).

(10) *Vocabulary entries for the Guébie verb li, 'to eat'*

a. $\text{li}^2 \longleftrightarrow$ [IPFV]
b. li^3

The tone 2 allomorph would be inserted in the environment of an imperfective feature, and the tone three allomorph would be inserted everywhere else. However, suppletive allomorphy does not imply that any regular phonological relationship holds between one form

[2]See McPherson (2016) for a recent binary feature account of a scalar tone shift in Seenku. A featural account works for Seenku because there are only two underlying tones which undergo shift: extra-low becomes low, and high becomes extra-high in plural contexts. A featural analysis becomes obsolete in a system with more than two underlying tones, like the four-tone system of Guébie.

[3]While vocabulary insertion is generally thought to occur before phonology, Trommer (2001), Wolf (2008) assume that vocabulary is inserted during the phonological component.

[4]One could consider Archangeli & Pulleyblank (forthcoming)'s emergent morphology to be a suppletive allomorphy approach where all allomorphs are possible output candidates and the optimal one is chosen given the morphophonological environment. This is an inadequate analysis in Guébie for the same reasons that DM-style suppletive allomorphy is ruled out; namely, redundancy.

of a vocabulary item (VI) and another. Thus, on such an account it would be coincidental that every verb whose 'elsewhere' form does not have tone 1 would have two segmentally identical vocabulary entries, one inserted in imperfective contexts whose tone is exactly one step lower than the allomorph underspecified for insertion environment.

We should also consider that every subject noun phrase must also have two entries, one whose final tone is exactly one step higher than the other and occurs just in case the following imperfective verb has default low tone.

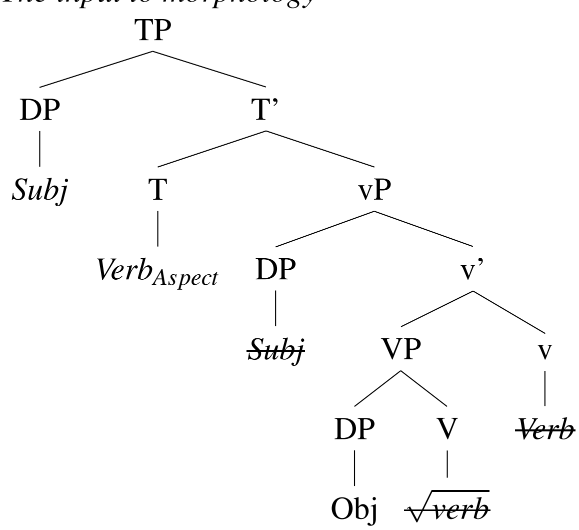
Suppletive allomorphy results in an uneconomical lexicon. It fails to capture the generalization that the imperfective tone shift is phonologically predictable. In the following sections I propose a model of DM that avoids suppletive allomorphy and abstract underlying phonological representations.

3.2 The structure of the model

This section presents a novel model of realizational morphology combining aspects of Distributed Morphology (Halle & Marantz 1993, 1994) with morpheme-specific grammars of constraint evaluation, Cophonology Thoery (Itô & Mester 1995, Anttila 2002, Inkelas & Zoll 2005). I begin by describing my assumptions about the morphological component of the grammar and the output of morphology, which I assume is the input to the phonological component. I then describe the interworkings of the phonological component.

Like DM, the model of the morphology/phonology interface presented here assumes that syntactic structure is the input to the morphological component. The syntactic structure of a regular transitive verb in Guébie, argued for by Sande (2017), is given in (11). A hierarchical structure of this type is assumed to be both the output of syntax and the input to morphology.

(11) *The input to morphology*



Following DM, I assume that morphological operations apply to the hierarchical syntactic structure in (11). For the purposes of this paper, I assume that the spell-out-by-phase approach is correct, and that relevant phases are at least DP, vP, and CP (Marvin 2002, Embick 2010, Jenks & Rose 2015).

Unlike the suppletive allomorphy approach dismissed in section 3.1.2, there is no need for duplicate vocabulary entries for each verb on this model. Instead, each verb has only one entry, unspecified for insertion context. The tonal difference between imperfective and imperfective verb forms will fall out later, during the phonological component. The single vocabulary entry proposed for the verb 'eat' is given in (12).

(12) *Vocabulary entry for the Guébie verb li, 'to eat'*

a. li^3

Due to its lack of specified insertion context, the vocabulary entry in (12) will be inserted in both perfective and imperfective contexts. For this reason, perfective and imperfective derivations are structurally and phonologically identical through the morphology, where li^3 is inserted into both the perfective and imperfective structures.

After vocabulary items are inserted, they are linearized. At this point the imperfective and perfective derivations are identical except for the presence of an imperfective or perfective feature (13).

(13) *Input to phonology for Guébie perfective and imperfective li, 'to eat'*

a. $/\text{e}^4\ \text{li}^3{}_{IPFV}/$
b. $/\text{e}^4\ \text{li}^3{}_{PFV}/$

After linearization, the string of vocabulary items and morphosyntactic features is evaluated by the phonological grammar. It is during the phonological component that the tone in imperfective contexts undergoes shift. Note that in this model, morphosyntactic features are preserved through morphology, including Linearization, and are available to the phonology. This assumption contradicts Bobaljik (2000)'s proposed Rewrite Rule, which says that morphosyntactic features are erased upon insertion of vocabulary items; however, I follow the growing body of literature arguing against the Rewrite Rule (cf. Gribanova & Harizanov 2015, Winchester 2016, and Match Theory constraints which reference hierarchical structure, Selkirk 2011).

I follow Cophonology Theory (Itô & Mester 1995, Anttila 2002, Inkelas & Zoll 2005) in saying that languages have multiple distinct morpheme-specific phonological grammars. Not every morpheme triggers a distinct grammar; rather, there are morpheme-specific grammars as well as an 'elsewhere' grammar. If the phase or spell-out domain being evaluated contains a morpheme for which there is a morpheme-specific phonological grammar, that grammar applies, as in the Guébie imperfective. Otherwise, the 'elsewhere' phonological grammar applies, as in the Guébie perfective. See Sande (2017) for arguments in favor of Cophonology Theory over other constraint-based approaches.

The specific constraints relevant for scalar tone shift in imperfective grammar and to avoid scalar shift in elsewhere contexts are discussed in section 3.3.

3.3 The constraints relevant for Guébie tone shift

The input to the phonological component is made up of vocabulary items and morphosyntactic features. Possible outputs are evaluated by constraints ranked differently based on the morphosyntactic construction in question. Crucially for the Guébie imperfective, the optimal output candidate must be tonally different than the input. Thus, we need a constraint motivating the difference between input and output tone.

I propose the use of a PITCHDROP constraint, which is violated when there is not a larger pitch drop between subject and verb in the output than there was in the input.

(14) PITCHDROP (adapted from Mortensen 2006)
Assign one violation if the juncture between a DP immediately preceding T is not associated with more of a pitch drop in the output than in the input[5].

This constraint is similar to antifaithfulness constraints (Alderete 2001), REALIZEMORPH (Kurisu 2001), and DIFF (Mortensen 2006), in that it prefers candidates whose outputs differ from their inputs. Following Mortensen (2006), I assume that phonological scales are theoretical objects that can be referenced by constraints; here PITCHDROP references the Guébie four-height tone scale. This particular constraint is shorthand for a combination of two scale-referencing constraints proposed by (Mortensen 2006, 14) to account for scalar shifts across languages: HIGHER and NOHIGHER.

Along with the antifaithfulness constraint PITCHDROP, we need a corresponding faithfulness constraint. This identity constraint must be defined in a scalar manner, where the further along the scale an output element is from the original input, the more violations are incurred (cf. Kirchner 1997). The scalar evaluation of ID-TONE is necessary to ensure that the optimal candidate only minimally differs on the tonal scale from the corresponding input tone (16)c).

(15) ID-TONE
Assign one violation for each step on the tone scale that an output tone differs from its corresponding input tone.

The following tableau shows the ranking of the antifaithfulness and corresponding faithfulness constraint in the imperfective grammar. I set aside discussion of the elsewhere grammar for now, knowing that faithfulness must be undominated in the elsewhere (perfective) context.

[5]This constraint is a restatement of the formula in (7), where the difference between final subject tone and initial verb tone is one step larger in the imperfective than in the input.

(16) PITCHDROP ≫ ID-TONE

e^4 li^3_{ipfv}	PITCHDROP	ID-TONE
a. ☞e^4 li^2		*
b. e^4 li^3	*!	
c. e^4 li^1		**!

The ranking PITCHDROP ≫ ID-TONE results in more of a pitch drop in the output of the imperfective cophonology than in the input, but with as little scalar tone change as possible.

Candidates and inputs here cannot only consist of a verb, because the imperfective tone shift also affects subjects, (5), (6). For this reason I evaluate multiword candidates of subject and verb together. This follows from the structure of the grammar proposed here, where after each syntactic phase, morphological operations apply, and then phonological constraints evaluate that entire phase simultaneously.

Because Ds are syntactic phase heads, and the subject is inside a DP but its tone can be manipulated in imperfective contexts, our model must allow for the phonological content of spelled out phases to be manipulable. I follow Michaels (2013), Surkalović (2013), McPherson & Heath (2016) in assuming that phonological content of phases is indeed manipulable after spell-out, contra a strict view of the modular phase impenetrability condition (d'Alessandro & Scheer 2015). A constraint IDENT-PHASE protects previously phonologically determined content, but is violable.

(17) IDENT-PHASE (adapted from (McPherson & Heath 2016, 613))
Assign one violation if the phonological content of a phase is distinct in the output from the input.

(18) PITCHDROP ≫ ID-TONE ≫ID-PHASE

e^4 li^3_{ipfv}	PITCHDROP	ID-TONE	ID-PHASE
a. e^4 li^3	*!		
b. e^4 li^4	*!	*	
c. e^3 li^3	*!	*	*
d. e^4 li^1		**!	
e. e^5 li^3		*	*!
f. ☞e^4 li^2		*	

The constraints in (18) rule out a faithful imperfective candidate (a), as well as those candidates with are tonally antifaithful by raising the verb (b), lowering the subject (c), lowering the verb to too far (d), or raising the subject (e). This ranking accounts for all cases where the input of the verbal tone is higher than 1.

To account for subject raising in cases where the verb is already low, we need to say something more in order to get the correct output (19).

(19) PITCHDROP ≫ ID-TONE ≫ID-PHASE

e^4 pa^1_{ipfv}	PITCHDROP	ID-TONE	ID-PHASE
a. e^4 pa^1	*!		
b. e^4 pa^2	*!	*	
c. e^3 pa^1	*!	*	*
d. e^5 pa^1		*	*!
e. ☹ e^4 pa^0		*	

In order to ensure that the candidate with a superlow tone, candidate e in (19), does not win, I propose a markedness constraint *0 which ensures no superlow tones in the output.

(20) **0*
Assign one violation for every instance of a superlow tone in the output.

This *0 constraint is typologically motivated, because very few languages allow superlow tones. In fact, many more languages allow superhigh than superlow, according to a database of over 600 tone languages worldwide (Hyman, p.c.). It is also motivated within Guébie, where we never find a surface superlow tone.

The addition of this constraint results in the desired optimal candidate, (21).

(21) **0* ≫ PITCHDROP ≫ ID-TONE ≫ ID-PHASE

e^4 pa^1_{ipfv}	*0	PITCHDROP	ID-TONE	ID-PHASE
b. e^4 pa^0	*!		*	
a. e^4 pa^1		*!		
c. e^4 pa^2		*!	*	
d. e^3 pa^1		*!	*	*
e. ☞e^5 pa^1			*	*

The tableaux in (18) and (21) show that the proposed constraint ranking accounts for tonal shift in the imperfective grammar, both in verb lowering and subject raising contexts.

In the elsewhere grammar, which evaluates subjects and verbs in perfective contexts, the only crucial ranking is that ID-TONE must outrank all markedness and antifaithfulness constraints. This will result in the faithful candidate surfacing every time, as is true of the perfective in Guébie: ID-TONE ≫ PITCHDROP, *0. The ranking of ID-PHASE with respect to ID-TONE in the elsewhere grammar is irrelevant.

The proposed analysis has the following benefits: it results in the correct optimal candidates, it uses constraints needed to account for scales and tonal overlays cross-linguistically (Mortensen 2006, McPherson & Heath 2016), and it captures the intuitive generalization about what is happening in the data: In imperfective contexts, the verb tone lowers if possible. If not, the subject raises.

4. Conclusion

The contributions of this paper to morphological theory are numerous. First, I have shown that existing DM mechanisms do not adequately account for morphologically conditioned phonology, and I have proposed a synthesis of existing theoretical tools to fill that gap. While I do not doubt the existence of root suppletion, it is not an adequate model of predictable morphologically conditioned phonology. The analysis proposed here makes clear predictions about which cross-linguistic phenomena involve root suppletion and which involve phonological processes triggered by morphosyntactic features: If a change is unpredictably lexically conditioned, root suppletion is the right analysis, but if it is construction specific (triggered by a particular morphosyntactic feature or syntactic position), it involves constraint-driven phonological changes tied to particular cophonologies.

Second, the proposed analysis bears on the discussion of whether phonological content can be manipulated after spell-out (the phonological phase impenetrability condition). Recall that the ranking of IDENT-PHASE constraints allowed for a candidate to surface as optimal (in imperfective subject raising contexts, (21)) despite lack of identity with the already spelled out subject DP. This analysis is built on the assumption that identity to previously spelled out phases or domains is violable. One effect of IDENT-PHASE is that we end up with inflected verbs undergoing tone shift in the default case, and spelled out subjects undergoing change only as a last resort. This follows the cross-linguistic generalization made by Smith (2011) that nouns are less likely to undergo alternations than verbs.

Third, I have shown that the morphologically conditioned phonological process of Guébie scalar tone shift can be modeled without an underlying phonological representation. The availability of morphosyntactic features to the phonological component of grammar is enough to trigger phonological change in the appropriate context. Since syntactic and morphological operations must already refer to morphosyntactic features, and the proposed model utilizes the same features in the phonological domain, rather than positing additional abstract representations, the proposed model is more economical than an account relying on a particular UR.

In the Guébie tone shift, we see syntagmatic contrast maintained not just within words, but across multiple words within a morphosyntactic domain. By combining aspects of DM with Cophonology Theory, we get a model of realizational morphophonology that accounts for the predictability of morphologically conditioned phonological processes, including scalar tone shift, without requiring abstract underlying phonological representations.

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