Nat Lang Linguist Theory (2020) 38:1211–1261
https://doi.org/10.1007/s11049-020-09467-x

Cophonologies by Ph(r)ase

Hannah Sande[1] · Peter Jenks[2] · Sharon Inkelas[2]

Received: 8 January 2019 / Accepted: 7 March 2020 / Published online: 19 March 2020

Abstract Phonological alternations are often specific to morphosyntactic context. For example, stress shift in English occurs in the presence of some suffixes, *-al*, but not others, *-ing*: *ˈpa.rent*, *pa.ˈren.tal*, *ˈpa.ren.ting*. In some cases a phonological process applies only in words of certain lexical categories. Previous theories have stipulated that such morphosyntactically conditioned phonology is word-bounded. In this paper we present a number of long-distance morphologically conditioned phonological effects, cases where phonological processes within one word are conditioned by another word or the presence of a morpheme in another word. We provide a model, Cophonologies by Phase, which extends Cophonology Theory, intended to capture word-internal and lexically specified phonological alternations, to cyclically generated syntactic constituents. We show that Cophonologies by Phase makes better predictions about the long-distance morphologically conditioned phonological effects we find across languages than previous frameworks. Furthermore, Cophonologies by Phase derives such effects without requiring the phonological component to directly reference syntactic features or structure.

Keywords Morphologically conditioned phonology · Cophonologies by Phase · Cophonology Theory · Syntactic phases · Spell-out · Syntax-phonology interface

This work is partially funded by NSF-DEL grant 1760302.

✉ H. Sande
hannah.sande@georgetown.edu

P. Jenks
jenks@berkeley.edu

S. Inkelas
inkelas@berkeley.edu

1 Department of Linguistics, Georgetown University, 1421 37th Street NW, Poulton Hall 240, Washington, DC, USA

2 Department of Linguistics, University of California, 1203 Dwinelle Hall #2650, Berkeley, CA 94720-2650, USA

1 Introduction

Some phonological alternations are seen only in specific morphological contexts (see e.g. Inkelas 2014 for a recent overview). For example, in Moro (Kordofanian: Sudan), a left-aligned high tone is epenthesized on all verb stems (in brackets), but only in certain inflectional categories of the verb (Jenks and Rose 2011). In (1), this tone occurs on the leftmost syllable, underlined, of imperfective verbs stems (1a), but not in perfective verbs such as (1b). The all-L venitive imperative form in (1c) shows that the absence of this H tone cannot simply be attributed to the presence of a final H suffix.

(1) *Moro verbs* (cp. Rose 2013; Jenks and Rose 2015:270–274)

	Verbal inflection	PREV-['tickle'-*v*]	*Gloss*
a.	IMPERFECTIVE	ga-[t<u>ʃóm</u>bəð-a]	'S/he is tickling it.'
b.	PERFECTIVE	ga-[t<u>ʃom</u>bəð-ó]	'S/he tickled it.'
c.	VENITIVE IMPERATIVE	[t<u>ʃom</u>bəð-a]	'Tickle it and come.'

However, prefixes in the pre-verb (PREV), including the exponents of subject agreement and tense morphology, do not participate in the morphologically conditioned alternations above. For example, the H tone realized in the imperfective cannot target the preverb (*/gá[tʃombða]/), and when H tone is associated with the preverb, it occurs in both the perfective and imperfective:

(2) Preverbal H unaffected by aspect

	Verbal inflection	PREV-['tickle'-*v*]	*Gloss*
a.	IMPERFECTIVE	é-ga-[t<u>ʃóm</u>bəð-a]	'I am tickling it.'
b.	PERFECTIVE	é-ga-[t<u>ʃom</u>bəð-ó]	'I tickled it.'

Another example of morpheme-specific phonology comes from the Buguumbe dialect of Kuria (Bantu), where tense/aspect determines the position of the first high tone on a verb stem (Marlo et al. 2015). When tense/aspect prefix *o-* is present, a high tone surfaces on the immediately following mora, while the *ra-* prefix co-occurs with a H on the fourth mora to the right (3).

(3) *Mora-counting H assignment in Kuria verb stems* (Marlo et al. 2015:252–253)

μ1	n-to-**o**-[h<u>ó</u>ótóótér-a] FOC-1PL-TA-[reassure-FV]	'We have reassured.'
μ4	to-**ra**-[hooto<u>ó</u>tér-a] 1PL-TA-[reassure-FV]	'We are about to reassure.'

The domain of H tone assignment is not limited to the verb stem, however. If the verb stem is shorter than four moras, in the presence of *ra-*, the H will be assigned on the following word, landing on the object of the verb (4).

(4) *Mora-counting H assignment into object position (inceptive)*

$\mu 4$	to-**ra**-[rom-a eɣé̠tɔ́ɔ́kɛ]	'We are about to bite a banana.'
$\mu 4$	to-**ra**-[ry-a eɣetɔ̠́ɔ́kɛ]	'We are about to eat a banana.'

The Moro and Kuria patterns show that the domain of morpheme-specific phonology shows considerable, and seemingly arbitrary variation: morpheme-specific phonology in Moro scopes over a sub-word domain, while the Kuria process scopes over a constituent larger than a word.

In light of this contrast, we raise the following questions: 1) How do the morphology and syntax tell the phonological component which phonological alternations to apply in any particular instance of phonological evaluation?, and 2) What principles should a model of the morphology/phonology interface use to predict possible domains of such alternations?

To address these questions, we outline a model of the syntax-phonology interface we call COPHONOLOGIES BY PHASE (CBP) which combines Cophonology Theory (Orgun 1996; Inkelas et al. 1997; Anttila 2002, 2009; Inkelas and Zoll 2005, 2007) with Phase Theory, the contemporary version of the syntactic cycle (Chomsky 2001, 2004, 2008; Abels 2012; Bošković 2014). In CBP, morpheme-specific cophonologies scope over morphological constituents, namely syntactic phases. This model allows morphologically conditioned phonological processes that affect sub-word and cross-word domains to be modeled within a single system, while deriving the phonological domains of these processes from their syntax (cf. Newell and Piggott 2014).

One central innovation in this model is an enriched conception of the content of lexical items, or vocabulary items, to adopt the terminology of Distributed Morphology (DM) (Halle and Marantz 1994). We propose that vocabulary items consist of a mapping between morphosyntactic features and a phonological feature matrix with three components: 1) lexically represented (supra)segmental features, 2) a prosodic subcategorization frame or template, and 3) a subranking or subweighting of constraints. Each of these components may be contentful or empty. While both (supra)segmental content and prosodic subcategorization (Inkelas 1990; Yu 2007; Paster 2006; Bennett et al. 2018) have previously been assumed to be associated with vocabulary items, in CBP we add morpheme-specific subrankings of constraints to DM-style vocabulary entries. This addition of cophonologies to morphemes is novel for distributed morphology but has been proposed, for example, in sign based morphology and phonology (Orgun 1996).

In addition, CBP adopts the view that phonological interpretation takes place at syntactic phase boundaries. This differs from traditional Cophonology Theory, which assumed one phonological cycle per affix (Inkelas 2008). In this way, one advantage of CBP over traditional Cophonology Theory is that, due to its coupling with Distributed Morphology, it is able to model both word-internal and cross-word morpheme-specific effects (cf. the Kuria data in (3) and (4)). CBP predicts that the same types of morpheme-specific effects that occur word-internally—such as assimilation, deletion, harmony, and tone spreading—also apply in domains larger than the word, but within a single syntactic phase. Stratal frameworks such as Lexical Phonology (Kiparsky et al. 1982) allow for the same set of rules to be present at lexical (word or sub-word) and post-lexical (phrasal, cross-word) levels of evaluation. However, phrasal phonology is expected to be fully general in such frameworks, not morphologically specific. We see in Sects. 4-6 that morpheme-specific processes do indeed occur in sub-word domains and across word boundaries, as long as those domains are co-extensive with phase boundaries.

The following section illustrates the core properties of CBP by deriving the distribution of root tone on Moro verbs (1). We then work through four additional case studies that highlight the benefits of CBP over previous models. In Sect. 3 we illustrate how CBP extends to category-specific phonological processes in Hebrew. In the next three sections we illustrate morphological conditioning in the domain of tone. In Sect. 4 we illustrate how CBP captures morphologically-triggered phrasal phonological processes, with a case study from tone assignment in Kuria (Bantu). Section 5 motivates the idea that such processes can affect syntactically higher positions within the same phase, based on data from Guébie (Kru). Section 6 looks at Dogon tonal override effects, illustrating how multiple cophonologies interact within a single phase. Along the way we compare the predictions of CBP to those of alternative models of morphologically conditioned phonology.

2 The model: Cophonologies by phase

We adopt the following three points of general consensus in the generative literature on the syntax-morphology-phonology interface. First, there is a general feeding relationship between syntax and morphology, and hence, phonology (Bobaljik 2000, 2008; Embick and Noyer 2001; Julien 2002). Second, morphological and phonological operations are interleaved (Kiparsky et al. 1982; Orgun 1996; Inkelas 1998; Anttila 2002; Pater 2007; Wolf 2008; Inkelas 2014; Jenks and Rose 2015). Third, prosodic domains bear resemblance to syntactic domains, though this relationship can be overridden by higher ranked language-specific phonological or prosodic considerations (Nespor and Vogel 1986; Selkirk 2009, 2011; Truckenbrodt 1999).

In this section we integrate these assumptions into a single model of the syntax-phonology interface. In Sect. 2.1 we introduce Cophonology Theory; Sect. 2.2 illustrates how cophonologies can be integrated with DM-style vocabulary items; Sect. 2.3 discusses the role of phases, including in deriving prosodic domains; Sect. 2.4 introduces the process of constraint resolution and the use of constraint weights rather than rankings; and Sect. 2.5 illustrates how these components work together to produce a phonological representation from a syntactic one. Section 2.6 outlines some of the general consequences of the framework.

Along the way, we use the simple Moro examples in (1) to demonstrate how the model accounts for the different behavior of tone in different morphological environments, as well as the boundary between preverb and stem from their syntax. In later sections this theory is extended to category-specific phonology and morphologically-conditioned phrasal phonological effects.

2.1 Cophonologies

Cophonology Theory is motivated by the non-uniformity of the phonological grammar of single languages. In this theory, every language contains multiple phonological sub-grammars which apply in different morphosyntactic environments. To date, cophonologies have been indexed to part of speech (Anttila 2002; Smith 2011) and to specific morphological constructions (Orgun 1996; Inkelas 1998; Inkelas and Zoll 2005, 2007).

One benefit of Cophonology Theory is its ability to unify process morphology, where a phonological process is the sole exponent of a morphosyntactic feature, and morphologically-conditioned phonology, where phonological processes accompany affixation. The motivation for unifying these two phenomena is the fact that the phonological processes that they invoke are identical, as summarized in the following generalization (Inkelas 2008, 2014).

(5) *Inkelas's Generalization*
Morphologically conditioned phonology and process morphology make reference to the same phonological operations in terms of *Substance*, *Scope*, and *Layering*.

Inkelas's Generalization highlights the point that the presence or absence of a morphologically conditioned phonological process does not rely on whether an affix is overt or null. This produces a four-way typology of such processes (6).

(6) *The independence of conditioned phonological processes and affixation*

	+Phonological process	*–Phonological process*
+Affix	Morph. conditioned phon.	Regular affixation
–Affix	Process morphology	Zero affixation

Because affixation and conditioned phonological processes are independent, but both are tied to specific morphological exponents, they should be modeled as separate components of morphemic content.

If morphologically conditioned phonological processes are due to cophonologies, constraint adjustments that apply in a particular morphological context, it follows that they should be independent from affixation. In the Moro verbs in (1), for example, whether left-aligned H tone is inserted in verb stems is independent from the specific verbal suffix; this can be seen by comparing the imperfective, which has root H tone with final suffix *-a*, with the venitive imperfective, which has no root H tone with final suffix *-a*. Hence, tone and affix together expone inflectional category of the verb. According to Jenks and Rose (2015), while imperfective verbs are associated with a cophonology that inserts a left-aligned root tone, for example, perfective verbs, and venitive imperative verbs are associated with a constraint ranking which does not allow H tones to be inserted.[1]

To be more concrete, the cophonologies which insert or block H tone on roots can be modeled as follows:

(7) *Constraint definitions* (from Jenks and Rose 2015:285)

MAX-IO(H): Do not delete H tone.
DEP-IO(H): Do not insert H tone.

[1]Other inflection patterns and melodies are also attested and discussed in Jenks and Rose (2015), we restrict our attention to these examples for simplicity.

INTEGRITY-H: No input H can be linked to more than one output tone bearing unit (Do not spread or shift input H tone).
*H: Penalize each occurrence of H.
ALIGN(H,L;ω,L): Align the left edge of some H with the left edge of a prosodic word.[2]

(8) *Moro cophonologies* (cp. Jenks and Rose 2015:286–7)
  a. Default ranking (ϕ): MAX-IO(H), DEP-H, INT-H $\gg$ *H $\gg$ ALIGN-H,L
  b. Imperfective verb tone ranking ($\phi_{v\text{-ipfv}}$): MAX-IO(H), INT-H $\gg$ ALIGN-H,L $\gg$ DEP-H, *H

The ranking ϕ in (8a) is the default ranking in Moro; this ranking prefers faithful realization of the input, only allowing lexically-associated input H to surface. This cophonology accounts for the absence of root H tones in perfective and venitive imperative verbs (1). The cophonology specified by $\phi_{v\text{-ipfv}}$ (8b), on the other hand, favors a left-aligned H in a word; this cophonology is associated with imperfective verbs, overriding the default ranking and resulting in the insertion of a left-aligned H. These effects are put into action below.

2.2 Expanding the phonological content of vocabulary items

We propose that morpheme-specific cophonologies are part of the lexical entry, or vocabulary item, associated with a morpheme. We propose that vocabulary items consist of three components: (supra)segmental content, prosodic content, and cophonologies.

In Distributed Morphology, the traditional morpheme is reframed as a vocabulary item, a lexically specified mapping from an abstract set of morphosyntactic features to a phonological representation. The following allomorphs of the English plural suffix provide a simple illustration. The choice of morpheme can be either unrestricted (9a) or contextually restricted, for example by adjacency to a particular root (9b, c), (Embick and Noyer 2007:298–299).

(9) a. [pl] $\longleftrightarrow$ z
  b. [pl] $\longleftrightarrow$ -en/$\{\sqrt{\text{OX}}, \ldots\}$___
  c. [pl] $\longleftrightarrow$ Ø/$\{\sqrt{\text{MOOSE}}, \ldots\}$___

While the vocabulary items in (9) specify the segmental content of the plural allomorphs, they say nothing about their phonological effects or their distribution. Distributed Morphology in principle allows morpheme-specific phonological rules to be encoded via lexically indexed 'readjustment rules' (Harley and Noyer 1999; Embick and Halle 2005), in the tradition of Chomsky and Halle (1968). Instead, we will adopt a different approach to morpheme-specific phonology which uses cophonologies, and hence can be integrated with the results of a constraint-based phonological component.

[2]The alignment constraint here is different from the version in (Jenks and Rose 2015) in that it does not need to refer to the left edge of a 'stem,' but rather refers to a prosodic word as it exists at the relevant point in the derivation. This will be clarified below. We have also eliminated all of the constraints which require that this H be associated with a left-aligned bimoraic foot, for which see Jenks and Rose (2011).

More specifically, we propose that three kinds of phonological content are encoded in vocabulary items: featural content, prosodic content, and a cophonology, modeled as a constraint subranking (or reweighting, see Sect. 2.4).[3]

(10) A *vocabulary item* is an association of a morphosyntactic feature set with a set $\{\mathcal{F}, \mathcal{P}, \mathcal{R}\}$:

a. Featural content ($\mathcal{F}$): Suprasegmental or segmental features
b. Prosodic content ($\mathcal{P}$): Prosodic subcategorization frame
c. Cophonology ($\mathcal{R}$): A partial constraint ranking (or weighting), which overrides a default master constraint ranking (or weighting) (Anttila 2002; Inkelas and Zoll 2005, 2007).

We intend $\mathcal{P}$-content to serve as a well-formedness condition on the morpheme's prosodic realization. Such conditions contribute lexically-specified prosodic structure, and allow the grammar to encode lexically-triggered exceptions to the general isomorphism between syntax and prosody (see Nespor and Vogel 1986; Inkelas 1990; Bennett et al. 2018; Kalivoda 2018; Bennett and Elfner 2019), as well as enabling processes such as prosodic adjunction (Ito and Mester 2007) or prosodic smothering (Bennett et al. 2018; Rolle and Hyman 2019). Following Inkelas (1990), we take affix or clitic direction to be part of the $\mathcal{P}$ specification, as affixation typically makes explicit reference to prosodic domains such as words or larger prosodic constituents for its well-formedness.[4]

To illustrate the effect of a phonologically active $\mathcal{P}$ specification, we draw on second-position clitics in Serbo-Croatian, which target the first syntactic constituent or prosodic word, a point which can result in the clitics intervening in a syntactic constituent as in (11b) (Zec and Inkelas 1990; Schütze 1994:a.o):[5]

(11) a. Taj čovek=joj=ga=je poklonio.
that man=her=it=AUX presented.
'That man presented her with it.'
b. Taj=joj=ga=je=čovek poklonio.
that=her=it=AUX=man presented.
'That man presented her with it.' (Zec and Inkelas 1990:367)

However, such clitics cannot break up a constituent to prosodically deficient elements such as prepositions (12c):

[3] The proposal that a cophonology can be associated with a particular morpheme or morphological construction was proposed in Sign-Based Morphology (Orgun 1996), modeled in a framework comparable to HPSG (Pollard and Sag 1994). However, Sign-Based Morphology restricts its attention to word-grammar and operates under the assumption that one cophonology at a time applies, unlike the model proposed here.

[4] The $\mathcal{P}$-content of a morpheme could in principle be used to model templatic effects via prosodic affixation, as in prosodic morphology (McCarthy and Prince 1996, 1990). Alternatively, such effects could arise due to cophonologies (Downing 2006; Urbanczyk 2006).

[5] Serbo-Croatian clitics, and Slavic clitics more generally, have been intensively studied. See Werle (2009) for a recent review of different approaches to Serbo-Croatian clitics and an alternative to a subcategorization approach for these cases.

(12) a. U kući =je Pétar.
in house =AUX Peter
'In the house is Peter.'

b. *U =je kući Pétar.
in =AUX house Peter
'In the house is Peter.' (Zec and Inkelas 1990:367)

The requirement that *je* and other Serbo-Croatian clitics be preceded by a prosodic word can be encoded as its $\mathcal{P}$-content, leading us to our first example of a vocabulary item in CBP:

(13) *Serbo-Croatian second-position clitics*:

$$[\text{T,PRES,3P,SG}] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & /\text{je}/ \\ \mathcal{P}: &]_{\omega}\text{-X} \\ \mathcal{R}: & \emptyset \end{Bmatrix}$$

The variable X in $\mathcal{P}$ specifies the position of the featural content in $\mathcal{F}$. No special cophonology is associated with these clitics, so $\mathcal{R}$ is null. This constraint will rule out representations like (12b), as the preposition *u* is prosodically deficient.

The richness of vocabulary items in our approach can be used to model pure process morphology as well. We illustrate with Yapese vocatives, which are often marked by truncation to a single syllable (14).

(14) *Yapese vocatives* (Jensen 1977)

Name	*Vocative name*
luʔag	luʔ
bajaad	baj
maŋɛfɛl	maŋ

Both the featural and prosodic content of the vocative is null, but $\mathcal{R}$ contains a cophonology which results in truncation to a single syllable.

(15) *Yapese vocative morpheme*:

$$[\text{VOCATIVE}] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & \emptyset \\ \mathcal{P}: & \emptyset \\ \mathcal{R}: & \omega = \sigma \gg \text{MAX-IO} \end{Bmatrix}$$

The cophonology in (15) will be inserted into syntactic nodes just like featural content, triggering truncation in spell-out domains containing this morpheme.

Returning to Moro, we now integrate the cophonologies in (8) with specific vocabulary items associated with the inflectional patterns on verbs in (1). The perfective and imperfective are marked with a final vowel which is required on all verbs, and only on verbs, so we follow Jenks and Rose (2015) in assuming that such inflectional features occur on v in Moro, the vP phase head.

(16) a. *Moro imperfective vocabulary item*:

$$[v, (\text{IPFV})] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & /\text{a}/ \\ \mathcal{P}: & \text{-}X]_{\omega} \\ \mathcal{R}: & \text{ALIGN-H,L} \gg *\text{H} \end{Bmatrix}$$

b. *Moro perfective vocabulary item*:

$$[v, \text{PFV}] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & /\acute{o}/ \\ \mathcal{P}: & \text{-}X]_{\omega} \\ \mathcal{R}: & \emptyset \end{Bmatrix}$$

c. *Moro venitive imperative vocabulary item*:

$$[v, \text{PFV}] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & /a/ \\ \mathcal{P}: & \text{-}X]_{\omega} \\ \mathcal{R}: & \emptyset \end{Bmatrix}$$

All of these morphemes are word-internal suffixes. However, the imperfective introduces a cophonology which derives the ranking in ϕ_v from the default ranking. In contrast, perfective and venitive imperative v have no $\mathcal{R}$ content, so the default ranking in ϕ survives intact, penalizing the insertion of H tone. Observe that the venitive imperative vocabulary item combines the content of imperfective $\mathcal{F}$, the suffix /a/, with the null perfective $\mathcal{R}$.

These examples have illustrated that any of $\mathcal{F}$, $\mathcal{P}$, or $\mathcal{R}$ can be null, accounting for the independence of conditioned phonological processes and affixation noted in (6), as well as the independence of morphologically-triggered prosodic subcategorization from each of the other two components. Focusing first on the independence of affixation and morpheme-specific phonological properties, cases where both $\mathcal{F}$ and $\mathcal{R}$ are specified correspond to morphologically conditioned phonology. If $\mathcal{R}$ is specified while $\mathcal{F}$ is null, the realization of the morpheme is purely processual, as in Yapese. If $\mathcal{R}$ is null and $\mathcal{F}$ specified, regular affixation results, as in Serbo-Croatian. Null $\mathcal{R}$ and $\mathcal{F}$ correspond to null affixes with no phonological effect.

(17) *The independence of conditioned phonology and affixation in CBP*

	Specified $\mathcal{R}$	$\mathcal{R}$*: ∅*
Specified $\mathcal{F}$	Morph. conditioned phon.	Regular affixation
$\mathcal{F}$*: ∅*	Process morphology	Zero affixation

This 2x2 typology splits further based on whether $\mathcal{P}$ is specified or null: null $\mathcal{P}$ corresponds to prosodically neutral morphology while specified $\mathcal{P}$ enforces some prosodic requirement, the most typical example of which is affixation to a prosodic word or phrase.

2.3 Cophonologies by phase

Morpheme-specific cophonologies apply in the syntactic spell-out domain in which they are introduced. In Minimalism, a spell-out domain is a subtree called a phase (Chomsky 2000, 2001). Once a phase is assembled, it is transferred to PF, at which point it becomes impenetrable to further syntactic operations (Uriagereka 2005; Chomsky 2004, 2008). Phase Theory has been used to derive the domains of central syntactic phenomena such as movement, agreement, case-assignment, and binding, simultaneously supplying domains for phonological and morphological processes (Ishihara 2003, 2007; Kratzer and Selkirk 2007; Pak 2008; Kahnemuyipour 2009; Jenks and Rose 2015; Deal and Wolf 2017; Sande 2017; Kastner 2019:a.o.).

Informally, phases correspond to any noun phrase, verb phrase, or clause, as well as to words or word-internal stems formed by derivational morphology. We adopt the relatively standard view that phases correspond to the c-command domain of lexically specified phase heads such as C and D (Chomsky 2000, 2001; Marvin 2002), as well as category-defining heads such as *n* and *v* (Arad 2003; Embick 2010). We also assume that the spell-out of a phase includes phase heads themselves (cp. Bošković 2016:a.o.), but not the specifier, which provides a doorway through which syntactic material from the lower phases can move in order to participate in syntactic operations at higher structural levels (Chomsky 2001).

There is some debate in the literature over what constitutes a phase. It is typically assumed that DP is a phase (Svenonius 2004; Heck et al. 2009; Kramer 2010; Jenks 2014:a.o.); critics of this idea include Matushansky (2005). For our purpose, DPs are reliable domains for phonological processes across languages, so they are phases. Similarly, we follow Arad (2003) and Embick (2010) in assuming that category-defining heads are phases, though Horvath and Siloni (2016) argue that they are not. From a phonological perspective, the fact that different lexical categories are associated with different cophonologies, as we show in Sect. 3, supports their status as phase heads.[6]

Returning to Moro, recall that the cophonologies specified in (16) scope over the verb stem (1), but not over the pre-verb (2). One might be tempted to view the boundary between preverb and verb-stem as an arbitrary morphological division, and it is treated as such by Jenks and Rose (2011), reminiscent of the distinction between stem and word in lexical phonology and morphology (Kiparsky et al. 1982) and its OT-decendants (Kiparsky 2000; Bermúdez-Otero 2008). However, there is evidence that this boundary is syntactic, where the verb stem is the portion of the verb which originates inside of the *v*P phase while the preverb originates in T or higher heads, as schematized below for a few verb forms:

(18) [$_{CP}$ íg-ɜ= [$_{vP}$ tʃúmbəð-ən-iə]]
1SG-PRES.FIN= tickle-PASS-IPFV
'I am being tickled.'

(18) [$_{CP}$ é-gá-ga= [$_{vP}$ tʃombəð-ó]]
1SG-PST-FIN= tickle-PFV
'I had tickled it.'

First, the preverb realizes categories typically associated with T, including subject agreement, finiteness, and tense.[7] The verb stem, on the other hand, contains the verb root and voice morphology such as the passive and applicative, typically associated with the *v*P domain. These suffixes are available in all contexts where verbs occur, including imperatives and gerunds:

[6] We set aside the question of whether the phasehood of syntactic heads might be sensitive to other syntactic factors (Gallego and Uriagereka 2007; Bošković 2014; Deal 2016), although such proposals do make phonological predictions in the context of a theory like CBP.

[7] In the glossing above we depart from the regular glossing convention for Moro, where the 'finite' vowel is typically glossed RTC for root clause. Note that this vowel does not occur in infinitives, which also show a distinct agreement paradigm (Jenks and Rose 2017).

(19) *Non-finite verbs in Moro include verb stems*

	Imperatives	*Gerund*	
Active:	[lág-ó]	ðә́-[lág-ә́ŋ]	'cultivate'
Applicative -*ә́t̪*:	[lә́g-ә́t̪-ú]	ðә́-[lә́g-ә́t̪-ә́ŋ]	'cultivate for s.o'
Passive -*әn*:	[lә́g-ә́n-ú]	ðә́-[lә́g-ә́n-ә́ŋ]	'be cultivated'

We further adopt the idea that the final vowel suffix is the *v* head (Jenks and Rose 2015), as in (16). This proposal finds support in the fact that the inflectional distinctions found in this position are unique to morphological verbs. These distinctions are perfective and imperfective in finite verb forms, and infinitive, imperative, and gerunds elsewhere, along with a special verbal deixis distinction in some verb forms (Rose 2013; Jenks and Rose 2015). These inflectional categories are always marked by a combination of suffix and a particular tone melody, as we have already seen.

In contrast, preverbs are not necessarily associated with verbs, so they must be the morphological reflex of a syntactic head above *v*. For example, preverbs occur as proclitics on adjectives, non-verbal deictic predicates, and possessive nominal predicates, none of which are morphologically verbal (Jenks 2019):

(20) a. ðamala ð-a= [ŋer-á]
camel CLð-FIN= good-ADJ
'The camel is good.'

b. ðamala ð-ɜ= [nní]
camel CLð-FIN= here
'The camel is here.'

c. ðamala ð-ә́= [Káka]
camel CLð-POSS= Kaka
'The camel is Kaka's.'

If the preverb originates on T, its ability to occur with non-verbal predicates is unsurprising. The status of the preverb as a clitic can be attributed to its $\mathcal{P}$ specification, which forces it to attach to a word (X-$[_{\omega}$), as with Serbo-Croatian clitics (13). However, the preverb still is able to phonologically interact with its host, undergoing stem-controlled vowel-height harmony (Rose 2013; Ritchart and Rose 2017), seen in the alternation between *ð-a=* in (20a) vs. *ð-ɜ=* in (20b). Such cross-phasal phonological interactions are predicted to occur in phase-based spellout as long as they are of a purely phonological nature and are not triggered by a cophonology or prosodic requirement of the lower phase, as detailed in Sect. 2.5.

More generally, we can conclude that the verb stem is generated in the *v*P phase, while the preverb is generated higher. Phonological requirements introduced inside *v*P cannot access the preverb, because the preverb has not yet entered the derivation, as we illustrate further below. This domain effect thus illuminates the central prediction of CBP, which is that lexically-associated cophonologies are constrained by phases:

(21) *Cophonologies by Phase (CBP):*
Cophonologies are introduced by vocabulary items and scope over the phase in which they are phonologically interpreted.

Phonological interpretation is the process by which morpho-syntactic structure is transformed into a phonological string, described in Sect. 2.5. The central claim of CBP, then, is that a lexically specified cophonology, like verbal tone melodies in Moro, will only be able to participate in a single cycle of phonological evaluation.

Spelling out phonology phase-by-phase unlocks a natural derivation of the regular correspondence between syntactic and prosodic structure (cf. Dobashi 2003; Adger 2007; Sato 2009). While phonological constraints can override such correspondence, in CBP they are only able to manipulate prosodic structure within their phase. To capture this isomorphism between syntax and prosody as the default, we propose the following phonological constraint, which has the effect of parsing all phonological material in a spell-out domain (phase-internal material) into a single prosodic domain.

(22) MAXIMIZE PROSODIC DOMAINS
All phonological content should be parsed into a single prosodic domain (e.g. word, prosodic phrase, intonational phrase).

In the absence of other heavily weighted prosodic constraints, (22) has the effect of making a prosodic constituent the same size as the spell-out domain. This universal constraint derives some of the effects of Match Theory (Selkirk 2011), though without explicit reference to syntactic XPs (or words) in constraint definitions. One benefit of (22) over the class of MATCH constraints is that the latter putatively apply to all XPs. But such a theory seems to overgenerate: there are fewer prosodic domains than XPs once functional structure is taken into account. In practice, Match Theory and its predecessors (e.g. Truckenbrodt 1999) typically only apply their constraints to constituents such as DP, VP, or CP, which happen to correspond to syntactic phases, but ignoring functional projections that are non-phasal. Restricting prosodic domains to a subset of XPs, namely phases, follows from phase-based spellout plus (22).

We follow Match Theory and its predecessors in allowing for non-isomorphism between prosody and syntax, via treating (22) as a violable constraint. Architecturally, such violations arise from cases where prosodic markedness penalizes faithful isomorphism or cases where some lexically-associated prosody, encoded for us in $\mathcal{P}$-specifications, interrupt regular mapping from XP to phonological phrase. Examples of the first case include Northern Bizkaian Basque (Elordieta 2007), which Selkirk (2011) shows violates regular XP-to-prosody mapping due to prosodic well-formedness. Kalivoda (2018) looks at several other such mismatches, for example in Japanese ditransitives (Kubozono 1989). Examples of lexical specifications overriding (22) include the Serbo-Croatian clitics examined in the previous section.

In this paper we do not analyze phenomena where (22) might be violated, as our goal is simply to motivate CBP. As such, we only generate candidates for which maximal prosodic boundaries are co-extensive with a phase domain. These prosodic domains must also be governed by prosodic well-formedness constraints which we leave implicit. Still, we consistently demonstrate how prosodic structure is built incrementally in CBP, phase by phase. Such structure is necessary because phonological constraints make reference to prosodic categories.

2.4 Constraint resolution

Classic Cophonology Theory, like cyclic theories before it, associates each node in a branching morphological structure with a cycle of phonological evaluation. The order of operations is clear and strict, inside-out. Such cyclic theories make some wrong predictions, as we will show, motivating a model more like CBP in which multiple cophonologies triggered within a single phase compile and apply just once.

This section addresses the mechanism by which cophonologies associated with distinct morphemes are combined, a process we call CONSTRAINT RESOLUTION. We adopt weighted constraints (Legendre et al. 1990), rather than ranked constraints. The choice of a weighted constraint model is motivated primarily by the existence of variation among outputs, as in the Dogon case study discussed in Sect. 6. Specifically, we adapt a Maximum Entropy-Harmonic Grammar model (MaxEnt-HG) (Goldwater and Johnson 2003; Hayes and Wilson 2008) to Cophonologies by Phase by modeling cophonologies as morpheme-specific constraint weight adjustments which are added to a master or default weighting. This results in a more nuanced implementation of CBP than that of Sande and Jenks (2018), who use ranked constraints. The choice of MaxEnt-HG over any other weighted constraint model is not crucial, but the choice of weighted constraints over ranked constraints is, in fact, crucial.

Throughout most of this paper we consider phenomena which have a single, categorically optimal output. However, rather than picking out a single output form, MaxEnt-HG determines a probability distribution over possible output candidates, where probabilities are calculated based on harmony scores (Goldwater and Johnson 2003; Hayes and Wilson 2008). For most of the case studies discussed in this paper, the results of the MaxEnt computation, then, will be (nearly) categorical, to closely match the categorical observed outputs. In the Nanga (Dogon) case study within Sect. 6, however, there is wider variation in how a given construction is produced, so the predicted probability distribution will not be categorical.

All of the weights presented in tableaux throughout this paper, both in default and phase-specific grammars, were calculated using the MaxEnt Grammar Tool (Wilson and George 2008) and rounding the weights up to the nearest whole number.[8] We choose to round weights so that our tableaux contain only whole numbers and are thus easier to read. While in each case study the predicted MaxEnt probability distribution closely matches our observed probabilities of output candidates, we caution our readers that most of the languages considered here are under- resourced and lack large corpora, so there is a possibility that the predicted MaxEnt probability distributions have been overfitted.

In this weighted constraint version of CBP, the $\mathcal{R}$ specification consists of constraint weight adjustments, rather than subrankings. Constraint resolution reduces to summing the weights of the morpheme-specific $\mathcal{R}$ specifications within a phase

[8] As Zymet (2018, 2019) shows, lexically-specific weights, or multiple weights for a single constraint in the same language, may be best modeled in a hierarchical regression model, rather than the single-level logistic regression model of traditional MaxEnt. We expect that future work might show that a hierarchical regression model would be a better fit for the data presented here than the output of the MaxEnt Grammar Tool.

with the default weighting of the language in question. Only those constraints whose weights are specifically adjusted by one or more vocabulary items in a phase domain will be affected. Other constraints retain their default weights and thus their relative power compared to other constraints. In this way, the steady drumbeat of the default weighting is felt throughout the phonological grammar. Additionally, more than one morpheme-specific $\mathcal{R}$ can work together to boost the weight of a single constraint (cf. traditional gang effects in weighted constraint models, for example, in Shih (2016)), such that only when two specific morphemes are present in a single phase do we see some alternation. (See Sande (2019) for an example of this kind of doubly morphologically conditioned phonological alternation analyzed in CBP.) Alternatively, two morphemes might adjust distinct constraints such that when each one individually is present, we see a distinct phonological effect; however, when both are present, the morpheme-specific effects compete for dominance. Section 6 discusses a case where such competition is resolved in different ways across Dogon languages. We show that morpheme-specific constraint weight adjustments within a phase make good predictions about the locality and directionality of dominance effects across languages.

To illustrate the effect of morpheme-specific constraint weight adjustments, we return to the Moro data discussed above. Recasting the Moro ranked constraint grammar in (8) in MaxEnt-HG, the relevant constraints are weighted as in (23) in the default grammar of the language.

(23) *Moro default weights* (compare ϕ in (8))

Constraint	Weight
MAX-IO(H)	9
DEP-IO(H)	9
INTEGRITY-H	2
*H	1
ALIGN-H,L	1

When no morpheme-specific constraint weight adjustments are present within a phase, the default grammar applies, allowing only lexically specified H tones to emerge in their pre-linked position. Because the perfective lacks any $\mathcal{R}$-specification, the weights of the default grammar survive intact.

Verb forms like the imperfective, however, introduce an adjustment of the weights of *H and ALIGN-H,L, such that their strength relationship is reversed.

(24) *Moro imperfective VI (revised)*:

$$[\text{IPFV}, v] \longleftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & /\acute{ɔ}/ \\ \mathcal{P}: & \text{-}X]_{\omega} \\ \mathcal{R}: & \text{DEP-H}^{-8}, \text{ALIGN-H,L}^{+9} \end{array} \right\}$$

In a vP phase containing the imperfective suffix, the weights in $\mathcal{R}$ are added to the default weights of DEP-H and ALIGN-H,L, such that DEP-H is 1 and ALIGN-H,L is 10. If multiple cophonologies make reference to the same constraint within a phase, their weight adjustments are added together, illustrated in Sect. 6.

2.5 Phonological interpretation

We assume a process which transforms a syntactic tree into a phonological string called *phonological interpretation*, which has three parts:

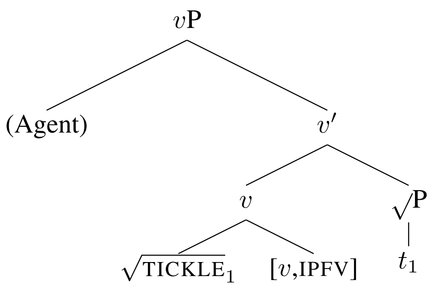
(25) *Phonological interpretation*
Vocabulary insertion → morphological composition → phonological evaluation

Phonological interpretation occurs after morphological rules have applied. In DM, these rules bundle, split, or delete the features generated by syntax, and such operations are compatible with CBP. These operations include m-merger (Matushansky 2006; Bobaljik 2012), morphological head-movement or lowering (Embick and Noyer 2001; Harizanov and Gribanova 2019), fission, or feature splitting, and impoverishment, or feature deletion, (Halle 2000; Keine 2010; Arregi and Nevins 2012; Baier 2018).[9] These operations are rule-governed and apply whenever their structural description is met. The motivation for keeping morphological rules distinct from phonological interpretation is the fact that they have no discernible phonological motivation, and that phonological interpretation takes the structures produced by these rules as its input.

After these rules are complete, phonological interpretation commences. The first step is Vocabulary Insertion, familiar from the Distributed Morphology literature, which involves replacing the (adjusted) morphosyntactic features with an appropriate contextual allomorph (Bobaljik 2000), following the requirements of the Subset Principle (Halle 2000; Embick 2015).

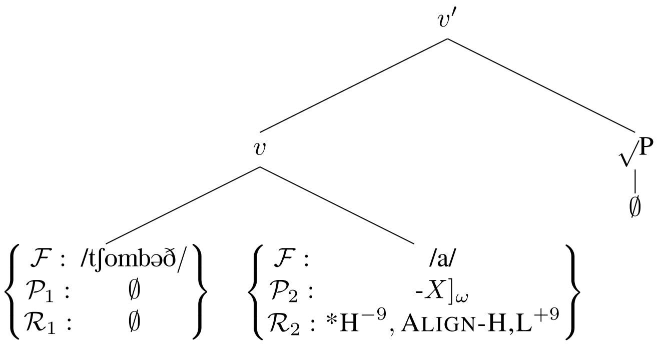
We illustrate Vocabulary Insertion with a simple Moro imperfective vP *tʃómbəð-a* ‘tickling it’, from (1). The terminal nodes for this vP, in (26a), are converted into the representation in (26b) by vocabulary insertion.

(26) a.



[9] Local Dislocation (Embick and Noyer 2001) might be better recast as a phonological effect, for us arising due to $\mathcal{P}$ specifications, as in the Serbo-Croatian discussed above. See Rolle (2019) for phonologically optimizing cases of putative local dislocation.

b.



The agent in [Spec, vP] is excluded from the spell-out of the vP phase. Lower copies of movement and null heads are replaced with null phonological content, while features which have phonological content show that content inserted. The subscripts on the $\mathcal{P}$ and $\mathcal{R}$ specifications are indices which will be put to use below. We use them in this paper for notational convenience; they have no theoretical status.

As specified by the procedure in (25), after vocabulary insertion, *morphological composition* transforms the structural representation in (26b) into a sequence of morphemes. Morpheme sequences are linearized according to the affixal requirements of the morphemes (Harley 2011), or, in the case of larger phrases, by c-command and the relative position of XPs, which is fixed in the mapping from syntax to the PF representations above (e.g. Fox and Pesetsky 2005; Embick 2010; Richards 2016).

(27) /tʃombəð a/$^{(\mathcal{P}^{1\oplus 2},\mathcal{R}^{1\oplus 2})}$

The join symbol ($\oplus$) indicates cumulative addition of the phonologically-specified material within a phase. The superscripts in (27) indicate that the phonological evaluation of the bracketed material is subject to the cumulated prosodic specification and cophonologies of the vocabulary items within a particular phase. The $\mathcal{P}$-specification of the imperfective v specifies that its featural component, /a/, is a word-internal suffix, subject to word-internal phonology.

(28) *Moro imperfective verb constraint weights* (compare $\phi_{v\text{-ipfv}}$ in (8))

Constraint	Weight
MAX-IO(H)	9
INT-H	2
*H	1
ALIGN-H,L	10
DEP-H	1

The final step in phonological interpretation is phonological evaluation, which uses the weights above to evaluate (27), shown in (29a). We included the perfective form for comparison in (29b), which uses the default weights in (23). In these tableaux, we use parentheses to indicate separate autosegmental H sequences to distinguish between spreading and insertion of H. In the tableaux throughout this paper, violations and harmony scores, **H**, are written as positive numbers, where the candidate with the lowest harmony score is most likely to be produced. Predicted output probabilities are calculated by exponentiating the negative harmony for each candidate, and dividing by their sum over all candidates (cf. Zymet 2019:3). For Moro, the predicted probabilities of the model (**Pred**) match exactly the categorical observed probabilities of each candidate (**Obs**).

(29) a. *Phonological evaluation of Moro imperfective vP*

/[$_\omega$ tʃombəð-a]/	MAX 9	INT 2	*H 1	AL-H,L 10	DEP 1	**H**	**Obs**	**Pred**
i. [$_\omega$ tʃombəða]				1		10	0	0
ii. ☞ [$_\omega$ (tʃóm)bəða]			1		1	2	1	1
iii. [$_\omega$ tʃombə(ðá)]			1	1	1	12	0	0

b. *Phonological evaluation of Moro perfective vP*

/[$_\omega$ tʃombəð-ó]/	MAX 9	INT 2	*H 1	AL-H,L 1	DEP 9	**H**	**Obs**	**Pred**
i. ☞ [$_\omega$ tʃombə(ðó)]			1	1		2	1	1
ii. [$_\omega$ (tʃóm)bə(ðó)]			2		1	11	0	0
iii. [$_\omega$ (tʃómbə́ðó)]		2	1		1	14	0	0
iv. [$_\omega$ tʃombəð-o]	1			1		10	0	0

The phonology of imperfective verbs favors the insertion of a left-aligned H tone, as in (29a-ii). But the default ranking, which survives in perfective *v*Ps, penalizes the insertion of a left-aligned H (b), spreading (c), and deletion of input H (d), resulting only in the faithful emergence of the input H on the suffix.

After phonological evaluation, the output forms above are cached as the phonological realization of the phase head: ([*v*, IPFV] ⟷ [$_\omega$ (tʃóm)bəða]). This proposal is predicated on the idea that phase heads link the higher and lower phases: their cophonologies scope over the lower phase, but their syntactic features and phonological output are retained for later stages of the computation.

We now show how the higher CP phase in Moro, consisting of C and its TP complement, fail to inherit the cophonologies introduced in the lower one. We consider a maximally simple CP consisting of two separate feature bundles on T: those realizing finite T and those realizing subject agreement, which are copied in the syntax from the DP in [Spec, TP], and whose realization we treat as a contextual allomorph of *phi*-features sensitive to the presence of an adjacent T.

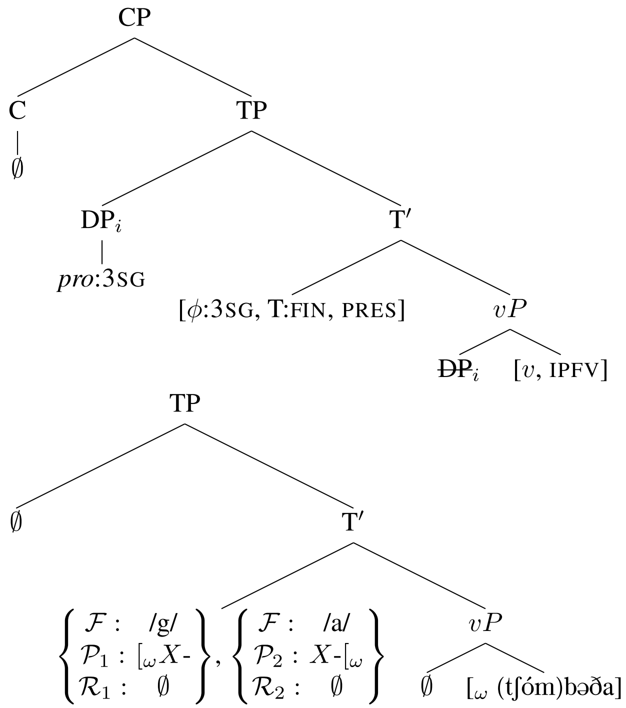
(30) *Vocabulary items for preverb (T)*

a. [T:FIN] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & /a/ \\ \mathcal{P}: & X\text{-}[_\omega \\ \mathcal{R}: & \emptyset\end{array}\right\}$

b. [ϕ:3SG] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & /g/ \\ \mathcal{P}: & [_\omega X\text{-} \\ \mathcal{R}: & \emptyset\end{array}\right\}$/_T

The features on T are replaced with corresponding phonological content at vocabulary insertion, and v, the head of the earlier phase, is replaced with its cached phonological representation. Terminal nodes which lack phonological content are replaced with null content.

(31) a.



Morphological composition produces the input to phonological evaluation below:

(32) /[$_\omega$ g-a [$_\omega$(tʃóm)bəða]]/$^{(\mathcal{P}^{1\oplus 2},\mathcal{R}^{1\oplus 2})}$

Because both $\mathcal{R}^1$ and $\mathcal{R}^2$ are empty, phonological evaluation of (32) will use the master ranking in (23), which simply favors faithful realization of input H. This derives the observation that the phonological scope of cophonologies associated with v are limited to the verb stem in Moro without any explicit reference to descriptive notions like ‘stem’.

2.6 Predictions of cophonologies by phase

CBP makes predictions in two areas: the locality of phonological operations and the isomorphism between morphosyntax and phonology.

Beginning with locality, CBP predicts that morphologically conditioned cophonologies should be able to interact within a phase. This includes the ability of lower cophonologies to affect higher material within a phase, an effect we illustrate for Guébie and Dogon (Sects. 5 and 6) as well as for multiple cophonologies to interact within a phase, as we demonstrate in the complex interactions of tonal overrides across Dogon languages (Sect. 6).

Second, because phases are nested, cophonologies in higher phases should be able to scope over and phonologically affect phases contained in them. This property of the theory also enables morphologically specified, word-internal phonological processes to cross word boundaries, a process which occurs in Kuria, Guébie, and Dogon (Sects. 4, 5, and 6). Simultaneously, while the spelled-out content feeds up into later stages of the phonological computation, only phonological information remains, deriving the principle of Bracket Erasure (Pesetsky 1979; Orgun and Inkelas 2002), which says that morphological boundaries are irrelevant once morphological cycles are complete.

Third, CBP predicts the following locality principle (Sande and Jenks 2018):

(33) *The Phase Containment Principle*
Morphological operations conditioned internal to a phase cannot affect the phonology of phases that are not yet spelled out.

More concretely, if a cophonology $\mathcal{R}$ takes scope over a syntactic domain d that is a phase, it will not apply in a domain d' such that d' contains d.

This principle has both syntactic and morphological consequences. In Sect. 6, we show that cophonologies internal to a noun phrase can affect the realization of other constituents inside that noun phrase, but never the realization of adverbs contained in the higher verb phrase, for example. Similarly, morphologically-triggered phonological processes inside of a word will not affect morphology that has not been spelled-out at the point that a particular morphological operation applies, accounting, for example, for the application of the v cophonology in Moro to affect a sub-word domain (not affecting the preverb).

The second type of prediction made by CBP is about the mapping of syntax to prosodic structure. In Sect. 2.3 we proposed the constraint MAXIMIZE PROSODIC DOMAINS (22), which penalizes prosodic domains which are not isomorphic with a phase. This constraint builds prosodic structure but avoids explicit reference to XPs, which constitutes a form of syntactic indexation. Additionally, because prosodic domains are constructed phase by phase, they will be recursive, corresponding to successive instances of spell-out (cp. Wagner 2005, 2010; Elfner 2015).

However, because it retains a constraint-based view of prosodic structure building, CBP avoids the pitfalls associated with direct reference theories of prosodic structure, which assume that prosodic domains are always identical to syntactic domains (see Cheng and Downing 2016 for discussion).

In general, then, CBP can model morphologically specific phonological phenomena, derive the scope of these phenomena from their syntactic distribution, and capture the regular but imperfect isomorphism between syntactic and prosodic domains without any indexation of syntactic or morphological information in phonological constraints. We believe that this simplification represents a substantial advantage over alternative theories which require reference to morphemes or syntactic phrases in their phonological constraint space.

In the remainder of the paper, we survey four case studies where syntactic heads trigger a phonological process whose domain demonstrably corresponds to a phase. The first is a case of category-specific phonology (Smith 2011), previously difficult to model without indexing phonological constraints to a syntactic category. The remaining three cases are examples of morphologically conditioned phonology or process morphology which cross word boundaries but are constrained by syntactic phase boundaries. Each case constitutes a distinct kind of empirical argument for CBP, as they show that the expressive power of the theory is warranted without violating the predictions about phase-based locality.

3 Category-specific phonology: Hebrew

Many languages exhibit phonotactic or prosodic requirements in one syntactic category that do not hold elsewhere in the language. For example, in Ewe (Kwa, Niger-Congo) [Ghana], there are two lexical level tones, H and L. Among nouns, there is a neutralization of H and L to L following a voiced obstruent in syllable onset position. However, among verbs, both H and L occur with any type of syllable onset (Ansre 1961) (also see Smith (2011) for more on this and other examples of phonology sensitive to syntactic category). Category-specific phonology is difficult to account for in any model which assumes that a single phonological grammar applies uniformly across an entire language (cf. Chomsky and Halle (1968) who use indexed rules, and Pater (2007, 2010) using indexed constraints). This section shows by examining a case of verb-specific phonology in Hebrew that Cophonologies by Phase can straightforwardly account for such phenomena.

Outside of Cophonologies by Phase, there are alternative multiple-grammar models of morphologically conditioned phonology, which allow multiple phonological grammars to apply in different contexts within the same language. Lexical Phonology (Kiparsky et al. 1982) and Stratal OT (Bermúdez-Otero 1999; Kiparsky 2000, 2008), for example, build in morpheme-specific phonological effects as distinct levels or strata. The problem is that neither Lexical Phonology nor Stratal OT builds in enough levels to account for the array of distinct morpheme-specific phonological processes in a language (Inkelas 2008:159). Additionally, the distinct phonological levels predicted by Stratal OT are sensitive to whether the domain in question is a root, stem, word, or phrase. However, category-specific phonological processes such as the Ewe tonal realizations in nouns versus verbs discussed above, or the Hebrew prosodic specifications of nouns versus verbs discussed below, are not related to stem-hood or word-hood, but rather syntactic category, and thus are not predicted. In order to account for distinct phonological specifications of nouns versus verbs in Stratal OT, one would need to claim that nouns are evaluated at the stem level while verbs are evaluated at the word level, or vice versa. There is no principled reason, at least in the Ewe and Hebrew cases discussed here, to believe that either nouns or verbs are full prosodic words while the other is not.

In CBP, verb-specific phonological phenomena are accounted for by associating a reweighting of constraints with the verbalizing head v. Whenever a v head is present in the spell-out domain, the v-specific phonological requirements will apply. The remainder of this section discusses a case of category-specific phonology in Hebrew, demonstrating that it is straightforward to account for in CBP.[10]

In Hebrew (Semitic), verbs are disyllabic, but the prosodic shape of nouns is less restricted (Bat-El 1994; Smith 2011).[11] This categorical difference is most clearly seen in loan words, (34).

(34) *The prosodic shape of Hebrew nouns vs. verbs* (Bat-El 1994:577–578)

	Noun		*Verb*	
a.	xantariʃ	'nonsense'	xintreʃ	'talk nonsense'
b.	télegraf	'telegraph'	tilgref	'telegraph'
c.	sinxróni	'synchronic'	sinxren	'synchronize'
d.	ksilofon	'xylophone'	ksilfen	'play the xylophone'
e.	nostálgia	'nostalgia'	nistelg	'be nostalgic'
f.	flirt	'flirt'	flirtet	'to flirt'
g.	blof	'bluff'	bilef	'to bluff'

We can see in (34) that borrowed words are faithful to the number of syllables in the lending language when produced as nouns. Trisyllabic borrowed words are produced faithfully as trisyllabic when nominal (a-e). However, the corresponding verbs are produced with only two syllables. Similarly, the monosyllabic borrowed words in (f-g) are produced faithfully as monosyllabic in their nominal form, but as disyllabic when verbal.

Arad (2003) argues that similar cases are instances of noun-to-verb derivation, making these instances of truncation (in the trisyllabic case) or expansion (in the monosyllabic case) to a disyllabic foot. Prosodic size constraints constitute a classic type of process morphology, as they involve fitting a phonological input to an independent prosodic template. Arad argues based on patterns of phonological and semantic irregularities, that nouns constitute spell-out domains, or phases, and that verbs are built on top of a nominal phase.

The expanded notion of vocabulary items in Cophonologies by Phase permits a straightforward account of the prosodic size specifications in Hebrew verbs and prosodic faithfulness in Hebrew nouns. The same root occurs in both the nominal and verbal constructions of 'telegraph,' for example. However, the nominalizing and verbalizing heads specify different restrictions on prosodic word shapes. These different restrictions are due to different constraint reweightings associated with the nominalizing and verbalizing vocabulary items.

Recall that vocabulary items in CBP contain three parts: (supra)segmental content, prosodic subcategorization, and constraint weight specifications. The relevant

[10]There are additional examples of category-specific phonology in Hebrew such as the site of vowel deletion in the presence of a vowel-initial suffix (Bat-El 2008). The word size example that we discuss here might be better characterized as specific to certain subtypes of v, but in CBP both category-specific and sub-category-specific phenomena would be handled in the same way, as cophonologies associated with a particular categorizing head, as with the v_{asp}-specific cophonology in Moro in Sect. 2.

[11]Disyllabicity does not only apply to derived verbs in Hebrew, as Becker (2003) shows that mobile-stress nouns also are subject to a disyllabic maximum. Becker's stratum-based account could be modeled by associating the relevant nominal roots with a cophonology which prefers disyllabic words. See Sande (2019) for an example of lexically specific effects modeled in CBP.

Hebrew v head is associated with the featural content of two vowels: [i e].[12] The same v head is also associated with a prosodic subcategorization specifying its status when combined with the root as a phonological word, ω. Finally, the head v is associated with a specific cophonology specifying the prosodic size requirements of all verbs; the weight of the constraint ω=$\sigma\sigma$ is increased to overpower the default weight of a general faithfulness constraint FAITH, only in the phase containing a v head. This reweighting results in the surface phonotactic constraint on the number of syllables in a prosodic word. More specifically, it specifies that all prosodic words, ω, should contain exactly two syllables, σ (37c).

(35) *Constraint definitions*

FAITH: Assign one violation for each output candidate that is unfaithful to its corresponding input candidate.

REALIZEMORPHEME: Assign a violation for each input morpheme that is not realized in the output.

ω=$\sigma\sigma$: Assign one violation for each prosodic word ω that does not contain exactly two syllables σ.

(36) *Hebrew default constraint weights*

Constraint	Weight
FAITH	9
REALIZEMORPH	9
ω=$\sigma\sigma$	1

Unlike verbalizing heads, nominalizing heads n do not affect the quality of vowels in borrowed roots. This root-vowel faithfulness in nouns is due to the fact that the nominalizing head is not associated with any segmental content in Hebrew. Similarly, the nominalizing head is not associated with a constraint reweighting, so it does not affect the default constraint weights of the language. The nominalizing head, like the verbalizing head, is associated with a subcategorization frame specifying that it forms a prosodic word when combined with the root, (37b).

A root like $\sqrt{\text{TELEGRAPH}}$ is associated with segmental content, but not with a prosodic subcategorization frame or reweighting, (37a). It is not until the root $\sqrt{\text{TELEGRAPH}}$ combines with a categorizing head and is spelled out that it has prosodic word status. The vocabulary items for the Hebrew v, n, and root $\sqrt{\text{TELEGRAPH}}$ are provided below.

(37) *Vocabulary items*

$$\text{a.}\quad [\sqrt{\text{TELEGRAPH}}] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & \text{/télegraf/} \\ \mathcal{P}^1: & \emptyset \\ \mathcal{R}^1: & \emptyset \end{Bmatrix}$$

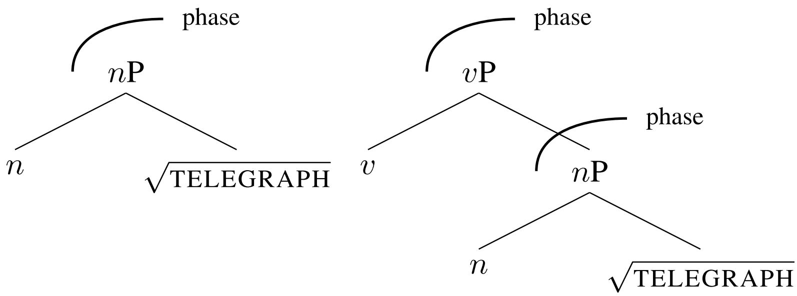
[12] For Kastner (2019) vowels are associated with Voice, rather than a verbalizing head. In a framework where Voice is a phase head and there is no separate verbalizing phase head, it could instead be a Voice head which is associated with vowel segments. Such a model would not make different predictions from ours.

b. $[n] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & \emptyset \\ \mathcal{P}^2: & \emptyset \\ \mathcal{R}^2: & \emptyset \end{Bmatrix}$

c. $[v] \longleftrightarrow \begin{Bmatrix} \mathcal{F}: & \text{/ie/} \\ \mathcal{P}^3: & \emptyset \\ \mathcal{R}^3: & \omega{=}\sigma\sigma^{+9}, \textsc{Faith}^{-8} \end{Bmatrix}$

The structures of nouns (n) and denominal verbs (v) with the root ‘telegraph’ are given in (38). The proposed structure is based on Arad (2003), who shows that this class of verbs are derived from nouns, and thus include an n phase.[13]

(38) *Structure of Hebrew noun and denominal verb*



Both structures contain a nominalizing head, which is a phase head. When the nominalizing head is merged, it triggers spell-out. Because neither the root nor nominalizing head is associated with a reweighting of constraints, the default weights of faithfulness overpowering markedness will apply (36), and the faithful output is reinserted into the syntactic structure, available for manipulation in future instances of spell-out.

In the verbal case, when the v head is merged, it triggers another instance of spell-out, where this time the constraint weights associated with the v head, add to the default weights of the language to result in domain-specific weights, $\omega{=}\sigma\sigma^{10}$, $\textsc{Faith}^{1}$. This reweighting applies only in the domain containing the v head, resulting in disyllabic verbal words.

As summarized in Sect. 2.5, morphological composition proceeds by vocabulary insertion, which replaces the morphosyntactic features in the structure with their corresponding phonological content and an assembly process, which concatenates the featural exponents of each head while unifying their prosodic and (co)phonological exponents. This assembled morphological material provides the input to phonological evaluation (39).

(39) a. *Noun after morphological composition*
/télegraf/$^{(\mathcal{P}^{1\oplus 2}, \mathcal{R}^{1\oplus 2})}$

[13] While we could have simply treated *tilgref* as a verb derived directly from a root, we have opted to run the n phase first, in part to illustrate the theory applying to multiple phases, and in part because we find the arguments of Arad (2003) convincing in this regard.

b. *Verb after morphological composition*
/i,e-[$_\omega$ té.le.graf]/$^{(\mathcal{P}^3,\mathcal{R}^3)}$

In (39b), the noun [$_\omega$ té.le.graf] has input prosodic structure because it has already passed through a single cycle, resulting in the assembly of prosodic structure, illustrated below.

The tableau in (40) corresponds to the phonological evaluation in (39a). Due to the lack of reweighting associated with the root or the *n* morpheme, the only elements within the lower phase, the faithful candidate is predicted to occur 100% of the time, matching the observed categorical probabilities.

(40) *Phonological evaluation of Hebrew noun*

/$_\omega$ té.le.graf /	ω=$\sigma\sigma$ 1	REALIZE 9	FAITH 9	**H**	**Obs**	**Pred**
a. ☞ [$_\omega$ té.le.graf]	1			1	1	1
b. [$_\omega$ til.gref]			1	9	0	0

The output candidates are prosodic words, isomorphic with the content of the spell-out domain, due to the effect of the highly weighted MAXIMIZE PROSODIC DOMAINS constraint, left out of the tableaux. We only consider candidates which do not violate MAXIMIZE PROSODIC DOMAINS. Candidate b is unfaithful to the input form prosodically and segmentally, and thus incurs a violation of FAITH. Since FAITH has a higher weight than ω=$\sigma\sigma$, candidate a, which violates ω=$\sigma\sigma$, is most likely to surface.

The tableau in (41) corresponds to the phonological evaluation of (39b). We do not list the constraints enforcing vowel replacement, which we take to be part of the default weighting; see Kastner (2019) for details. Additionally, here the weight of the REALIZEMORPH constraint (Kurisu 2001) becomes relevant. It must be high enough to overpower the effects of FAITH such that the vowels associated with the *v* morpheme actually surface, ruling out a disyllabic candidate like d.

(41) *Phonological evaluation of Hebrew verb*

/[$_\omega$ i,e [$_\omega$ télegraf]]/	ω=$\sigma\sigma$ 10	REALIZEMORPH 9	FAITH 1	**H**	**Obs**	**Pred**
a. [$_\omega$ té.le.graf]	1	1		19	0	0
b. [$_\omega$ tí.li.gref]	1		1	11	0	0
c. ☞ [$_\omega$ til.gref]			1	1	1	1
d. [$_\omega$ tel.graf]		1	1	10	0	0

The preferred candidate from the lower instance of spell-out, [$_\omega$ té.le.graf], is stored and linearized relative to later phonological constituents and phases. During phonological evaluation of later stages in the derivation (the *v* phase), previously spelled-out content can be manipulated further. Despite the fact that the trisyllabic [$_\omega$ té.le.graf] was preferred in the lower cycle of phonological evaluation, the specifications of the *v* phase head are such that the effects of the later evaluation cycle override the trisyllabic form, ultimately resulting in the disyllabic output [$_\omega$ til.gref].

In summary, the categorizing *v* head triggers verb-specific phonotactic requirements in Hebrew via a lexically-specified cophonology. In CBP, where phonological evaluation occurs at syntactic phase boundaries, the *v*-specific weights only apply within the phase containing the *v* phase head, and as such do not apply to words in other categories. CBP also extends to account for category-specific phonological effects in other languages (Smith 2011).[14]

4 Top-down cross-word phonology: Kuria

Many models of phonological evaluation assume that phonological outputs are evaluated at the word or sub-word level. For example, Stratal OT assumes that phonological evaluation takes place multiple times, once at the stem level, once at the word level, and once at the phrase level (Bermúdez-Otero 1999; Kiparsky 2000, 2008). In this model, processes triggered by a specific morpheme must apply during the level where that morpheme is first introduced, since bracketing information about morpheme boundaries is lost after each level.

However, many phonological processes, some morpheme-specific and some general across a language, cross word boundaries. In Stratal OT, morpheme-specific processes are only expected to apply at the Stem and Word levels, where new dependent morphemes are introduced. Phrase-level phonology is expected to be general. Thus, phonological phenomena that affect whole phrases, but only in the presence of a particular morpheme, are not predicted to exist. We will see in this and following sections that such processes do, in fact, exist. A morpheme internal to word A can affect the phonology of word B. In CBP this is accounted for straightforwardly; as long as the triggering morpheme in word A is spelled out in the same phase domain as word B, its morpheme-specific requirements can affect the phonological output of word B.

The remainder of this section examines a case of morphologically conditioned phonology where the trigger is a tense/aspect morpheme on a verb, and the effect of this trigger is seen on both the verb and a following object noun.

In the Buguumbe dialect of Kuria (Bantu), tense/aspect prefixes (henceforth TA, in bold below) have lexically specified tone patterns (Marlo et al. 2015). Different TAs surface with H tone on the first, second, third, or fourth mora of the verb (underlined), and from there, high tone spreads to the penultimate tone-bearing unit (TBU).

(42) *Mora-counting H assignment in Kuria verb stems* (Marlo et al. 2015:252–253)

μ1	n-to-**o**-[h<u>ó</u>ótóótér-a] FOC-1PL-TA-[reassure-FV]	'We have reassured.'
μ2	n-to-**oka**-[ho<u>ó</u>tóóté-éy-a] FOC-1PL-TA-[reassure-PFV-FV]	'We have been reassuring.'

[14] An interesting generalization about these effects made by Smith (2011) is that nouns are often more "faithful" than verbs. In CBP, this might follow if verbs are more often derived from nouns than vice versa, as in the Hebrew example above, providing additional phonological distance from the root. See Anttila et al. (to appear) for an alternative, and perhaps complementary, explanation of this generalization in terms of the different ways that stress is realized on nouns and verbs in English.

μ3 n-to-**re**-[hootóótér-a] ‘We will reassure.’
FOC-1PL-TA-[reassure-FV]
μ4 to-**ra**-[hootoótér-a] ‘We are about to reassure.’
1PL-TA-[reassure-FV]

In (42) we see that the mora following the TA prefix /o-/ has a H tone, as do all following moras up to the penult. The mora immediately following the /oka-/ TA prefix, however, does not show H tone. When /oka-/ is present, H is realized on the second mora of the verb stem, and on all moras up to the penult. After the /re-/ prefix, it is the third mora of the stem that begins the domain of H tone, and after the /ra-/ prefix, the H tone domain begins on the fourth mora of the stem. In all cases, the final mora of the stem lacks H tone, a wider pattern in the language, which we follow Marlo et al. (2015) in analyzing as being due to a phrase-final L (not discussed further here).

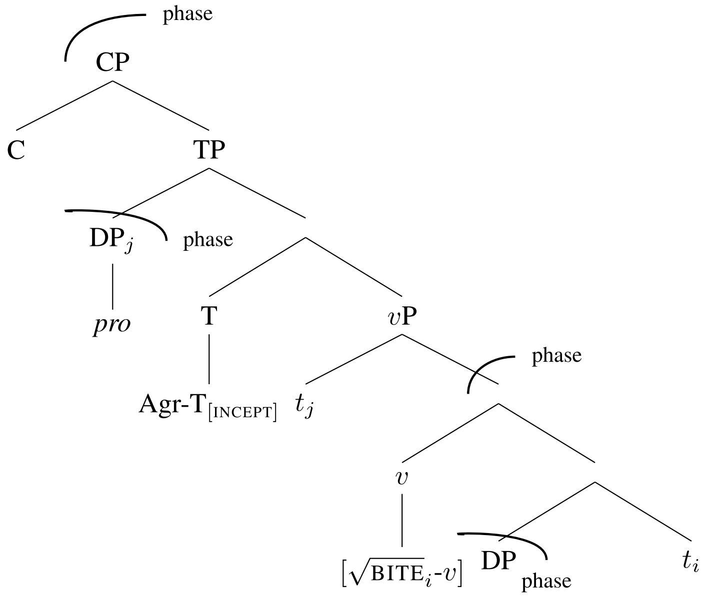
The domain of this H-assignment process is phrasal, and includes objects. Inclusion of objects in the domain of TA-specified H tone is easiest to see when the verb stem contains fewer than four moras, and is prefixed with /ra-/, after which the H tone docks on the fourth mora of the relevant domain, (43).

(43) *Mora-counting H assignment into object position (inceptive)*
μ4 to-**ra**-[rom-a eɣétɔ́ɔ́kɛ] ‘We are about to bite a banana.’
μ4 to-**ra**-[ry-a eɣetɔ́ɔ́kɛ] ‘We are about to eat a banana.’

This cross-word mora-counting phenomenon, and others like it, pose problems for theories such as Stratal-OT (Bermúdez-Otero 2008), which assume word-internal levels of phonological evaluation necessarily precede phrasal phonology, and that the phrasal phonology level or stratum does not contain exceptional or morpheme-specific effects. On the other hand, such a cross-word process is easily captured in CBP, which allows word-internal, morphologically-triggered phonological operations to scope over entire syntactic phase domains, which can include multiple phonological words. This is a key departure from both Stratal OT and traditional Cophonology Theory.

The syntactic structure we assume for Kuria clauses is provided below (44). Following proposals for other Bantu languages, we assume the verb undergoes head movement to v in Kuria. The final vowel of a verbal word expones the v head, which is a phase head (cf. Julien 2002; Cheng and Downing 2016). The vP is then spelled out, consisting of the verb stem (enclosed in brackets above) and other vP-internal material, including objects. The general importance of the verb stem in Bantu languages as a domain for both phonological and morphological phenomena is well-documented (e.g. Myers 1987, 1997; Hyman et al. 2009). Treating the stem as a complex v head captures the importance of this domain. Note that object DPs inside the vP have previously been spelled out in a separate DP phase, but remain manipulable in future instances of spell-out.

(44) *Syntactic structure of the Kuria clause*



The output of the vP phase is a phonological string associated with prosodic structure, accessible to later instances of spell-out and phonological evaluation. However, phonological processes specified inside of vP do not have access to material which enters the derivation later (as described in Sect. 2.6).

We modify the phonological rules proposed by Marlo et al. (2015) to a constraint-based analysis.

(45) *Constraint definitions*

IDENT-TONE: Assign one violation for each output tone-bearing-unit whose tonal specification differs from the corresponding input tone-bearing-unit.

μ4: Assign one violation for each floating tone that does not surface four moras from its input location.

SPREAD-(H, R): Assign one violation for each input H that is not associated with at least one tone-bearing unit to the right of its input location.

In the default grammar of the language, faithfulness has a high weight, as does rightward tone spreading, which is a regular process in the language.

(46) *Default constraint weights*

Constraint	Weight
IDENT-TONE	9
μ4	1
SPREAD-(H, RIGHT)	9

The vocabulary item associated with the inceptive T, provided below, manipulates these weights.

(47) [T,INCEPTIVE] $\longleftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & /\text{ra-}^{\text{H}}/ \\ \mathcal{P}_1: & [_{\omega} X\text{-} \\ \mathcal{R}_1: & \mu 4^{+3},\ \text{SPREAD-(H, R)}^{+8},\ \text{IDENT-TONE}^{-8} \end{array} \right\}$

The $\mathcal{P}$-specification of the inceptive marker is nontrivial; it contains the information that the inceptive is a ω-internal prefix, like other inflectional prefixes in Bantu languages (cf. Myers 1987). This specification forces prosodic adjunction, leading to a recursive word (Ito and Mester 2007).

Vocabulary insertion into T, including the realization of subject agreement, results in the composed representation below. The verb stem and object have specified prosodic structure and lack internal morpheme boundaries because they were spelled out in an earlier phase, v- and D-headed phases, respectively.

(48) a. *Morphological composition of CP*
/to-ra$^{\text{H}}$-[$_{\omega}$ roma] [$_{\omega}$ eɣetɔ́ɔ́kɛ]/$^{\mathcal{R}_1, \mathcal{P}_1}$

b. *Phonological evaluation of CP*

/to-ra$^{\text{H}}$-[$_{\omega}$ roma] [$_{\omega}$ eɣetɔ́ɔ́kɛ]/	μ4 9	H, R 9	ID-T 1	**H**	**Obs**	**Pred**
a. [[$_{\omega}$ toraroma] [$_{\omega}$ eɣetɔ́ɔ́kɛ]]	1			9	0	0
b. ☞ [[$_{\omega}$ toraroma] [$_{\omega}$ eɣétɔ́ɔ́kɛ]]			1	1	1	1

The bracketing notation in the composition and tableau above represent prosodic structure. Prosodic words are marked with ω, and outer brackets in the output candidates of the tableau represent higher levels of prosodic structure. The entire phase domain is coextensive with a prosodic phrase, as per the highly weighted MAXIMIZE PROSODIC DOMAINS constraint. The categorical predictions of the model shown in (48b) match the observed predictions (though note that we do not have access to a large corpus of Kuria data, so we base our generalizations on the description in Marlo et al. (2015)).

The domain of evaluation of the preverbal aspect marker in Kuria includes previously spelled-out phases, like the object. The surface form of the object is determined by the tonal requirements of the TA prefix in the higher spell-out domain. In CBP, the higher cophonology can override the tone of both the verb stem, spelled out in the same domain as the prefix, and the object, originally evaluated at an earlier instance of spell-out. CBP thus accounts for the ability of word-internally triggered cophonologies to scope over their entire spell-out domain, which may include neighboring words. These cross-word effects are not uncommon for phrasal tone, as we will see in the following two sections, and similar analyses could be proposed for other cases detailed by Hyman (2011, 2018), Harry and Hyman (2014).

A possible alternative analysis of the Kuria data is a complex underlying form, such as ra-$\mu\mu\mu\mu$=H, with H being realized in post-lexical phonology, when more than one word is present (see Rolle and Lionnet (2019) for another alternative analysis that does not rely on the phonology counting to four). However, as pointed out by a reviewer, in a model of phonology where multiple words are only present at the post-lexical level, it is unclear how to prevent morpheme-specific phonology from being realized until the post-lexical level. Even if it were possible to specify, with a diacritic or in the computation, that the H on the fourth mora after /ra/ should remain unassigned or unassociated until post-lexical phonological evaluation, we would need to somehow specify that the H can only be realized on the syntactic complement of the verb, and not on just any phonological material following the verbal word. These issues of domain sensitivity and the timing of applying morpheme-specific phonology are simplified in CBP, where morpheme-specific weight adjustments affect only the syntactic phase in which they originate. CBP predicts cross-word morpheme-specific effects, limited to the phase in which the triggering morpheme is introduced.

5 Bottom-up phonological effects: Guébie

In Sect. 4 we saw that CBP accounts for morpheme-specific phonological processes that affect the output form of neighboring words, as long as those words are within the same phase or were previously spelled out in lower phases. In this section we look at another such process, but with one key difference: a morpheme-specific process affects the output of a hierarchically *higher* morpheme. In Kuria, a TA prefix affects the tone of the verb stem it attaches to, as well as the direct object, lower in the structure. However, we will see that in some cases morpheme-specific phonological requirements can also affect the output of a hierarchically higher morpheme or word, as long as that morpheme is introduced in the same domain as the triggering morpheme.

In a recent implementation of Cophonology Theory, Rolle (2018) makes a specific claim about the scope of cophonologies associated with particular morphemes: the cophonology of a specifier scopes over the cophonology of a head, which scopes over its complement. His proposal resembles previous work claiming that morpheme-specific phonological requirements only scope over elements that are syntactically c-commanded by the triggering morpheme (McPherson 2014; McPherson and Heath 2016). According to Rolle (2018:12), “all dominance is inward, and cases of outward dominance would falsify this theory.” We will see in this and the next section that this claim does not hold. There are cases of hierarchically lower elements (say, syntactic heads), whose presence affects the phonological output of a higher element (say, a specifier of that head). While such cases are not predicted by Rolle or c-command based accounts, they are unproblematic for CBP. Elements introduced lower in the syntactic hierarchy can affect the phonology of hierarchically higher elements as long as the higher element is present within the phase where the lower element is introduced (recall the Phase Containment Principle in (33)).

In Guébie (Kru), the distinction between perfective and imperfective aspect is marked by a scalar shift in tone (Sande 2017, 2018). This tone shift can be realized either on the verbal head, which is the default scenario, or on the immediately preceding phonological word, the final word of the subject DP. Nothing can ever intervene between subject and inflected verb, so only subject and verb ever show surface tone effects associated with the imperfective (Sande 2017, 2018).

Guébie has four underlying tone heights, 1–4 where 4 is high. In imperfective contexts, tone on a verbal head surfaces one step lower than in other contexts. It is this step-wise shift that leads us to call it a scalar process. For example, the lexically specified tone on the verb root [li], 'eat', is a level 3, a mid-high tone. 'Eat' surfaces with its lexical tone, 3, when the verb is clause final (49a), and in perfective clauses (49b). However, in imperfective contexts we see it surfacing with a level tone 2, a mid-low tone (49c).

(49) *Verb tone lowering in imperfective contexts*

a. e^{4} ji^{3} ɟa^{31} li^{3}
1SG.NOM will coconuts eat
'I will eat coconuts.'

b. e^{4} li^{3} ɟa^{31}
1SG.NOM eat.PFV coconuts
'I ate coconuts.'

c. e^{4} li^{2} ɟa^{31}
1SG.NOM eat.IPFV coconuts
'I eat coconuts.'

When the underlying verb tone is low (tone 1) (50a), it does not lower further to super-low (50c). Instead, the final tone of the subject raises one step (50b).

(50) *Subject tone raising when imperfective verb is already low*

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

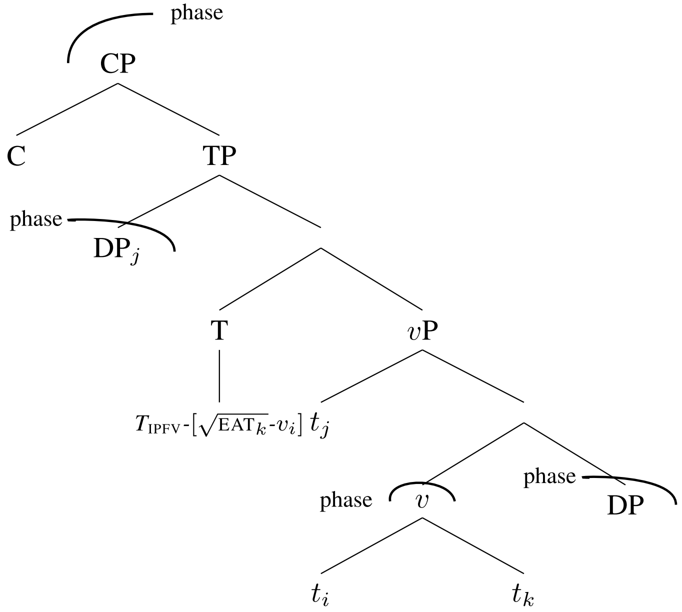
b. ɟaci$^{23.2}$ pa^{1}
Djatchi run.IPFV
'Djatchi runs.'

c. *ɟaci$^{23.1}$ pa^{0}

The Guébie imperfective alternation can be summarized as verb tone lowering one step, unless the verb is already low, in which case the subject tone raises one step. See Sande (2017, 2018) for more on the realization of the imperfective scalar tone shift on polysyllabic verbs, and with different subject-verb tone combinations.

Crucially, the tonal shift triggered by the imperfective in T can affect the subject tone (50), which is in the specifier position of T (51).

(51) *Syntactic structure for Guébie*



The imperfective aspect in Guébie motivates a tonal chain shift. Chain shifts are opaque alternations, which are a challenge for constraint-based models (Łubowicz 2003, 2012). In the analysis presented below, we adopt modified versions of scalar identity and antifaithfulness constraints from Mortensen (2006) to model synchronic chain shifts.

While this process is difficult to account for in most constraint-based models, both because of its scalar nature and the fact that it crosses word boundaries, the latter challenge disappears in CBP: Cophonologies of vocabulary items scope over the phase containing them, and apply to the whole spell-out domain, here CP.

In the case of the Guébie scalar tone shift, there is no underlying segmental or suprasegmental content to the imperfective morpheme (see Sande 2018 for justification). However, there is a cophonology associated with the imperfective T head, which scopes over the CP phase containing it. The imperfective morpheme is associated with morpheme-specific constraint weights which trigger a pitch drop between subject and inflected verb. We model this with a PITCHDROP constraint, following Sande (2017, 2018) (note that as for Sande, less of a pitch rise between input and output satisfies PITCHDROP).[15]

[15]The PITCHDROP constraint defined here targets the juncture between two prosodic phrases. The imperfective vocabulary item introduces a left edge of a prosodic phrase, which will always ensure a phrase boundary between subject and inflected verb. In fact, this will always be the leftmost phrase boundary in a clause or intonational phrase. For space, we leave out examples with more than two prosodic phrases; however, to ensure that only the subject/verb juncture and no other phrase boundaries are affected, one could reference the leftmost phrase boundary, specifically.

(52) *Constraint definitions*

IDENT-TONE: Assign one violation for each step on the tone scale that an output tone differs from its corresponding input tone.

IDENT-TONE(RIGHT, ϕ_v): Assign one violation for each step on the tone scale that an output tone at the right edge of a prosodic phrase differs from its corresponding input tone.

PITCHDROP: Assign one violation for each sequence of consecutive prosodic phrases whose shared edge is not associated with more of a pitch drop in the output than in the input.[16]

*0: Assign one violation for any superlow tone, 0, in the output.

IDENT-TONE and the position-specific IDENT-TONE(RIGHT, ϕ_v) are defined in a scalar manner, where the further along the scale an output element is from the original input, the more violations are incurred (cp. Kirchner 1997). The scalar evaluation of ID-TONE ensures that the most likely output candidate only minimally differs on the tonal scale from the corresponding input tone. A verb with an input phonological tone 3 does not show lowering all the way to a low tone level 1, only to level 2.

The default status of these constraints is faithfulness weighted more heavily than PITCHDROP: IDENT-TONE = 10, IDENT-TONE(RIGHT, ϕ_v) = 8, *0 = 16, PITCHDROP = 1. The *0 markedness constraint is externally motivated by a cross-linguistic rarity of super-low tones, and internally motivated by a complete lack of super-low tones on the surface in Guébie. The weights of *0 and IDENT-TONE(RIGHT, ϕ) are unaffected by the specifications of the imperfective morpheme. Thus, in imperfective contexts they will maintain their default weights. However, the weight of PITCHDROP is promoted, and that of ID-TONE demoted.

(53) $$[\text{T,IPFV}] \longleftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \emptyset \\ \mathcal{P}_1: & [_\phi X \ldots \\ \mathcal{R}_1: & \text{PITCHDROP}^{+22}, \text{ID-TONE}^{-2} \end{array} \right\}$$

The prosodic requirements of the imperfective morpheme specify that upon insertion, it marks the left edge of a prosodic phrase, ϕ_v. Even though there is no featural content to the vocabulary item, it still results in additional prosodic structure building. This is motivated by the fact that the auxiliary or inflected verb in the T position phrases prosodically with the following elements, namely, objects, adverbs, or postpositional phrases. These phrase separately from the immediately preceding subject, which forms a prosodic phrase on its own. Guébie language-internal diagnostics for prosodic phrase boundaries include a lack of vowel coalescence at phrase edges. We never see coalescence between the final vowel of the subject and the initial vowel or syllable of the verb. We do, however, see such coalescence between verbs and following objects. The prosodic phrasing of subject separately from object and verb, [S][VO], is common cross-linguistically. For a diverse array of languages that also

[16] Note that PitchDrop is an antifaithfulness constraint (Kurisu 2001; Alderete 2001; Mortensen 2006). The status of antifaithfulness constraints is debated, but Mortensen (2006) and Sande (2018) show that they are the only way to account for scalar phonological phenomena in a constraint-based model.

show [S][VO] phrasing, see Elordieta et al. (2003) on Spanish and Catalan, Selkirk and Tateishi (1991) on Japanese, and Hyman et al. (1987) on Luganda.

To comply with the weighting specifications of the imperfective morpheme, the weight of the PITCHDROP constraint goes from 1 to 23, and ID-TONE from 10 to 8, resulting in a strength reversal between PITCHDROP and IDENT-TONE from default to imperfective contexts.

The locality of the PITCHDROP constraint, targeting the juncture between prosodic phrases, ensures that the tone of the object or other hierarchically lower elements inside the same prosodic phrase as the verb in T, is unaffected. The definition of the PITCHDROP constraint adopted here differs from that proposed by Sande (2018) in one crucial respect; for Sande, PITCHDROP targets the juncture between subject and verb, requiring the phonological component of grammar to have access to syntactic category information, namely the identity of the subject and verb. Thus, Sande's PITCHDROP is an indexed constraint. In our updated PITCHDROP constraint definition, we do away with the need for indexed constraints by referencing prosodic boundaries rather than syntactic categories.

The phonological evaluation of the imperfective clause 'I eat coconuts' is shown below. The weight associated with the imperfective T head adds to the default weight of PITCHDROP, only in clauses with an imperfective T head. This results in verb tone lowering (55).

(54) *Output of morphological composition of the Guébie imperfective CP*
/[$_\omega$ e^4] [$_\omega$ li^3] [$_\omega$ ɟa^{31}]/$^{\mathcal{R}_1,\mathcal{P}_1}$

(55) *Phonological evaluation of Guébie imperfective CP*

/[$_\phi$ [$_\omega$ e^4]] [$_\phi$[$_\omega$ li^3] [$_\omega$ ɟa^{31}]]/	*0 16	PDROP 23	ID-T(R, ϕ_v) 8	ID-T 8	**H**	**Obs**	**Pred**
a. [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ li^3][$_\omega$ ɟa^{31}]]		1			23	0	0
b. ☞ [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ li^2][$_\omega$ ɟa^{31}]]				1	8	1	1
c. [$_\phi$ [$_\omega$ e^5]][$_\phi$ [$_\omega$ li^3][$_\omega$ ɟa^{31}]]			1	1	16	0	0
d. [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ li^1][$_\omega$ ɟa^{31}]]				2	16	0	0
e. [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ li^0][$_\omega$ ɟa^{31}]]	1			3	40	0	0

Note that the subject and object DPs, and the verb, have been previously spelled out, and thus at the CP stage of the derivation are simply strings of phonological content, including a prosodic specification. The output prosody is faithful to those input phonological strings, and to the prosodic specification of the T head.

If the verb has an input low tone, 1, then we do not see verb tone lowering to 0. Rather, we see PITCHDROP satisfied via subject raising. This is captured by the highly weighted *0 constraint, which rules out candidate b in (56). Candidate c is then most likely to surface, despite its violating IDENT-TONE(RIGHT, ϕ_v).

(56) *Phonological evaluation of Guébie imperfective CP with low-toned verb*

/[[[$_\phi$ [$_\omega$ e^4]] [$_\phi$[$_\omega$ pa^1]]]/	*0 16	PDROP 23	ID-T(R, ϕ_v) 8	ID-T 8	H	Obs	Pred
a. [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ pa^1]]		1			23	0	0
b. [$_\phi$ [$_\omega$ e^4]][$_\phi$ [$_\omega$ pa^0]]	1			1	24	0	0
c. ☞ [$_\phi$ [$_\omega$ e^5]][$_\phi$[$_\omega$ pa^1]]			1	1	16	1	1

Subject raising is ruled out as the default way to satisfy PITCHDROP by the ID-TONE(RIGHT, ϕ_v) constraint, penalizing non-faithfulness to the right edge of a prosodic phrase. The subject will only raise to satisfy PITCHDROP if there is some higher-weighted markedness constraint, in this case *0, preventing verb tone lowering.

As seen in the Guébie data, it is a benefit of CBP that phonological processes triggered by vocabulary-specific constraint weight effects do not apply until the application of phonology at the end of a phase. This allows processes triggered by T_{ipfv} to apply to the entire CP containing that T, including the subject DP, which is higher in the structure, in the specifier of T. This upward-looking process is possible because cophonologies triggered by heads lower than the phase head take scope over their entire spell-out domain. The effect of the imperfective morpheme on the preceding word (the subject) in Guébie is not predicted by frameworks like those adopted by McPherson (2014), McPherson and Heath (2016), or Rolle (2018), which derive the scope of morpheme-specific phonological effects via syntactic c-command, predicting that only hierarchically lower elements should be affected.

6 Interacting morpheme-specific phonologies: Dogon

This section discusses how CBP handles multiple morpheme-specific cophonologies that interact, specifically those which conflict. For example, in Chichewa (Bantu) [Malawi], a H tone can surface on the final or penultimate vowel of the verb stem (Mtenje 1987; Kanerva 1989; Hyman and Mtenje 1999; Downing and Mtenje 2017).[17] A H tone underlyingly associated with a verb root or derivational affix will result in a final H (*pez-á*, cf. *meny-a*, (57)), while a H tone underlyingly associated with an inflectional affix (proposed to be both hierarchically and linearly outside of derivational affixes) will result in a penultimate H (*ku-sa-mény-a*). When an inflectional affix assigns a H to the penultimate vowel, a H assigned to the final vowel by a root or derivational affix fails to surface (*ku-sa-p éz-a*, **ku-sa-pez-á*, **ku-sa-péz-á*). As Hyman (2016) points out, in this case, two morphological tone assignments are in conflict, and “the ‘later’ macro-stem domain thus overrides the earlier stem domain” (quotes from source).

[17] H tones can also surface earlier in the verb stem, but due to an independent set of phonological factors. See Hyman and Mtenje (1999), Downing and Mtenje (2017) for more detail.

(57) **Conflicting morphological tone requirements in Chichewa**

	H root		*Ø root*	
Ø infl	pez-á	'find!'	meny-a	'hit!'
H infl	ku-sa-péz-a	'to not find'	ku-sa-mény-a	'to not hit'

There are two configurations in which morpheme-specific phonologies (cophonologies) might appear in conflict in CBP. First, the two cophonologies might be separated by a phase head, and thus will apply in two separate spell-out domains. In this phase-divided configuration, we expect both cophonologies to apply in turn, and if in conflict, CBP predicts that the effect of the higher cophonology will overwrite the effect of the lower during phonological evaluation of the higher phase domain. The Chichewa data above fall into this first category. If we adopt the Bantu syntactic analysis from Sect. 4, inflectional affixes which trigger a H on the penult are in a separate, higher phase domain (CP) than the phase where the verb root is originally spelled out (vP). Due to the morpheme-specific effects of the higher inflectional morpheme, H tones are assigned to the penult rather than the final vowel. There must also be a constraint prohibiting consecutive H tones, which prevents the root-associated H and H-toned inflectional affix from co-occurring *[ku-sa-péz-á], 'to not find'.

At higher levels of spell-out, lower cophonologies no longer have an effect; the grammar reverts to the default weighting, as we saw in the Moro example in Sect. 2.5. As a result, the requirements of a cophonology in the higher spell-out domain will prevail apparently in competition with cophonologies in lower spell-out domains. This prediction of CBP is formalized as the Phase Containment Principle in Sect. 2.6. We saw instances of phasal anti-faithfulness in the case studies in Sects. 3, 4, and 5, and all of these instances involve overwriting of previously spelled-out phases, which is compatible with the Phase Containment Principle.

The second possible configuration of two or more conflicting cophonologies is for the two to be present within the same spell-out domain. In this case, the decision to appeal to constraint weights rather than constraint rankings (Sect. 2.4) is crucial in determining possible phonological outputs. Ultimately, all weighting effects for a given constraint within a spell-out domain are added together with the default weights, cumulatively determining the constraint weights for that particular cycle of phonological evaluation. The degree of reweighting of constraints associated with particular morphemes is language-specific; thus, within a spell-out domain, if multiple morpheme-specific phonological requirements are in conflict, we predict that the effect of either the hierarchically higher or lower morpheme could surface. We take this prediction of language-specific dominance determinedness within a spell-out domain to be a positive aspect of CBP, because it predicts the range of empirical facts across the Dogon language family, as discussed in this section.

Much literature on morphologically conditioned phonological requirements in conflict has claimed that cross-linguistically the hierarchically higher (outermost) morpheme's requirement is met. Formally, this has been built into various frameworks in different ways. Referring to Cophonology Theory couched within Sign-based Morphology and Phonology (Orgun 1996), Inkelas (2008:158) says, "The way two cophonologies in the same word interact depends intrinsically on the hierarchical structure of the word. The outer construction has the last say." See also Revithiadou (1999). For Rolle (2018), the cophonologies of specifiers scope over their heads, and the cophonologies of heads scope over their complements, similar to the syntactic c-command relationship which determines conflict resolution for McPherson (2014) and McPherson and Heath (2016). We saw in Sect. 5 that Rolle's scope hierarchy makes bad predictions for cases where a lower head within a spell-out domain affects the phonological output form of a higher element within that domain (i.e. imperfective scalar tone shift affecting a subject in Guébie). Here we show that both Rolle's and Inkelas's formalisms are too restrictive: within a single syntactic phase, it is not always the highest morpheme's phonological requirement which 'wins.'

The remainder of this section discusses tonal overlays across Dogon languages [Mali], focusing on morphemes with conflicting tonal requirements that originate in the same spell-out domain. In Dogon languages, certain modifiers within a noun phrase (DP) assign a tone melody to other elements inside that DP (McPherson 2014; McPherson and Heath 2016). For example, an inalienable possessor assigns a H(L) tone to its right (the noun), and an adjective assigns a L tone to its left (the noun). In some Dogon languages, the L-tone assigned by the adjective can spread left from the noun onto the inalienable possessor, if there is one: [[[Poss] N] Adj].[18] An example from Tommo So is given in (58).

(58) *Tonal overlays in Tommo So*

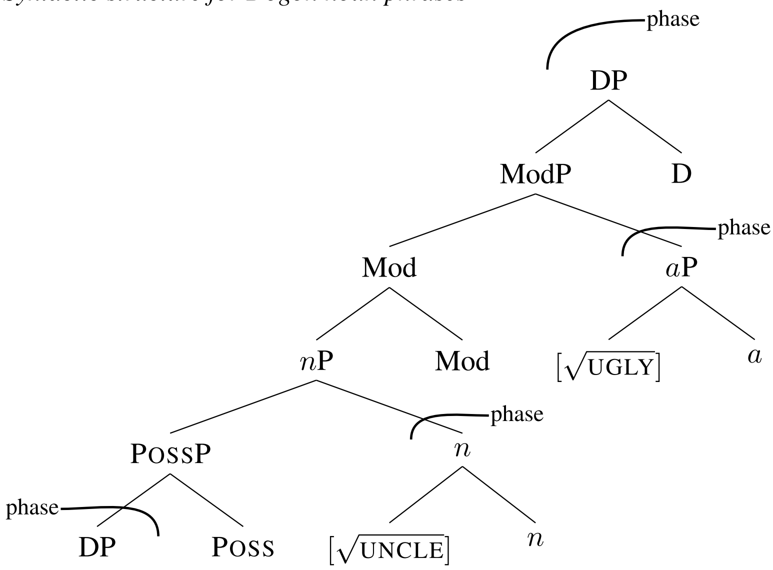
a. N^{L} Adj
gàmmà gɛ́m
'black cat' (cp. gámmá)

b. InalPoss $^{H(L)}$N
mí bábé
'my uncle' (cp. bàbè)

When both an inalienable possessor and an adjective are present, there is a conflict between the tonal requirements associated with the possessor and the adjective, resolved differently in different Dogon languages. We analyze the tonal requirements of these morphemes as cophonologies or reweightings associated with each morpheme. The relevant syntactic structure for Dogon noun phrases, containing both an inalienable possessor and an adjective is given below, adapted from McPherson and Heath (2016).

[18] This section focuses on tonal interactions of possessors, adjectives, and nouns. For tonal interactions of numerals, which are sometimes part of the tonal overlay domain, and demonstratives, which can also trigger a tonal overlay in certain Dogon languages, see McPherson (2013, 2014), Heath (2016). We do not believe that any of the data on numerals or demonstratives is problematic for CBP, and we leave out a thorough discussion for purposes of space.

(59) *Syntactic structure for Dogon noun phrases*



This structure is head-final, like Dogon syntax more generally, with specifiers and adjuncts on the left, with the exception of ModP (Rubin 1995, 2003; Scontras and Nicolae 2014), which introduces a rightward specifier, an *a*P.

In (59), the Poss head, Mod head, and D are all introduced within the highest DP phase domain. This means that cophonologies associated with the Poss, Mod, and D will all be present during the same evaluation cycle, and could potentially conflict. Elements outside the DP phase domain are not affected by the tonal requirements of DP-internal elements (see McPherson (2014) for relevant examples and discussion). We have seen that the presence of an inalienable possessor assigns a H(L) tone to a prosodic constituent on its right. We propose that the Poss head is associated with a constraint weighting that results in the Poss-specific tonal override. We analyze the Poss head, and not the possessive DP itself, as associated with the constraint reweighting because all inalienable possessors show the same tonal effect; thus, it is more economical to propose that the functional head, rather than all possessive nouns, is associated with the HL-assigning reweighting. Similarly, adjectives assign a L to their left. This L-assignment is not associated with the adjective (adjectival modifiers, which precede the adjective, are not affected by the L tonal override, (McPherson p.c.)), but with a functional head Mod. The Mod head is associated with a constraint weighting that requires a L on a prosodic constituent to its left. When both Poss and Mod are present, there is a conflict: is H(L) or L assigned to the noun?

Different Dogon languages use different strategies to resolve the tonal conflict in constructions like (59) (McPherson 2014:74). Here we discuss three different surface patterns in three Dogon languages, which are generally representative of patterns exhibited across the 10 Dogon languages discussed by McPherson. First, in Tommo So the tonal requirements of the Mod head surface, and the H(L) tone assigned by the possessor is suppressed. This results in the noun surfacing with a L tone, rather than the possessive-assigned H(L) or the noun's lexical tone. The tone of the possessor is unaffected. In Jamsay, the tonal requirements of the Mod head again dominate; however, unlike Tommo So, the tone of the possessor also surfaces as low. We analyze the difference between Tommo So and Jamsay as due to the prosodic target of the active tonal overlay constraints. For Tommo So, leftward docking of the modifier's L tone targets a prosodic word (the noun), whereas in Jamsay it targets a prosodic phrase (Poss + Noun). Lastly, in Nanga, tonal assignment is variable. One possible surface form is for the hierarchically lower cophonology, associated with the possessor, to prevail (McPherson 2014:74). Another possible surface form shows the modifier's tonal assignment dominating, such that both the possessor and noun surface with a low tone, as in Jamsay (McPherson 2014:149).[19]

Possible surface forms for [[[Poss] N] Adj] constructions in the three languages are shown in (60).[20]

(60) *Different cophonologies take precedence in different Dogon languages*

a. Poss N^{L} <u>Adj</u>: *Tommo So*

ú **bàbè** mɔ̀ɲjú
2.SG uncle ugly

'your ugly uncle' (cp. *bàbé*)

b. Poss^{L} N^{L} <u>Adj</u>: *Jamsay*

ù **lèjù** mɔ̀ɲú
2.SG uncle ugly

'your ugly uncle' (cp. *ú*, *lèjú*)

c. <u>Poss</u> ^{HL}N Adj: *Nanga*

ú **lésî** mɔ̀sí́
2.SG uncle ugly

'your ugly uncle' (cp. *lèsí*)

d. Poss^{L} N^{L} <u>Adj</u>: *Nanga*

ù **lèsì** mɔ̀sí́
2.SG uncle ugly

'your ugly uncle' (cp. *ú*, *lèsí*)

The Nanga pattern of possessor tonal assignment dominance is particularly relevant for distinguishing between frameworks. The tonal requirements of the hierarchically lower Poss head may dominate, such that the noun surfaces with a H(L) tone, while

[19]There is a third possible output form in Nanga, where the HL Poss assignment surfaces on the noun, and the Adjective L-tone assignment self-docks, surfacing on the Adjective. For reasons of space, we do not consider a self-docking candidate or constraints relevant to result in a self-docking output, though see McPherson (2014) for a full-fledged analysis.

[20]Heath (2015a) discusses data from two additional Dogon languages, Donno So and Togo Kan, in which two morphological triggers must be present for a particular tone pattern to surface. When one is present on its own, there is no surface effect. See Sande (2019) for an analysis of a similar doubly conditioned process in Cophonologies by Phase, which we expect could straightforwardly extend to these additional Dogon languages.

the tonal requirements of the higher modifier are suppressed (60c). Thus, it is not the case that the hierarchically highest morpheme-specific requirement always prevails, as is predicted by Rolle (2018) or Inkelas (1998).

The variation in surface forms in Nanga (cf. (60c) and (60d)) can straightforwardly be accounted for with constraint weighting in a MaxEnt-HG model, which provides a probability distribution over possible output forms. This variation would be difficult to account for with ranked constraints or traditional Harmonic Grammar, where a single optimal output is determined.

We analyze the possessor and adjective (or more specifically, the Poss and Mod head) as associated with cophonologies where association of floating tone melodies (HL from Poss and L from Mod) outweigh IDENT-TONE. Relevant constraints are defined below, adapted from McPherson (2014) and McPherson and Heath (2016).

(61) *Constraint definitions*

IDENT-TONE: Assign one violation for each output tone-bearing-unit whose tonal specification differs from the corresponding input tone-bearing-unit.

ASSOCIATE(HL, RIGHT$_{\omega}$): Assign one violation for each floating HL tone melody that is not associated to the tone bearing units within the prosodic word on its right.

ASSOCIATE(L, LEFT$_{\omega}$): Assign one violation for each floating L tone melody that is not associated to the tone bearing units within the prosodic word on its left.

ASSOCIATE(L, LEFT$_{\phi}$): Assign one violation for each floating L tone melody that is not associated to the tone bearing units within the prosodic phrase on its left.

The constraints above are based on the definitions of tone assignment constraints proposed by McPherson and Heath (2016), but they differ in one crucial way: While McPherson and Heath's constraints necessarily make reference to particular syntactic categories which assign a given tone melody, and rely on syntactic hierarchical c-command relationships, the adapted versions of the constraints presented above need not reference morphosyntactic information, only prosodic domains and input phonological content. Note that there are two different versions of the ASSOCIATE(L, LEFT) constraint, one which targets a prosodic word and another which targets a prosodic phrase. The particular association constraint active in a given language will determine whether the tone of the Mod head targets only the prosodic word on the left, the noun (Tommo So), or whether it targets a larger domain, Poss + Noun (Jamsay).

There is no active constraint specifying that tones can associate to a prosodic phrase on the right. This captures the fact that across Dogon languages we see leftward association of a L tone to a word-level domain (the noun) or a larger prosodic phrase domain (possessor plus noun), though we only ever see rightward association of an HL melody to a prosodic word in Dogon.[21]

[21] Another Dogon language, Toro Tegu, supplies evidence that tonal overrides can apply to prosodic phrases on the right, filling out the one possibility which is not attested in the three Dogon languages con-

We adopt a single set of default weights for Tommo So, Jamsay, and Nanga (62).

(62) *Default constraint weights across Dogon*[22]

Constraint	Weight
IDENT-TONE	8
ASSOCIATE(HL-RIGHT$_\omega$)	1
ASSOCIATE(L-LEFT$_\omega$)	1
ASSOCIATE(L-LEFT$_\phi$)	1

The cophonologies associated with Mod and Poss are inherited by the phase head. The determining factor in which melody surfaces in a given language is the relative weight of the morpheme-specific constraint weight adjustments in that language (McPherson 2014). In Nanga, rightward (upward) tone association outweighs leftward (downward) association, but vice versa in Tommo So and Jamsay.

The vocabulary items associated with POSS and MOD heads in Tommo So, Jamsay, and Nanga are given below, where language-specific weight adjustments result in different output probability distributions.

(63) *Tommo So*

a. [POSS] $\longleftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \text{HL} \\ \mathcal{P}_1: & \emptyset \\ \mathcal{R}_1: & \text{ASSOCIATE(HL-RIGHT}_\omega)^{+15} \end{array} \right\}$

b. [Mod] $\longleftrightarrow \left\{ \begin{array}{ll} \mathcal{F}: & \text{L} \\ \mathcal{P}_2: & \emptyset \\ \mathcal{R}_2: & \text{ASSOCIATE(L-LEFT}_\omega)^{+16} \end{array} \right\}$

c. *Morphological composition of DP*
/[$_\omega$ ú] HL [$_\omega$ bàbé] L [$_\omega$ mɔ̀ɲjú]/$^{\mathcal{R}_{1\oplus 2}, \mathcal{P}_{1\oplus 2}}$

d. *Phonological evaluation of DP*

/[$_\omega$ú] HL [$_\omega$ bàbé] L [$_\omega$ mɔ̀ɲjú]/	HL-R$_\omega$	L-L$_\omega$	ID			
	16	17	8	**H**	Obs	Pred
a. ☞ [[[$_\omega$ú] [$_\omega$**bàbè**]] [$_\omega$mɔ̀ɲjú]]	1		1	24	1	1
b. [[[$_\omega$ú] [$_\omega$**bàbé**]] [$_\omega$mɔ̀ɲjú]]	1	1		33	0	0
c. [[[$_\omega$ú] [$_\omega$**bábè**]] [$_\omega$mɔ̀ɲjú]]		1	2	33	0	0
d. [[[$_\omega$ú] [$_\omega$**bábé**]] [$_\omega$mɔ̀ɲjú]]	1	1	1	41	0	0
e. [[[$_\omega$ù] [$_\omega$**bàbè**]] [$_\omega$mɔ̀ɲjú]]	1		2	32	0	0

Floating tones are listed in (63c) and (63d) in their input positions. One could imagine the input structure as an autosegmental representation, where on the the tonal tier there is a floating HL between underlying tonal representations of possessor and noun, and a floating L between noun and adjective.

sidered here (Heath 2015b:130). See also data from the Dogon language Yorno So (Heath 2017). Overrides to prosodic phrases on the right are also found outside of Dogon in Ijoid languages (Nigeria) (Harry and Hyman 2014; Hyman 2018).

[22] For Dogon, we first fit the master weighting, then fit the weighting adjustment for when the cophonologies interact. From there we worked backwards towards the weighting adjustments for each cophonology independently.

In Tommo So, the reweighting of ASSOCIATE(L-LEFT) as higher than ASSOCIATE(HL-RIGHT) and IDENT-TONE results in association of the input L tone from the Mod head to the left, the nominal prosodic word (63). The ASSOCIATE(L-LEFT$_\phi$) constraint is not active in this process in Tommo So. We leave it out of the tableau here for space purposes, but believe that it is still present in the grammar of Tommo So, despite having a negligible weight.

If only a Poss head is present, the reweighting of HL-R$_\omega$ and ID-TONE is enough to categorically see HL spreading from the possessor's floating tone to the noun (64). If only a Mod head is present, the reweighting of L-L$_\omega$ is enough to see categorical leftward spreading of the L from the modifier onto the noun (65).

(64) *Tommo So: Possessor only*

/[$_\omega$ú] HL [$_\omega$ bàbé]/	HL-R$_\omega$	L-L$_\omega$	ID			
	16	1	8	**H**	Obs	Pred
a. [[[$_\omega$ú] [$_\omega$**bàbè**]]]	1		1	24	0	0
b. [[[$_\omega$ú] [$_\omega$**bàbé**]]]	1			16	0	0
c. [[[$_\omega$ú] [$_\omega$**bábè**]]]			2	16	0	0
d. ☞ [[[$_\omega$ú] [$_\omega$**bábé**]]]			1	8	1	1

When an inalienable possessive is present to the exclusion of an adjective, candidate d, where the noun surfaces with a H tone melody, is categorically preferred in Tommo So. For further discussion of why the floating HL surfaces as H, see McPherson (2014). Following McPherson, we consider the initial H on the noun to be due to association of the floating HL tone, so candidate d does not violate HL-R$_\omega$.

(65) *Tommo So: Modifier only*

/[$_\omega$ bàbé] L [$_\omega$ mɔ̀ɲjú]/	HL-R$_\omega$	L-L$_\omega$	ID			
	1	17	8	**H**	Obs	Pred
a. ☞ [[$_\omega$**bàbè**]] [$_\omega$mɔ̀ɲjú]]			1	8	1	1
b. [[$_\omega$**bàbé**]] [$_\omega$mɔ̀ɲjú]]		1		17	0	0
c. [[$_\omega$**bábè**]] [$_\omega$mɔ̀ɲjú]]		1	2	33	0	0
d. [[$_\omega$**bábé**]] [$_\omega$mɔ̀ɲjú]]		1	1	25	0	0

When a single trigger is present as in (64) and (65), a single constraint weight is boosted, and its effects surface on the noun. When both triggers are present, the stronger weighted constraint results in a dominance effect. For space we show these single-trigger tableaux for Tommo So only, and for the other Dogon languages we focus only on the dominance patterns, where both a Poss and Mod head are simultaneously present.

The Jamsay reweightings look quite similar to Tommo So, except that the reweighting associated with the Mod head affects ASSOCIATE(L, LEFT$_\phi$), such that the entire prosodic phrase to the left surfaces with L tone (66).

(66) *Jamsay*

a. [Poss] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & \text{HL} \\ \mathcal{P}_1: & \emptyset \\ \mathcal{R}_1: & \text{ASSOCIATE(HL-RIGHT}_{\omega})^{+7}, \text{ID-TONE}^{-3}\end{array}\right\}$

b. [Mod] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & \text{L} \\ \mathcal{P}_2: & \emptyset \\ \mathcal{R}_2: & \text{ASSOCIATE(L-LEFT}_{\phi})^{+15}, \text{ID-TONE}^{-4}\end{array}\right\}$

c. *Morphological composition of DP*
/[$_\omega$ ú] HL [$_\omega$ lèjú] L [$_\omega$ mɔ̀ɲú]/$^{\mathcal{R}_{1,2},\mathcal{P}_{1,2}}$

d. *Phonological evaluation of DP*

/[$_\omega$ú] HL [$_\omega$ lèjú] L [$_\omega$ mɔ̀ɲú]/	HL-R$_\omega$	L-L$_\phi$	ID			
	8	16	1	**H**	Obs	Pred
a. ☞ [[$_\phi$[$_\omega$**ù**] [$_\omega$**lèjù**]] [$_\omega$mɔ̀ɲú]]	1		2	10	1	1
b. [[$_\phi$[$_\omega$ú] [$_\omega$**lèjù**]] [$_\omega$mɔ̀ɲú]]	1	1	1	25	0	0
c. [[$_\phi$[$_\omega$ú] [$_\omega$**lèjú**]] [$_\omega$mɔ̀ɲú]]	1	1		24	0	0
d. [[$_\phi$[$_\omega$ú] [$_\omega$**léjù**]] [$_\omega$mɔ̀ɲú]]		1	2	18	0	0

In Jamsay, candidate b is ruled out because the possessor, which is inside the prosodic phrase to the left, does not have L tone. Instead, candidate a is the most likely output.

The Nanga weighting specifications are shown in (67). Note that unlike for Tommo So and Jamsay, the observed values for Nanga are not categorical. Candidates a and b are both possible outputs. We follow McPherson (2014) in adopting similar but non-identical observed values for each valid output candidate. Actual frequency data is unavailable, as is common for under-resourced languages. The MaxEnt-HG model adopted here, as opposed to traditional Harmonic Grammar (Legendre et al. 1990) and classical OT, allows for an output probability distribution over candidates where more than one output is possible, and one output candidate is more likely to surface than another.

(67) *Nanga*[23]

a. [Poss] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & \text{HL} \\ \mathcal{P}_1: & \emptyset \\ \mathcal{R}_1: & \text{ASSOCIATE(HL-RIGHT}_{\omega})^{+9}, \text{ID-TONE}^{-3}\end{array}\right\}$

b. [Mod] $\longleftrightarrow \left\{\begin{array}{ll}\mathcal{F}: & \text{L} \\ \mathcal{P}_2: & \emptyset \\ \mathcal{R}_2: & \text{ASSOCIATE(L-LEFT}_{\phi})^{+8.5}, \text{ID-TONE}^{-4}\end{array}\right\}$

c. *Morphological composition of DP*
/[$_\omega$ ú] HL [$_\omega$ lèsí] L [$_\omega$ mɔ̀sí́]/$^{\mathcal{R}_{1\oplus 2},\mathcal{P}_{1\oplus 2}}$

[23]In this Nanga case only, we rounded the MaxEnt Grammar Tool weights up to the nearest .5 rather than the nearest whole number, for a closer fit of the observed to predicted output probabilities.

d. *Phonological evaluation of DP*

/[$_\omega$ ú] HL [$_\omega$ lèsí] L [$_\omega$ mɔ̀sí́]/	HL-R$_\omega$ 10	L-L$_\phi$ 9.5	ID 1	**H**	Obs	Pred
a. ☞ [[$_\phi$[$_\omega$ú] [**lésî**]] [mɔ̀sí́]]		1	1	10.5	.6	.62
b. ☞ [[$_\phi$[$_\omega$**ù**] [**lèsì**]] [mɔ̀sí́]]	1		1	11	.4	.38
c. [[$_\phi$[$_\omega$ú] [$_\omega$**lèsí**]] [$_\omega$mɔ̀sí́]]	1	1		19.5	0	0
d. [[$_\phi$[$_\omega$ú] [$_\omega$**lèsì**]] [$_\omega$mɔ̀sí́]]	1	1	1	20.5	0	0

The realization of the HL as H.HL in candidate a is a language-specific realization of HL tones. We leave out constraints to rule out a H.L realization, but see McPherson (2014) for more details.

We have shown that cophonologies can be in conflict in two different configurations in CBP: 1) across a phase boundary, and 2) within the same phase. In the former case, the lower cophonology applies in the lower spell-out domain, but when the higher domain is spelled out, the cophonology of the higher morpheme applies and overwrites the effects of the lower one. When there is a conflict across phase boundaries, the higher morpheme-specific phonological requirement will prevail, as predicted by previous approaches. However, when conflicting morpheme-specific requirements originate within the same syntactic phase, we expect to see language-specific effects, determined by the value of morpheme-specific constraint weight adjustments. Thus, all cases of bottom-up phonological effects, such as Nanga possessor-dominant tonal overrides, are predicted to be phase-internal.

7 Implications and conclusion

Cophonologies by Phase unifies process morphology and morphologically conditioned phonology within a theory that also encodes prosodic structure and subcategorization, all in the context of a restrictive and mainstream set of assumptions about the relationship of syntax, morphology, and phonology. In doing so, CBP predicts category-specific, lexical class-specific, and morpheme-specific phonological effects to exist and interact, and predicts long-distance morpheme-specific phonological effects to be phase bounded. In addition to the category-specific and cross-word effects specifically discussed here, CBP has the potential to account for other phase-bounded alternations on the syntax/morphology/phonology interface. For example, Shih and Zuraw (2017) discuss the variable word order of adjective and noun in Tagalog, which is at least partially determined by phonological effects. Because adjective and noun are within the same DP phase domain, this variable word order could straightforwardly be accounted for with phase-based spell-out and weighted phonological constraints, or, to quote the title of this paper, with cophonologies by ph(r)ase.

CBP also has the potential to encompass phonological processes that have been analyzed as *syntactically* conditioned (e.g. French liaison (Selkirk 1974; Pak 2008);[24]

[24] Though see (Smolensky and Goldrick 2016) for a recent phonological representational account of French liaison.

Luganda and Xitsonga prosody (Hyman et al. 1987; Selkirk 2011)). In CBP, the restriction of certain phrasal phonological processes to specific syntactic domains follows from the fact that the relevant XPs are phases. A full examination of the consequences of prosodic subcategorization in CBP may reveal that it is possible to eliminate the need for Match Theory (Selkirk 2009, 2011), which relies on the ability of constraints to explicitly reference syntactic structure during a separate syntax-to-prosody mapping interface step of the grammar. If prosodic structure is assembled during spell-out according to the $\mathcal{P}$-specifications of vocabulary items and the MAXIMIZE PROSODIC DOMAINS constraint (22), we may be able to do away with a syntax/prosody mapping stage (see also Agbayani et al. 2015).

In addition, CBP makes explicit typological predictions about phonological locality. In particular, the theory predicts that lexically or morphologically conditioned phonological processes can only take scope over the phase that contains them (68), repeated from (33):

(68) *The Phase Containment Principle*
Morphological operations conditioned internal to a phase cannot affect the phonology of phases that are not yet spelled out.

While our case studies have illustrated the feed-forward nature of cyclic phonology, where phonological material in previously spelled-out phases can be overridden in later cycles, these overwriting processes never affect material from structurally higher phase domains (cp. d'Alessandro and Scheer 2015). Moro tonal cophonologies are restricted to the verb stem, the disyllabic word size requirement seen in Hebrew verbs fails to apply in Hebrew DPs, the μ4 tonal pattern only takes place in Kuria clauses with an inceptive prefix, PITCHDROP only takes place between an imperfective T head and its local subject in Guébie, and tonal override only occurs within DPs containing specific modifiers in Dogon.

In both Guébie and Dogon, morpheme-specific reweightings associated with a lower element in the syntactic structure affect the phonological output of a hierarchically higher word or morpheme. However, this is only predicted to be possible in CBP when the trigger and the affected morpheme are evaluated in the same phase domain as the morpheme-specific cophonology responsible for the effect. This prediction about the phase-determined locality of bottom-up override patterns is consistent with the data we have presented here, and as far as we know, is consistent with attested cross-linguistic facts.

Many of the phenomena discussed here (tone assignment and spreading in Kuria, tone shift in Guébie, and tonal override in Dogon) involve a process triggered within one phonological word affecting the phonological output of a nearby word or words. These cross-word phenomena are not predicted in other cyclic models meant to handle morphologically conditioned phonology: Lexical Phonology, Stratal OT, Cophonology Theory. The ability to handle cross-word effects is a key improvement of CBP over traditional Cophonology Theory. We see many such processes across languages, particularly in examining tonal phenomena and vowel or consonant harmony (cf. cross-word harmony in Akan, Clements 1985). We do not believe that there is anything inherently different about tone and harmony which lend them to cross-word behavior. In fact, we expect that any phonological effect that applies within a word could also apply across word boundaries within a phase domain. In most cases, phonological processes across word boundaries will be local, found at word edges. This is simply because most phonological alternations are local: local assimilation, vowel hiatus resolution, deletion for syllable structure reasons, etc. The inherent long-distance nature of harmony and tone spreading contribute to making these particular cross-word effects somewhat more noticeable. We do acknowledge that there are some tonal alternations that do not seem to have segmental equivalents. For example, in Giryama (Bantu), some morphemes assign a H-tone to the penultimate tone-bearing unit of a particular domain, which could be many words long (Volk 2011; Hyman 2018). The phrase [ni-na-mal-a ku-gul-a ŋguuwo], 'I want to buy clothes', is all low-toned, but changing the subject prefix to be third-person results in a penultimate H: [a-na-mal-a ku-gul-a ŋguúwo], 'he/she wants to buy clothes'. We are unaware of any equivalent segmental process where, say, the final segment of some multi-word domain must be voiceless only when the verb shows third-person agreement. We leave it to future work to determine whether this difference between tonal and segmental processes is due to some inherent difference between the nature of tone and segments, or whether it should be built into the generative model.

An important question raised by CBP is what happens when multiple interacting cophonologies are active in the same phase. We see at least three possible options: the structurally higher cophonology takes precedence, the structurally lower cophonology blocks the higher one, or their effects are combined, an appealing possibility with weighted constraints. The most relevant phonological phenomena we know of for determining between these three possibilities are phrasal tonal override patterns, surveyed in Hyman (2018) and Rolle (2018). These cases tend to show the structurally highest tone pattern surfacing, indicating the highest cophonology may tend to take precedence, which is what Inkelas (2014:202–203) predicts. However, as discussed in Sect. 6, McPherson (2014) and McPherson and Heath (2016) describe different tonal override effects in different Dogon languages: In Tommo So and Jamsay, the higher cophonology dominates, but in Nanga, the lower cophonology within a noun phrase often prevails. The latter is unpredicted by previous frameworks. Cophonologies by Phase accounts for this apparent exception to the rule that the higher cophonology takes precedence. Reweightings specified in a higher phase will always override specifications of an element in a lower phase, resulting in an overall preference for the structurally higher cophonology to dominate. However, two conflicting cophonologies introduced within the same phase can interact such that the one with the higher weight prevails, even if that is the structurally lower morpheme (as in Nanga). This is due to the architectural design of CBP, where all elements within a phase are spelled out simultaneously, and phase-internal reweightings are added together with the default weights of the grammar to derive the cophonology that applies to each given phase domain.

We propose CBP as an amended version of Cophonology Theory that is integrated with Distributed Morphology and minimalist syntax. The resulting theory makes better predictions about the types of morphologically conditioned phonology that we see across languages, and their locality.

Acknowledgements We'd like to thank Larry Hyman, as well as audiences at Georgetown University, UC Berkeley, CUNY, U Chicago, and NELS 48 for feedback on various aspects of this work. Thanks also to Laura McPherson for discussing details of the data relating to the Dogon case study, and to Michael Marlo and Chacha Mwita for discussion of the Kuria facts. Any errors are our own.

References

Abels, Klaus. 2012. *Phases: An essay on cyclicity in syntax*. Berlin: Walter de Gruyter.

Adger, David. 2007. Stress and phasal syntax. *Linguistic Analysis* 33(3–4): 238–266.

Agbayani, Brian, Chris Golston, and Toru Ishii. 2015. Syntactic and prosodic scrambling in Japanese. *Natural Language & Linguistic Theory* 33(1): 47–77.

Alderete, John D. 2001. Dominance effects as transderivational anti-faithfulness. *Phonology* 18(02): 201–253.

Ansre, Gilbert. 1961. *The tonal structure of Ewe*. Hartford: Hartford Seminary Foundation.

Anttila, Arto. 2002. Morphologically conditioned phonological alternations. *Natural Language & Linguistic Theory* 20(1): 1–42.

Anttila, Arto. 2009. Derived environment effects in colloquial Helsinki Finnish. In *The nature of the word: Studies in honor of Paul Kiparsky*, eds. Sharon Inkelas and Kristin Hanson, 433–460.

Anttila, Arto, Timothy Dozat, Daniel Galbraith, and Naomi Shapiro, to appear. Sentence stress in presidential speeches. In *Prosody in syntactic encoding, special issue of Linguistische Arbeiten*, eds. Gerrit Kentner and Joost Kremers.

Arad, Maya. 2003. Locality constraints on the interpretation of roots: The case of Hebrew denominal verbs. *Natural Language & Linguistic Theory* 21: 737–778.

Arregi, Karlos, and Andrew Nevins. 2012. *Morphotactics: Basque auxiliaries and the structure of spellout*. Dordrecht: Springer.

Baier, Nico. 2018. Anti-agreement. PhD diss., UC Berkeley.

Bat-El, Outi. 1994. Stem modification and cluster transfer in Modern Hebrew. *Natural Language & Linguistic Theory* 12(4): 571–596.

Bat-El, Outi. 2008. Morphologically conditioned v–Ø alternation in Hebrew: Distinction among nouns, adjectives & participles, and verbs. In *Generative approaches to Hebrew linguistics*, eds. Sharon Armon-Lotem, Gabi Danon, and Susan Rothstein, 27–60. Amsterdam: Benjamins.

Becker, Michael. 2003. Lexical stratification of Hebrew: The disyllabic maximum. *Proceedings of the Israel Association for Theoretical Linguistics* 19.

Bennett, Ryan, and Emily Elfner. 2019. The syntax-prosody interface. *Annual Review of Linguistics* 5.

Bennett, Ryan, Boris Harizanov, and Robert Henderson. 2018. Prosodic smothering in Macedonian and Kaqchikel. *Linguistic Inquiry* 49: 195–246.

Bermúdez-Otero, Ricardo. 1999. Constraint interaction in language change: Quantity in English and Germanic. PhD diss., University of Manchester.

Bermúdez-Otero, Ricardo. 2008. *Stratal optimality theory*. Oxford: Oxford University Press.

Bobaljik, Jonathan D. 2008. Missing persons: A case study in morphological universals. *The Linguistic Review* 25(1–2): 203–230.

Bobaljik, Jonathan David. 2000. The ins and outs of contextual allomorphy. *University of Maryland working papers in linguistics* 10: 35–71.

Bobaljik, Jonathan David. 2012. *Universals in comparative morphology: Suppletion, superlatives, and the structure of words*. Cambridge: MIT Press.

Bošković, Željko. 2014. Now I'm a phase, now I'm not a phase: On the variability of phases with extraction and ellipsis. *Linguistic Inquiry* 45(1): 27–89.
Bošković, Željko. 2016. What is sent to spell-out is phases, not phasal complements. *Linguistica* 56: 25–66.
Cheng, Lisa Lai-Shen, and Laura J. Downing. 2016. Phasal syntax = cyclic phonology? *Syntax* 19: 156–191.
Chomsky, Noam. 2000. Minimalist inquiries. In *Step by step: Essays on minimalist syntax in honor of Howard Lasnik*, eds. Roger Martin, David Michaels, and Juan Uriagereka. Cambridge: MIT Press.
Chomsky, Noam. 2001. Derivation by phase. In *Ken Hale: A life in language*, ed. Michael Kenstowicz, 1–52. Cambridge: MIT Press.
Chomsky, Noam. 2004. Beyond explanatory adequacy. In *Structures and beyond: The cartography of syntactic structures, volume 3*, ed. Adriana Belletti. Oxford: Oxford University Press.
Chomsky, Noam. 2008. On phases. In *Foundational issues in linguistic theory: Essays in honor of Jean-Roger Vergnaud*, eds. Robert Freidin, Carlos P. Otero, and Maria Luisa Zubizarreta. Cambridge: MIT Press.
Chomsky, Noam, and Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.
Clements, George N. 1985. Akan vowel harmony: A nonlinear analysis. In *African linguistics: Essays in honor of WMK Semikenke*, 55–98.
d'Alessandro, Roberta, and Tobias Scheer. 2015. Modular PIC. *Linguistic Inquiry* 46: 593–624.
Deal, Amy Rose. 2016. Cyclicity and connectivity in Nez Perce relative clauses. *Linguistic Inquiry* 47(3): 427–470.
Deal, Amy Rose, and Matthew Wolf. 2017. Outwards-sensitive phonologically-conditioned allomorphy in Nez Perce. In *The morphosyntax-phonology connection*, eds. Vera Gribanova and Stephanie S. Shih, 29–60.
Dobashi, Yoshihito. 2003. Phonological phrasing and syntactic derivation. PhD diss., Cornell University.
Downing, Laura J. 2006. *Canonical forms in prosodic morphology*. Oxford: Oxford University Press.
Downing, Laura J., and Alfred James Dailex Mtenje. 2017. *The phonology of Chichewa*. Oxford: Oxford University Press.
Elfner, Emily. 2015. Recursion in prosodic phrasing: Evidence from Connemara Irish. *Natural Language & Linguistic Theory* 33(4): 1169–1208.
Elordieta, Gorka. 2007. A constraint-based analysis of the intonational realization of focus in Northern Bizkaian Basque. In *Tones & tunes volume 1: Typological studies in word and sentence prosody*, eds. Thomas Riad and Carlos Gussenhoven, 199–232.
Elordieta, Gorka, Sónia Frota, Pilar Prieto, and Marina Vigário. 2003. Effects of constituent length and syntactic branching on intonational phrasing in Ibero-Romance. In *15th International congress of phonetic sciences*, Vol. 1, 487–490. Barcelona: Causal Productions.
Embick, David. 2010. *Localism versus globalism in morphology and phonology*. Cambridge: MIT Press.
Embick, David. 2015. *The morpheme*. Berlin: De Gruyter Mouton.
Embick, David, and Morris Halle. 2005. On the status of stems in morphological theory. *Amsterdam studies in the theory and history of linguistic science, series 4*.
Embick, David, and Rolf Noyer. 2001. Movement operations after syntax. *Linguistic Inquiry* 32(4): 555–595.
Embick, David, and Rolf Noyer. 2007. Distributed morphology and the syntax/morphology interface. In *The Oxford handbook of linguistic interfaces*, 289–324. Oxford: Oxford University Press.
Fox, Danny, and David Pesetsky. 2005. Cyclic linearization and syntactic structure. *Theoretical Linguistics* 31: 1–45.
Gallego, Ángel, and Juan Uriagereka. 2007. Subextraction from subjects: A phase theory account. In *Romance linguistics 2006*, eds. José Camacho, Nydia Flores-Farrán, Lilliana Sanchéz, Vivianne Déprez, and María José Cabrera, 149–162. Amsterdam: Benjamins.
Goldwater, Sharon, and Mark Johnson. 2003. Learning OT constraint rankings using a maximum entropy model. In *Stockholm workshop on variation within Optimality Theory*, 111–120.
Halle, Morris. 2000. Distributed morphology: Impoverishment and fission. *Research in Afroasiatic grammar: Papers from the third conference on Afroasiatic languages, Sophia Antipolis, 1996*.
Halle, Morris, and Alec Marantz. 1994. Some key features of Distributed Morphology. *MIT working papers in linguistics* 21(275): 88.
Harizanov, Boris, and Vera Gribanova. 2019. Whither head movement? *Natural Language & Linguistic Theory* 37: 461–522.

Harley, Heidi. 2011. Affixation and the Mirror Principle. In *Interfaces in linguistics*, eds. Raffaella Folli and Christiane Ullbricht, 166–186. Oxford: Oxford University Press.

Harley, Heidi, and Rolf Noyer. 1999. Distributed morphology. *GLOT International* 4(4): 3–9.

Harry, Otelemate, and Larry M. Hyman. 2014. Phrasal construction tonology: The case of Kalabari. *Studies in Language* 38(4): 649–689.

Hayes, Bruce, and Colin Wilson. 2008. A maximum entropy model of phonotactics and phonotactic learning. *Linguistic inquiry* 39(3): 379–440.

Heath, Jeffrey. 2015a. Dogon noncompositional constructional tonosyntax. *Journal of African Languages and Linguistics* 36(2): 233–252.

Heath, Jeffrey. 2015b. A Grammar of Toro Tegu (Dogon): Tabi mountain dialect. University of Michigan: Language Description Heritage Library.

Heath, Jeffrey. 2016. Dogon adjective-numeral inversion. *Linguistics* 54(1): 189–214.

Heath, Jeffrey. 2017. A Grammar of Yorno So (Toro So subgroup of Dogon, Mali). University of Michigan: Language Description Heritage Library.

Heck, Fabian, Gereon Müller, and Jochen Trommer. 2009. A phase-based approach to Scandinavian definiteness marking. *STUF-Language Typology and Universals Sprachtypologie und Universalienforschung* 62(4): 258–268.

Horvath, Julia, and Tal Siloni. 2016. The thematic phase and the architecture of grammar. In *Concepts, syntax and their interface*, eds. Eric Reuland, Martin Everaert, and Marijana Marelj, 129–174. Cambridge: MIT Press.

Hyman, Larry M. 2011. Tone: Is it different? In *The handbook of phonological theory*, eds. John Goldsmith, Jason Riggle, and Alan C. L. Yu, 197–239. Oxford: Blackwell.

Hyman, Larry M. 2016. Morphological tonal assignments in conflict: Who wins. In *Tone and inflection: New facts and perspectives*, ed. Jean Leo Leonard Enrique Palancar, 15–39. Berlin: De Gruyter Mouton.

Hyman, Larry M. 2018. Towards a typology of postlexical tonal neutralizations. In *Tonal change and neutralization*, eds. Haruo Kobozono and Mikio Giriko, 7–26. Berlin: De Gruyter Mouton.

Hyman, Larry M., and Al Mtenje. 1999. Prosodic morphology and tone: The case of Chichewa. In *The prosody-morphology interface*, 90–133. Cambridge: University Press Cambridge.

Hyman, Larry M., Sharon Inkelas, and Galen Sibanda. 2009. Morphosyntactic correspondence in Bantu reduplication. In *The nature of the word: Essays in honor of Paul Kiparsky*, eds. Kristin Hanson and Sharon Inkelas, 273–309. Cambridge: MIT Press.

Hyman, Larry M., Francis Katamba, and Livingstone Walusimbi. 1987. Luganda and the strict layer hypothesis. *Phonology* 4(1): 87–108.

Inkelas, Sharon. 1990. *Prosodic constituency in the lexicon*. New York: Garland Outstanding Dissertations in Linguistics.

Inkelas, Sharon. 1998. The theoretical status of morphologically conditioned phonology: A case study of dominance effects. In *Yearbook of morphology 1997*, eds. Geert Booij and Jaap van Marie, 121–155. Dordrecht: Kluwer Academic Publishers.

Inkelas, Sharon. 2008. The morphology-phonology connection. In *Annual meeting of the Berkeley Linguistics Society*, Vol. 34, 145–162.

Inkelas, Sharon. 2014. *The interplay of morphology and phonology*. Oxford: Oxford University Press.

Inkelas, Sharon, and Cheryl Zoll. 2005. *Reduplication: Doubling in morphology*. Cambridge: Cambridge University Press.

Inkelas, Sharon, and Cheryl Zoll. 2007. Is grammar dependence real? A comparison between cophonological and indexed constraint approaches to morphologically conditioned phonology. *Linguistics* 45(1): 133–171.

Inkelas, Sharon, Orhan Orgun, and Cheryl Zoll. 1997. The implications of lexical exceptions for the nature of grammar. In *Optimality theory in phonology: A reader*, ed. J. J. McCarthy, 542–551. Oxford: Blackwell.

Ishihara, Shinichiro. 2003. Intonation and interface conditions. PhD diss., MIT.

Ishihara, Shinichiro. 2007. Major phrase, focus intonation, multiple spell-out (map, fi, mso) major phrase, focus intonation, multiple spell-out (MaP, FI, MSO). *The Linguistic Review* 24: 137–167.

Ito, Junko, and Armin Mester. 2007. Prosodic adjunction in Japanese compounds. In *Formal approaches to Japanese linguistics 4. MIT working papers in linguistics 55*, 97–111.

Jenks, Peter. 2014. Head movement in Moro DPs: Evidence for a unified theory of movement. In *West Coast Conference on Formal Linguistics (WCCFL) 31*, 248.

Jenks, Peter. 2019. Verbal and verbless copular clauses in Moro. Ms., UC Berkeley.

Jenks, Peter, and Sharon Rose. 2011. High tone in Moro: Effects of prosodic categories and morphological domains. *Natural Language & Linguistic Theory* 29: 211–250.
Jenks, Peter, and Sharon Rose. 2015. Mobile object markers in Moro: The role of tone. *Language* 91(2): 269–307.
Jenks, Peter, and Sharon Rose. 2017. Documenting raising and control in Moro. In *Africa's endangered languages: Documentary and theoretical approaches*, eds. Jason Kandybowicz and Harold Torrence, 207–236. London: Oxford University Press.
Jensen, J. T. 1977. *Yapese reference grammar*. Honolulu: University of Hawaii Press.
Julien, Marit. 2002. *Syntactic heads and word formation*. Oxford: Oxford University Press.
Kahnemuyipour, Arsalan. 2009. *The syntax of sentential stress*. Oxford: Oxford University Press.
Kalivoda, Nicholas. 2018. Syntax-prosody mismatches in Optimality Theory. PhD diss., University of California Santa Cruz.
Kanerva, Jonni. 1989. Focus and phrasing in Chichewa phonology. PhD diss., Stanford University.
Kastner, Itamar. 2019. Templatic morphology as an emergent property: Roots and functional heads in Hebrew. *Natural Language and Linguistics Theory* 37: 571–619.
Keine, Stefan. 2010. *Case and agreement from fringe to core: A minimalist approach*, Vol. 536. Berlin: Walter de Gruyter.
Kiparsky, Paul. 2000. Opacity and cyclicity. *The linguistic review* 17: 351–367.
Kiparsky, Paul. 2008. Fenno-Swedish quantity: Contrast in Stratal OT. In *Rules, constraints, and phonological phenomena*. Oxford: Oxford University Press.
Kiparsky, Paul, et al. 1982. From cyclic phonology to lexical phonology. *The structure of phonological representations* 1: 131–175.
Kirchner, Robert. 1997. Contrastiveness and faithfulness. *Phonology* 14(01): 83–111.
Kramer, Ruth. 2010. The Amharic definite marker and the syntax–morphology interface. *Syntax* 13(3): 196–240.
Kratzer, Angelika, and Elisabeth Selkirk. 2007. Phase theory and prosodic spellout: The case of verbs. *The Linguistic Review* 24: 93–135.
Kubozono, Haruo. 1989. Syntactic and rhythmic effects on downstep in Japanese. *Phonology* 6(1): 39–67.
Kurisu, Kazutaka. 2001. The phonology of morpheme realization. PhD diss., University of California, Santa Cruz.
Legendre, Géraldine, Yoshiro Miyata, and Paul Smolensky. 1990. Harmonic grammar: A formal multi-level connectionist theory of linguistic well-formedness: Theoretical foundations. In *Conference of the cognitive science society 12*, 884–891. Mahwah: Lawrence Erlbaum Associates.
Łubowicz, Anna. 2003. Contrast preservation in phonological mappings. PhD diss., University of Massachusetts, Amherst.
Łubowicz, Anna. 2012. *The phonology of contrast*. Bristol: Equinox Publishing.
Marlo, Michael R., Leonard Chacha Mwita, and Mary Paster. 2015. Problems in Kuria h tone assignment. *Natural Language & Linguistic Theory* 33(1): 251–265.
Marvin, Tatjana. 2002. Topics in the stress and syntax of words. PhD diss., Massachusetts Institute of Technology.
Matushansky, Ora. 2005. Going through a phase. *MIT working papers in linguistics* 49: 157–181.
Matushansky, Ora. 2006. Head movement in linguistic theory. *Linguistic inquiry* 37(1): 69–109.
McCarthy, John, and Alan Prince. 1990. Prosodic morphology and templatic morphology. In *Perspectives on Arabic linguistics 2: Papers from the second annual symposium on Arabic linguistics*, 1–54. Amsterdam: Benjamins.
McCarthy, John, and Alan Prince. 1996. *Prosodic morphology 1986*. New Jersey: Rutgers University Center for Cognitive Science.
McPherson, Laura. 2013. *A grammar of Tommo So*. Vol. 62 of *Mouton grammar library*. Berlin: Walter de Gruyter.
McPherson, Laura, and Jeffrey Heath. 2016. Phrasal grammatical tone in the Dogon languages. *Natural Language & Linguistic Theory* 34(2): 593–639.
McPherson, Laura Elizabeth. 2014. Replacive grammatical tone in the Dogon languages. PhD diss., University of California Los Angeles.
Mortensen, David Roland. 2006. Logical and substantive scales in phonology. PhD diss., University of California, Berkeley.
Mtenje, Al. 1987. Tone shift principles in the Chichewa verb: A case for a tone lexicon. *Lingua* 72(2–3): 169–209.
Myers, Scott. 1987. Tone and the structure of words in Shona. PhD diss., University of Massachusetts.

Myers, Scott. 1997. OCP effects in Optimality Theory. *Natural Language & Linguistic Theory* 15 (4): 847–892.
Nespor, Marina, and Irene Vogel. 1986. *Prosodic phonology*. Dordrecht: Foris.
Newell, Heather, and Glyne Piggott. 2014. Interactions at the syntax–phonology interface: Evidence from Ojibwe. *Lingua* 150: 332–362.
Orgun, Cemil. 1996. Sign-based morphology and phonology with special attention to Optimality Theory. PhD diss., UC Berkeley.
Orgun, Cemil Orhan, and Sharon Inkelas. 2002. Reconsidering bracket erasure. In *Yearbook of morphology 2001*, eds. Geert Booij and Jaap van Marie, 115–146. Dordrecht: Kluwer Academic Publishers.
Pak, Marjorie. 2008. The postsyntactic derivation and its phonological reflexes. PhD diss., University of Pennsylvania.
Paster, Mary. 2006. Phonological conditions on affixation. PhD diss., UC Berkeley.
Pater, Joe. 2007. The locus of exceptionality: Morpheme-specific phonology as constraint indexation.
Pater, Joe. 2010. Morpheme-specific phonology: Constraint indexation and inconsistency resolution. In *Phonological argumentation: Essays on evidence and motivation*, ed. Steve Parker, 123–154. London: Equinox.
Pesetsky, David. 1979. Russian morphology and lexical theory. Ms., MIT.
Pollard, Carl, and Ivan A Sag. 1994. *Head-driven phrase structure grammar*. Chicago: University of Chicago Press.
Revithiadou, Anthoula. 1999. Headmost accent wins: Head dominance and ideal prosodic form in lexical accent systems. PhD diss., Leiden.
Richards, Norvin. 2016. *Contiguity theory*. Cambridge: MIT Press.
Ritchart, Amanda, and Sharon Rose. 2017. Moro vowel harmony: implications for transparency and representations. *Phonology* 34(1): 163–200. https://doi.org/10.1017/S0952675717000069.
Rolle, Nicholas. 2018. Grammatical tone: Typology, theory, and functional load. PhD diss., UC Berkeley.
Rolle, Nicholas. 2019. In support of an OT-DM model: Evidence from a morphological conspiracy in Degema. *Natural Language & Linguistic Theory*. https://doi.org/10.1007/s11049-019-09444-z.
Rolle, Nicholas, and Larry Hyman. 2019. Phrase-level prosodic smothering in Makonde. In *2018 Annual meeting on phonology*, eds. Katherine Hout, Anna Mai, Adam McCollum, Sharon Rose, and Matt Zaslansky. Washington, DC: Linguistic Society of America.
Rolle, Nicholas, and Florian Lionnet. 2019. Phantom structure: A representational account of floating tone association. Ms., Princeton.
Rose, Sharon. 2013. The morphological structure of the Moro verb. In *Nuba mountain language studies*, eds. Thilo C. Schadeberg and Roger M. Blench. Cologne: Rüdiger Köppe Verlag.
Rubin, Edward J. 2003. Determining pair-merge. *Linguistic Inquiry* 34(4): 660–668.
Rubin, Edward Jon. 1995. Modification: A syntactic analysis and its consequences. PhD diss., Cornell University.
Sande, Hannah. 2017. Distributing morphologically conditioned phonology. PhD diss., UC Berkeley.
Sande, Hannah. 2018. Cross-word morphologically conditioned scalar tone shift in Guébie. *Morphology* 28(3): 253–295.
Sande, Hannah. 2019. A unified account of conditioned phonological alternations: Evidence from Guébie. *Language* 95.3: 456–498.
Sande, Hannah, and Peter Jenks. 2018. Cophonologies by phase. In *North East Linguistic Society (NELS) 48*, eds. Sherry Hucklebridge and Max Nelson, Vol. 2, 39–52.
Sato, Yosuke. 2009. Spelling-out prosodic domains: a multiple spell-out account. In *Interphases: Phase theoretic investigations of the linguistic interfaces*, ed. Kleathes K. Grohmann, 234–262. London: Oxford University Press.
Schütze, Carson. 1994. Serbo-Croatian second position clitic placement and the phonology-syntax interface. *MIT working papers in linguistics* 21: 373–473.
Scontras, Gregory, and Andreea C. Nicolae. 2014. Saturating syntax: Linkers and modification in Tagalog. *Lingua* 149: 17–33.
Selkirk, Elisabeth. 1974. French liaison and the X notation. *Linguistic Inquiry* 5(4): 573–590.
Selkirk, Elisabeth. 2009. On clause and intonational phrase in Japanese: The syntactic grounding of prosodic constituent structure. *Gengo Kenkyu* 136: 35–73.
Selkirk, Elisabeth. 2011. The syntax-phonology interface. *The handbook of phonological theory* 2: 435–483.
Selkirk, Elisabeth, and Koichi Tateishi. 1991. Syntax and downstep in Japanese. In *Interdisciplinary approaches to language*, 519–543. Dordrecht: Springer.

Shih, Stephanie S. 2016. Super additive similarity in Dioula tone harmony. In *West Coast Conference on Formal Linguistics (WCCFL) 33*, 361–370. Somerville: Cascadilla.

Shih, Stephanie S., and Kie Zuraw. 2017. Phonological conditions on variable adjective and noun word order in Tagalog. *Language* 93(4): 317–352.

Smith, Jennifer L. 2011. Category-specific effects. *The Blackwell companion to phonology* 4: 2439–2463.

Smolensky, Paul, and Matthew Goldrick. 2016. Gradient symbolic representations in grammar: The case of French liaison. *Rutgers Optimality Archive* 1552.

Svenonius, Peter. 2004. On the edge. In *Peripheries*, 259–287. Dordrecht: Springer.

Truckenbrodt, Hubert. 1999. On the relation between syntactic phrases and phonological phrases. *Linguistic Inquiry* 30(2): 219–255.

Urbanczyk, Suzanne. 2006. Reduplicative form and the root-affix asymmetry. *Natural Language & Linguistic Theory* 24(1): 179–240.

Uriagereka, Juan. 2005. Multiple spell-out. In *Derivations*, 55–75. London: Routledge.

Volk, Erez. 2011. Mijikenda tonology. PhD diss., Tel Aviv University.

Wagner, Michael. 2005. Prosody and recursion. PhD diss., MIT.

Wagner, Michael. 2010. Prosody and recursion in coordinate structures and beyond. *Natural Language & Linguistic Theory* 28: 183–237.

Werle, Adam. 2009. Word, phrase, and clitic prosody in Bosnian, Serbian, and Croatian. PhD diss., University of Massachusetts, Amherst.

Wilson, Colin, and Benjamin George. 2008. Maxent grammar tool. Software package. University of California, Los Angeles.

Wolf, Mathew Adam. 2008. Optimal interleaving: Serial phonology-morphology interaction in a constraint-based model. PhD diss., University of Massachusetts, Amherst.

Yu, Alan CL. 2007. *A natural history of infixation*. Oxford: Oxford University Press.

Zec, Draga, and Sharon Inkelas. 1990. Prosodically constrained syntax. In *The phonology-syntax connection*, eds. Sharon Inkelas and Draga Zec, 365–378.

Zymet, Jesse. 2018. Lexical propensities in phonology: Corpus and experimental evidence, grammar, and learning. PhD diss., UCLA.

Zymet, Jesse. 2019. Learning a frequency-matching grammar together with lexical idiosyncrasy: MaxEnt versus hierarchical regression. In *Proceedings of the 2018 annual meeting on phonology*, eds. Katherine Hout, Anna Mai, Adam McCollum, Sharon Rose, and Matt Zaslansky. Washington, DC: Linguistic Society of America.